453. Beretning fra Statens Husdyrbrugs forsøg

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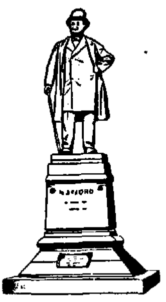
Growth, feed utilization, carcass quality and meat quality in Danish dual-purpose cattle.

Genetic analysis concerning 5 years data from the progeny tests for beef production at Egtved.

Tilvækst, foderudnyttelse, slagtekvalitet og kødkvalitet hos kvæg af danske kombinationsracer.

Genetiske analyser vedrørende 5 års data fra afkomsprøverne for kødproduktion på Egtved.



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PREFACE.

Since the beginning of the 'fifties' Denmark has had a considerable export of beef and veal, especially to the Italian market. This has caused that almost all bull-calves from the dairy herds have been and still are used in the beef-production. Consequently, a need for a genetic improvement of the beef-production traits of the Danish dual-purpose cattle has arisen.

The first "progeny tests for beef-production" were carried out on the progeny test stations for milk-production. In 1967, however, a central progeny test station for beef-production was established at Egtved. The capacity of this station is 540 veal calves and 240 young bulls.

The test station is run by the independent institution EGTVED, which was established by:

The Federation of Danish Farmers' Union,
The Federation of Danish Smallholders' Union,
The Federation of Danish Cattle Breeding Societies,
"Damexco", Danish Slaughterhouses Meat Export,
The Association of Danish Cattle and Meat Exporters' Whole salers, and
"Oxexport", Danish Farmers' Cattle and Beef Export.

The National Institute of Animal Science takes care of the experimental matters at the research station, while The Danish Meat Research Institute is in charge of the testing of carcass quality and meat quality. The Department of Meat-technology at The Royal Veterinary and Agricultural University carries out the individual special tests concerning meat quality.

Each year 30 progeny groups are tested. During the first 5 years of probation each progeny group consisted of 10 veal calves (250 kg) and 8 young bulls (450 kg). For each individual animal very detailed recordings concerning growth, feed utilization, carcass-quality and meat-quality were carried out.

The aim of this report is to present genetic and phenotypic parameters for 44 different traits of beef-production. The calculations are based on 136 progeny groups including a total of 1319 veal calves and 1011 young bulls. The results are presented in a report in English, in the hope that they may contribute to the international efforts to increase the efficiency and quality of the beef-production.

The report is worked out in a co-operation between the National Institute of Animal Science (Department of Cattle and Sheep Experiments), The Danish Meat Research Institute and the Royal Veterinary and Agricultural University (Department of Meat-technology). The calculations have been carried out by Th. Lykke and B. Bech Andersen with technical assistance of research assistant G.S. Andersen. Th. Lykke and B. Bech Andersen have written chapters I, II, III, VI, VII and VIII. Kr. Kousgaard and L. Buchter have written chapters IV and V.1., and J. Wismer Pedersen chapter V.2. The English text is prepared by K. Tolsgaard and J. Dalfoss has done the typewriting. Besides the above-mentioned, many others have collaborated in the collection of data and in the laboratory work. Thanks for this assistance are hereby expressed.

Copenhagen, February 1977 A. Neimann-Sørensen

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ENGLISH SUMMARY

This report treats of genetic investigations based on five years' data from the progeny tests for beef-production at the breeding station Egtved. From the breeds Danish Red Cattle (RDM), Danish Black and White Cattle (SDM) and Danish Red and White Cattle (DRK) a total of 136 progeny groups have been tested, each of which consists of 10 calves slaughtered at 250 kg live-weight and 8 young bulls slaughtered at 450 kg. All data from 1319 calves and 1011 young bulls were included in the analysis.

The progeny testing begins, when the calves are 15 days old, after which the animals are weighed every four weeks.

The feeding is carried out according to a standardized feeding scheme, and the feed consumption is individually recorded. All the animals are slaughtered at the same slaughterhouse according to a carefully controlled plan, and the carcass quality is registered in details. Meat samples from each animal are subjected to physical-chemical tests, panel evaluations and measurements of fiber diameters.

Both in daily gain, feed utilization, carcass quality and meat quality an effect of breed and weight at slaughter can be demonstrated. For certain traits an effect of interaction between breed and final weight has also been found.

Most traits have relatively high coefficients of heritability and a considerable phenotypic variation.

It is concluded that the possibilities of a genetic improvement of the beef-production capacity in dual-purpose cattle are favourable, if a performance test of potential AI bulls or a progeny test is carried out under standardized environmental conditions. The traits are interrelated in such a way that it is possible to improve more types of traits simultaneously.

DANSK SAMMENDRAG

Nærværende beretning omhandler statistisk-genetiske undersøgelser på 5 års data fra afkomsprøverne for kødproduktion på avlsstationen "Egtved".

Formålet med beretningen er at belyse nedarvning, variation og indbyrdes sammenhæng for ialt 44 forskellige kødproduktionsegenskaber. Resultaterne præsenteres i en engelsksproget beretning i håb om, at de kan bidrage til de internationale bestræbelser for at øge effektivitet og kvalitet i kødproduktionen.

Materialet er indsamlet i perioden 1967 til 1971. Det omhandler ialt 1319 skummetmælkskalve og 1011 ungtyre slagtet ved henholdsvis 250 og 450 kg og fordelt på ialt 136 afkomsgrupper af racerne RDM, SDM og DRK. Kalvene har startet i prøven 15 dage gamle,og samtlige dyr er derefter vejet med 14 dages intervaller. Fodringen er gennemført efter alder, og der har været individuel registrering af foderoptagelsen. Samtlige dyr er slagtet på samme slagteri efter en nøje fastlagt plan, og der er foretaget detaljerede opskæringer og registreringer for at fastlægge slagtekvaliteten. Endvidere er der på kødprøver fra hvert enkelt dyr foretaget fysisk-kemiske målinger, smagsbedømmelser og måling af muskelfibrene for at beskrive kødkvaliteten.

Kødproduktionsegenskaberne er opdelt og behandlet i tre hovedgrupper, nemlig: 1) tilvækst og foderudnyttelse, 2) slagtekvalitet og 3) kødkvalitet.

Tilvækst og foderudnyttelse.

Under kontrollerede og ensartede miljøforhold er der en fænotypisk spredning i gennemsnitlig daglig tilvækst på 60-70 gram. Denne spredning er stærkt arveligt bestemt med en heritabilitetskoefficient på 0.43. De gennemførte korrelationsberegninger viser, at en arveligt betinget forbedring af tilvækstkapaciteten indirekte medfører et stærkt nedsat foderforbrug pr. kg tilvækst samt lidt senere slagtemodne dyr med den deraf følgende lavere fedningsgrad, højere kødprocent og bedre muskelfordeling. Derimod har den arvelig betingede variation i tilvæksthastigheden kun lille indflydelse på de undersøgte kødkvalitetsmål.

Slagtekvalitet.

Den fænotypiske spredning for slagtekvalitetsmålene ligger generelt på et ret lavt niveau, men er til gengæld for de fleste egenskaber stærkt arveligt bestemt med heritabilitetskoefficienter omkring 0.5 til 0.6. Kun for den subjektive klassificering samt for kød-, talg- og knoglefordelingen er der fundet forholdsvis lave heritabilitetskoefficienter.

Procent pistolkød er et sammensat kvalitetsmål, der påvirkes af kød/knogle forholdet, fedningsgraden og kødfordelingen. Disse egenskaber vil alle påvirkes i ønsket retning ved at anvende % pistolkød som selektionskriterium. Endvidere viser de gennemførte undersøgelser, at slagtekroppens muskelareal er ret stærkt korreleret til de vigtigste slagtekvalitetsmål. Da dette areal samtidig har en variationskoefficient på 9%,og en h^2-værdi på 0.58, vil muskelarealet være en særdeles vigtig egenskab for selektion. Slagtekvaliteten er kun svagt korreleret til de vigtigste kødkvalitetsmål.

Kødkvalitet.

Kødkvalitetsegenskaberne har gennemgående en lav arvelig variation. Dog er der for konsistenstallet og points for mørhed fundet så høje h^2-værdier, at der gennem en afkomsprøve for kødproduktion er muligheder for en avlsmæssig forbedring af disse egenskaber, såfremt der skulle blive økonomisk basis for dette.

Arv x slagtevægt samspilseffekt.

For nettotilvækst, de vigtigste slagtekvalitetsmål og kødkonsistensen er der påvist en signifikant samspilseffekt mellem race og slagtevægt. Vekselvirkningen kommer til udtryk på den måde, at der for RDM-racen sker en større forbedring af muskelfylden og en mindre stigning i fedningsgraden fra 250 til 450 kg end for de to øvrige racer. Det fortæller, at RDM er senere slagtemoden end SDM og DRK. Selv om der ikke er fundet tilsvarende samspilseffekt mellem afkomsgruppe og slagtevægt, antyder resultaterne alligevel, at afkomsprøver og individprøver bør gennemføres med en slutvægt, der ikke afviger for meget fra de gældende produktions- og afsætningsforhold.

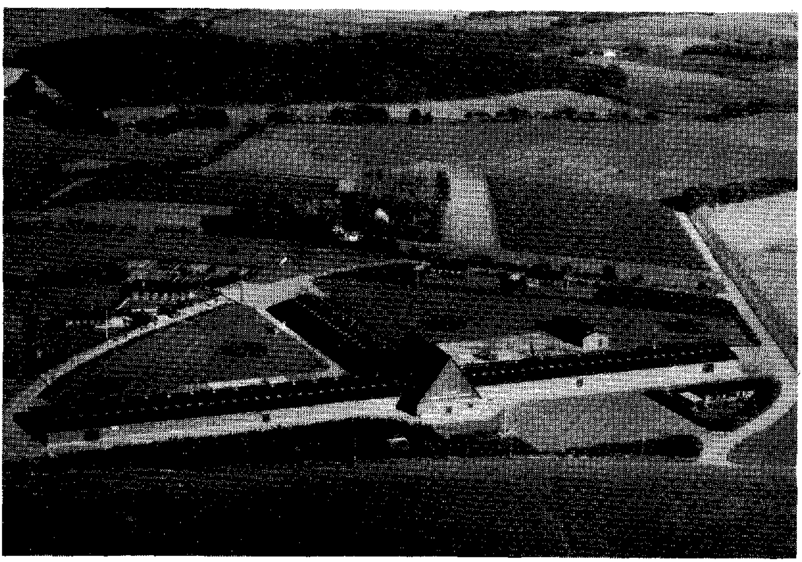
Nuværende afprøvningsforanstaltninger.

Resultaterne fra de første 5 år, især de høje heritabilitetskoefficienter, har medført, at afkomsprøverne for kødproduktion nu gennemføres med en gruppestørrelse, der er reduceret fra 18 til 10. Kun den letteste kategori af slagtedyr afprøves, men slagtevægten er hævet fra 250 til 300 kg. En tyrs avlsværdi for kødproduktion sammenfattes i et K-tal sammensat af egenskaberne nettotilvækst, % pistolkød og kødkonsistens.

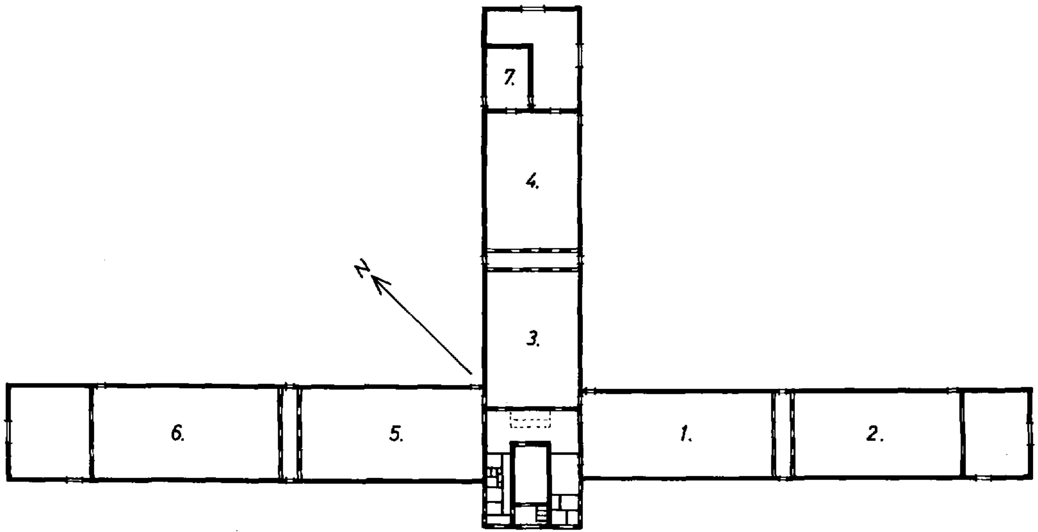
De forholdsvis høje heritabilitetskoefficienter for tilvæksthastighed og muskelareal viser, at avlsværdien for disse egenskaber med ret stor sikkerhed kan bestemmes ved en individprøve på dyret selv. Derfor gennemføres der nu individprøver på ca. 500 potentielle avlstyre pr. år. Prøven omfatter aldersperioden fra 1½ til 11 måneder, og avlsværdien for tilvækst udtrykkes ved et T-tal. Tværsnitsarealet af den lange rygmuskel bestemmes ved prøvens afslutning ved hjælp af en ultralydmåling. Ultralydmålet korrigeres til konstant 11 mdr.'s vægt og præsenteres som procent af racens gennemsnit.

Ved at inkludere individprøver og afkomsprøver for kødproduktion i avlsarbejdet med malke- og kombinationsracerne er det muligt at forbedre racernes tilvækst og slagtekvalitet, uden at mulighederne for at opnå avlsmæssig fremgang i mælkeproduktionsegenskaberne reduceres nævneværdigt.

En forbedring af racernes tilvækst og slagtekvalitet mindsker omkostningerne til foder, arbejde og forrentning hos opdræt og fededyr, ligesom slagteværdien af fededyr og udsætterkøer vil kunne forøges.



EGTVED



Ground-plan for EGTVED station. Since 1972 the different parts of the station have been used as follows:

Parts 1 and 2: Progeny tests (300 animals)
" 3 " 5: Crossbreeding experiments (240 animals)
" 4 " 6: Performance tests (140 animals)

CHAPTER I.

LITERATURE AND INTRODUCTION.

In Denmark the main part of the beef- and veal-production is based on bull-calves, fattening heifers and culled cows of the dual-purpose breeds Danish Red Cattle (RDM), Danish Black and White Cattle (SDM) and Danish Red and White Cattle (DRK).

The number of cattle slaughtered per year is 1.1 mill. head appr., and it accounts for 35-40% of the total income in the cattle herds. Table 1 shows the distribution on categories and breeds:

Table 1. Annual Danish production of beef in thousand heads distributed on categories and breeds.

	Categories:						
	Young bulls	Bulls	Steers	Calves	Heifers	Culled cows	Total
Thousand head	537	24	13	39	130	394	1,137
	Breeds:						
	RDM	SDM	DRK	Jersey	Beef x Dairy	Suckler herds	Total
Percentage	22	51	5	9	6	7	100

The breeding goal for the dual-purpose breeds is a simultaneous improvement of both milk-production capacity and beef-production capacity. The breeding schemes have to be planned in accordance to that goal.

Fortunately, there is no genetic antagonism between milk and beef. Summarizing, a number of investigations show a slightly positive genetic correlation between daily gain and milk yield ($r_A \simeq 0.2$) and a slightly negative genetic correlation between carcass quality and milk yield ($r_A \simeq -0.2$) (Andersen and Andersen,1975). The correlations reported are so slight that they do neither render superfluous nor complicate a simultaneous genetic improvement of the milk- and beef-production traits in the dual-purpose cattle breeds.

The beef-production of the cattle is a complex of traits, namely: Growth capacity, feed utilization, dressing percentage, carcass composition, carcass confirmation,meat quality and fat quality (figure 1).

Beef-production capacity

Traits of production	Traits of carcass quality	Traits of meat quality
Daily gain Feed utilization	Dressing percentage Carcass composition Carcass conformation	Meat colour % intramuscular fat Tenderness Fiber-characteristics

Figure 1. Diagram regarding the beef-production capacity of the cattle.

A genetic improvement of growth capacity will result in a cheaper production of fattening bulls and surplus heifers, as the expenditure on feed, labour, housing and investment will be reduced.

A genetic improvement of carcass quality will cause higher selling prices for fattening bulls and culled cows.

A genetic improvement of meat quality will lead to greater satisfaction among the consumers and thus, on the long view, it could contribute to improving the demand as well as the selling prices.

As will appear from the review of literature in Table 2, a number of analyses have shown that the phenotypic standard deviation of average daily gain in dual-purpose cattle varies from 60 to 100 g/day and the corresponding coefficient of heritability from 0.4 to 0.6.

Table 2. Average, standard deviation and coefficient of heritability for daily gain in dual-purpose cattle (review of literature).

Breed	Av., g/day	SD	h^2	Author	
Fleckvieh	-	-	0.41	Rittmannsperger,	1966
Braunvieh	-	-	0.55	Rittmannsperger,	1966
Finnish Ayrshire	1177	102	0.37	Lindström and Maijala	1970
Schwarzbunt	-	-	0.61	Dietert et al.,	1970
Schwarzbunt	-	-	0.45	Gravert et al.,	1971
Rotbunt	-	-	0.32	Gravert et al.,	1971
Schwarzbunt	1099	65	0.57	Langholz und Jongeling	1972
Schwarzbunt	1121	74	0.52	Trappmann,	1972
Rotbunt	1167	69	0.56	Trappmann,	1972
NRF	1158	78	0.49	Fimland,	1973
Fleckvieh	1100	95	0.59	Linner,	1973

The number of analyses of the genetic variation in the carcass quality traits in dual-purpose cattle breeds is rather limited owing to the high costs of carcass dissection.

The phenotypic coefficients of variation for % lean, % fat and % bone are 3-5%, 10-15% and 4-6% respectively. The corresponding coefficients of heritability vary from 0.3 to 0.7. Generally, h^2 is highest for % bone and lowest for % fat. (Hinks and Andersen, 1969, Averdunk, 1969, Torreele and Slawinski, 1970, Andersen, 1970, Langholz und Jongeling, 1972). The analyses referred to are based on both total and partial dissection of the carcasses. One of the most common indirect measurements of composition and conformation of the carcass is the long. dorsi area with coefficients of heritability, varying from 0.4 to 0.8 (Skjervold, 1958, Langholz, 1964, La Chevallerie, 1968, Hinks and Andersen, 1969). Subjective evaluations of the carcass show coefficients of heritability around 0.15 to 0.70 (Shelby et al., 1963, Cundiff et al., 1964, Langlet, 1965).

The heritability of the meat quality traits varies from analysis to analysis. Gravert (1962) found a heritability of 0.78 for % fat in the meat and 0.31 for the meatcolour. Shelby et al. (1955) and Shelby et al. (1963) have determined heritabilities for meatcolour of 0.31 and 0.49. Regarding measurements of tenderness Palmer (1963) found a heritability of 0.28 in Hereford, while Gravert (1962) did not find any genetic variation in data on Black Pied German Cattle. For the diameter of muscle fibers Gravert (1962) found a heritability of 0.31.

In order to develop a procedure for testing and a strategy for selection,variation of the economically most important traits and the interrelation between them should be known.

Thus a highly significant correlation between rate of gain and feed utilization has been found in many analyses. On data from progeny tests for beef production, genetic coefficients of correlation between daily gain and feed consumption/kg gain varying from -0.61 to -0.92 and phenotypic coefficients of correlation varying from -0.74 to -0.88 have been found by Averdunk (1969), Dietert et al. (1970), Langholz and Jongeling (1972) and Trappmann (1972).

The genetic determined growth capacity can also influence the carcass composition. Gallagher (1963), Cunningham et al. (1969), Dietert et al. (1970), Trappmann (1972) and Langholz and Jongeling (1972) have shown that at a constant weight basis, an increase in the rate of gain indirectly entails a reduction of the fatness of the carcass and a corresponding increase in the relative lean content, whereas the muscle distribution generally speaking is independent of rate of gain.

Several investigations have shown a positive relationship between fatness and dressing percentage (a.o. Callow, 1944, 1947, and 1961). However, in these experiments weight at slaughter is not held constant, and contrary to Callow's result, Kaufman et al. (1976) showed that on a constant weight basis fatter cattle did not have higher dressing percentage.

The correlation between a subjective evaluation of the carcass and the relative content of lean, fat and bone is generally on a low level (Hinks and Andersen, 1968, La Chevallerie, 1968, Andersen, 1974). Furthermore, the value of subjective carcass evaluation depends on the person, who carries out the grading, and the variation between graders is often big (Skjervold, 1958). Among objective measurements directly on the carcass, the M. long. dorsi area (rib eye area) gives a relatively good description of the composition and conformation of the carcass. The phenotypic coefficients of correlation vary from 0.3 to 0.7 (Skjervold, 1958, Cole et al.,1960, and 1962, Hertrampf, 1960, Lettner, 1965, Miller et al., 1965, La Chevallerie, 1968, Hinks and Andersen, 1968, and Andersen, 1970).

The results of the investigations described show that there is a genetic variation in daily gain, carcass quality and meat quality in the dual-purpose cattle. Consequently, it is possible to achieve an improvement of the beef-production traits through testing and selection of animals for breeding.

During the period from 1956 to 1966 Danish progeny tests for beef-production were carried out in several small, local testing stations. The results from these stations, however, showed a significant effect of station and slaughter house on daily gain, feed utilization, carcass quality and meat quality, respectively.

In 1967, therefore, a central breeding station was established, where feeding, management, transport, slaughtering, cooling, dissection, and treatment of muscle samples could be standardized and controlled. Basical investigations concerning the test of meat quality traits are described by Buchter (1970).

The progeny tests for beef-production at the breeding station, EGTVED, have opened up the possibility of:

1. A systematic test of the breeding value for beef-production capacity of Danish AI bulls.
2. A quantitative and qualitative description of the beef-production capacity of Danish dual-purpose cattle.
3. A test of the heredity of daily gain, feed utilization, carcass quality and meat quality in dual-purpose cattle.

CHAPTER II.

MATERIAL AND METHODS.

This report deals with genetic investigations on material from the progeny tests for beef-production in 1967, 1968, 1969, 1970 and 1971. The extent and composition of the material are shown in table 3.

Table 3. Number of progeny groups and distribution of calves and young bulls on breeds and final weight groups.

Breed[x)]	No. of progeny groups	No. of progenies: 250 kg calves	450 kg young bulls	Total
RDM	78	750	576	1326
SDM	51	501	382	883
DRK	7	68	53	121
Total	136	1319	1011	2330

x) RDM = Danish Red Cattle
SDM = Danish Black and White Cattle
DRK = Danish Red and White Cattle.

All the tested AI bulls are formerly progeny tested for milk-production with positive results. The progeny test for beef includes 18 male calves from each sire, randomly distributed into two weight groups. 10 are slaughtered at 250 kg live weight and 8 as young bulls at 450 kg live weight.

The calves are born in private dairy herds in the months of January, February and March. At the age of 5 to 12 days they are transported to the station in specially constructed lorries. The test starts, when the calves are 15 days old. The testing procedure is described in the following chapters.

All recorded data are transferred into and analyzed at NEUCC

(Northern Europe University Computing Center) by means of own EDP-programs as well as the standard program LSMLMM (Harvey,1972).

For all traits an investigation of the coefficient of skewness and curtosis is carried out. The results are shown in the appendix. In several cases a significant deviation from the normal distribution function was demonstrated, and a data-transformation has been considered, but not made. Investigations by Ovesen (1970) show that the effect of a data-transformation is insignificant for objective measured traits, whereas there can be a small effect for subjectively evaluated traits.

Following statistical models are used in the calculations:

(1) $Y_{ijkl} = \mu + y_i + b_j + c_k + (bxc)_{jk} + e_{ijkl}$

(2) $Y_{ijkl} = \mu + (y \cdot b)_i + p_{ij} + c_k + ((y \cdot b)xc)_{ik} + (pxc)_{ijk} + e_{ijkl}$

(3) $Y_{ijkl} = \mu + b_j + c_k + (bxc)_{jk} + e_{jkl}$

(4) $Y_{jklm} = \mu + b_j + p_{jm} + c_k + (bxc)_{jk} + (pxc)_{jmk} + e_{jklm}$

where:

Y = observed value for the individual animals.

μ = least squares means.

y_i = effect of year.

b_j = effect of breed.

$(y \cdot b)_i$ = effect of year - breed "i", i = 11, 12, 13, 21, 22, 23, 31, 32, 33, 41, 42, 43, 51, 52, 53 first figure = year of test, second figure = breed.

c_k = effect of final weight "k", k = 1, 2.

p_{ij} = effect of sire "j" nested within year-breed "i".

p_{jm} = effect of sire "m" nested with breed "j".

$(bxc)_{jk}$ = effect of interaction between breed and final weight.

$((y \cdot b)xc)_{ik}$ = effect of interaction between year-breed and final weight.

$(pxc)_{ijk}$ and $(pxc)_{jmk}$ = effect of interaction between sire and final weight.

e_{ijkl}, e_{jkl}, e_{jklm} = error.

The F-values for the different effects in models (1) and (3) are established by division of the mean square of the individual effects by the mean square of the residual components.

In the tables regarding coefficients of heritability the phenotypic coefficients are also shown. They are calculated on the sum of variation within bulls and between bulls, after adjustment for test-year, breed and final weight has been made (models (2) and (4)).

$$CV = 100 \times \frac{\text{Sum of variation}}{\text{Average of the trait}}$$

The following levels of significance are applied:

x significant on the 5% level
xx significant on the 1% level
xxx significant on the 0.1% level

CHAPTER III.

DAILY GAIN AND FEED UTILIZATION.

III.1. METHOD.

At the beginning of the test the male calves are distributed randomly in the test station, where they are tied up during the whole test period.

The feeding is carried out according to the schemes shown in tables 4 and 5.

In the test year 1967 part of the concentrates was replaced by grain. The composition of the concentrate is shown in table 6.

The quality of the feed used is determined through chemical analyses of collected samples.

The feed consumption of the animals is checked individually and feed left is weighed.

All the calves are weighed at the beginning of the test, when they are 15 days old, and thereafter every four weeks, until they have reached the final live weight of 250 kg and 450 kg, respectively. All the weighings are carried out before feeding in the morning.

The consumption of Scandinavian feed units of the individual animals is calculated on the basis of the feed consumption recorded as well as the results of the chemical analyses. In table 7 the average consumption for calves and young bulls, respectively, is shown.

The feed utilization is calculated as:

$$\text{Scand. f.u./kg gain} = \frac{\text{Total Scand. f.u. consumed}}{\text{Live weight at slaughter (kg) - weight at 15 days (kg)}}$$

Scand. f.u./kg carcass gain =

$$\frac{\text{Total Scand. f.u. consumed}}{\text{Cold carcass weight (kg) - weight at 15 days (kg) x 0.5}}$$

The rate of gain is calculated as:

Average daily gain, g =

$$1000 \times \frac{\text{Live weight at slaughter (kg) - weight at 15 days (kg)}}{\text{No. of days in test}}$$

Average daily carcass gain, g =

$$1000 \times \frac{\text{Cold carcass weight (kg) - weight at 15 days (kg) x 0.5}}{\text{No. of days in test}}$$

III.2. RESULTS.

III.2.1. Effect of Final Weight.

As appears from Table 8 the young bulls have a higher average daily gain and a higher carcass gain than the veal calves. Furthermore, the young bulls have the highest feed consumption per kg gain. This is due to a greater need of maintenance of the heavier young bulls as well as their growth requiring more energy, as the carcasses of the young bulls have a relatively higher fat content than the veal calves (chapter IV).

III.2.2. Effect of Breed.

The DRK breed has the heaviest calves at the age of 15 days, followed by SDM and RDM (table 8, in the middle). The same ranking of the three breeds can be seen for daily gain and feed utilization. In all cases the effect of breed is strongly significant.

III.2.3. Effect of Interaction between Breed and Final Weight.

The interaction between weight at slaughter and breed is analysed by use of model (1) page 20. The results are shown in Table 8 (at the bottom). The effect of interaction for average daily gain is significant on a 5% level, while for the average daily carcass gain and Scan. f.u./kg carcass gain it is significant on a 10% level.

III.2.4. Coefficients of Heritability.

The coefficients of heritability for gain and feed utilization are calculated by use of model (2), page 20. The results are shown in Table 9.

The coefficient of heritability for the weight at 15 days is very high. It is higher than shown in the literature, and it might be due to the fact that the male calves sent to the station may have been selected. As contributory cause of the high h^2-values can furthermore be mentioned that all weighings are made under strictly controlled conditions and that the material includes male calves only.

The coefficients obtained for daily gain and feed utilization are on the same level or a little below the level of those shown in literature (Table 2).

III.2.5. Interrelation between the Traits.

The phenotypic coefficients of correlation shown in Table 10 are calculated as residual coefficients within test year, breed and weight group. The corresponding genetic coefficients are calculated by use of model (2), page 20 . It appears from the table that the weight at 15 days is positively correlated to the later gain. Furthermore, it appears that there is a strongly positive correlation between daily gain and daily carcass gain as well as a strongly negative correlation between rate of gain and Scand. f.u./kg gain.

Table 4. Rations (kg/day) for bull calves.

Age in days	Whole milk substitute	Skim milk	Concen- trates	70 % dried sugarbeet pulp + 30% molasses	Hay
15- 38	5	1			
26- 52	4	2			0.3
40- 66	2	4	Ad	0.2	0.3
54- 80		6	libitum	0.4	0.3
68- 94		6		0.6	0.3
82-108		6		0.8	0.3
96-122		6		1.0	0.3
110-136		6		1.2	0.3
124-150		6		1.4	0.3
138-164		6		1.6	0.3
152-178		6		1.8	0.3
166-192		6		2.0	0.3
180-206		6		2.0	0.3
194-220		6		2.2	0.3
208-234		6		2.2	0.3
222-248		6		2.2	0.3

Table 5. Rations (kg/day) for young bulls.

Age in days	Skim milk	Concen-trates	70 % dried sugarbeet pulp + 30% molasses	Hay	Straw
15-165			as bull calves		
166-192	5		2.0	0.3	
180-206	4		2.2	0.5	1.0
194-220	3		2.2	0.5	1.0
208-238			2.4	0.5	1.0
222-248			2.6	0.5	1.0
236-262			2.8	0.5	1.0
250-276			2.8	0.5	1.0
264-290			3.0	0.5	1.0
278-304			3.2	0.5	1.0
292-318		Ad	3.4	0.5	1.0
306-332		libitum	3.6	0.5	1.0
320-346			3.8	0.5	1.0
334-360			3.8	0.5	1.0
348-374			4.0	0.5	1.0
362-388			4.0	0.5	1.0
376-402			4.0	0.5	1.0
390-416			4.2	0.5	1.0
404-430			4.2	0.5	1.0
418-444			4.2	0.5	1.0
432-458			4.2	0.5	1.0
446-472			4.2	0.5	1.0

Tabel 6. Composition of concentrates.

Concentrates for bull calves	Concentrates for young bulls.
10% soybean meal	25% soybean meal
15% linseed cakes	10% linseed cakes
10% linseed	35% barley
35% barley	28% oat
28% oat	1% dicalcium phosphate
1% dicalcium phosphate	1% monosodium phosphate
1% micromineral combination	

Composition of micromineral combination.

80.00% dicalcium phosphate
19.00% sodium chloride
0.50% manganese dioxide
0.30% copper sulphate
0.10% cobalt sulphate
0.09% zinc oxide
0.01% potassium iodide

Table 7. Total feed consumption in the test period (Scand. f.u.)

Category	Whole milk	Skim milk	Concen-trates	Dried sugar-beet pulp +molasses	Hay and straw	Total
250 kg calves	33.2	150.3	268.4	157.3	37.2	646.4
450 kg young bulls	33.5	141.7	815.5	580.7	138.2	1709.7

Table 8. Effect of final weight, breed and interaction on daily gain and feed utilization. (Least squares means).

	Number	Weight at 15 days (kg)	Age at slaughter (days)	Av. daily carcass gain (g)	Av. daily gain (g)	F.u./kg carcass gain	F.u./kg gain
Effect of final weight							
250 kg	1319	45.9	208.1	559.4	1096.7	5.58	3.04
450 "	1011	45.8	375.2	649.4	1151.0	7.32	4.13
Level of significance		N.S.		xxx	xxx	xxx	xxx
Effect of breed							
RDM	1326	45.3	298.2	598.2	1098.4	6.80	3.71
SDM	883	45.6	290.5	628.3	1130.5	6.43	3.58
DRK	121	46.7	286.2	646.8	1142.6	6.11	3.46
Level of significance		xx	xxx	xxx	xxx	xxx	xxx
Weight x breed interaction							
250 kg RDM	750	45.1	213.6	573.0	1069.3	5.92	3.17
250 kg SDM	501	45.7	206.3	606.9	1107.6	5.52	3.02
250 kg DRK	68	47.0	204.3	618.2	1113.2	5.29	2.93
450 kg RDM	576	45.5	382.8	623.4	1127.5	7.69	4.25
450 kg SDM	382	45.6	374.6	649.6	1153.4	7.35	4.14
450 kg DRK	53	46.4	368.0	675.3	1172.1	6.93	3.99
Level of significance		N.S.	N.S.	x	N.S.	N.S.	N.S.

Table 9. Coefficients of heritability and coefficients of variation for gain and feed utilization traits.

Trait	Coefficient of heritability	Phenotypic coefficient of variation %	Variation between progeny groups	Variation within progeny groups
Weight at 15 days, kg	0.72±0.10	10.5	4.1	18.8
Age in days at slaughter	0.41±0.07	6.1	30.8	266.8
Daily carcass gain, g	0.45±0.08	5.9	145.3	1148.9
Daily gain, g	0.43±0.07	5.6	411.0	3404.4
F.u./kg carcass gain	0.47±0.08	7.1	0.03	0.19
F.u./kg gain	0.36±0.07	7.1	0.01	0.06

Table 10. Phenotypic and genetic coefficients of correlation for gain and feed utilization traits.

	1	2	3	4	5	6
1. Weight at 15 days, kg		-0.82 0.10	0.57 0.09	0.56 0.09	-0.64 0.10	-0.72 0.10
2. Age in days at slaughter	-0.44		-0.89 0.13	-1.00 0.14	0.83 0.04	0.96 0.01
3. Daily carcass gain, g	0.24	-0.78		0.83 0.04	-0.98 0.13	-0.87 0.14
4. Daily gain, g	0.24	-0.91	0.86		-0.76 0.14	-0.95 0.15
5. F.u./kg carcass gain	-0.27	0.82	-0.89	-0.82		0.88 0.03
6. F.u./kg gain	-0.27	0.90	-0.75	-0.89	0.91	

Phenotypic correlations under the diagonal - all significant at the 99.9% level.
Genetic correlations above the diagonal - standard errors under the correlations.

CHAPTER IV

CARCASS QUALITY

IV.1. METHODS

It is absolutely essential to have definite instructions for slaughtering calves and young bulls from the progeny testing station, to reduce the influence by environmental factors. In the following the procedure used for the animals is given:

Monday	8:00 a.m.	Arrival of the animals at the slaughterhouse.
		Weighing the live animals.
	8:40 a.m.	Slaughter in uninterrupted succession. Weighing the hot carcasses and transport to the chilling room (+ 6^{o} C) within 45 min. post mortem.
Tuesday	6:30 a.m.	Weighing the cold carcasses. The temperature is lowered to + 4^{o} C.
	15:30 p.m.	Judgment and grading.
Wednesday	6:00 a.m.	Splitting (calves).
	6:30 a.m.	Removal of samples.
		Measuring carcass length.
		Photographing M. long. dorsi.
	7:30 a.m.	Dissection.

Slaughter

The animals must be slaughtered in uninterrupted succession, and any deviation from the normal procedure as well as abnormal reactions in live and slaughtered animals should be registered.

Carcasses of animals should be specially marked so that no interchange with carcasses from the normal production of the slaughterhouse can occur.

The veterinarians should be reminded to give special attention to experimental animals, and if something abnormal is noted or meat rejected, this should be registered and the weight of the meat rejected noted.

Chilling

The experimental animals must be chilled at + 6° C during the first 21 hours after slaughter and then at + 4° C. Temperature and humidity should be continously recorded.

Weighings

a. Live weight before slaughter.

b. Hot carcass weight without liver and tail; for young bulls also without kidney and kidneyfat.

c. Cold carcass weight after 21 hours chilling.

Judgments

Fleshiness for back, loin and thigh is judged in the following according to a scale from 1-10, where 1 is poor, 5 is medium and 10 is excellent.

Classification

The classification is carried out according to the regulations for the voluntary classification system. The classification concerns conformation, fatness and colour. Only conformation is included in the report with a scale from 1-10, where 1 is poor and 10 is excellent.

Length of carcass

Measured from the middle of the posterior edge of the first rib to the anterior edge of symphysis pubis (see Figure 2).

Photographing

The loin from the right side is cut across between the 1st and 2nd lumbar vertebrae, and a photo is taken to record the area of M. long. dorsi.

Samples

The following samples all from M. long. dorsi are used for estimation of meat quality (see Figure 2):

1. The sample for the test panel evaluations corresponds to the 2nd, 3rd, 4th and 5th lumbar vertebrae. Subcutaneous fat remains on this sample.

2. The sample for laboratory determinations corresponds to the 12th, 13th thoracic vertebrae and the 1st lumbar vertebrae.

2. The sample for muscle fiber characteristics corresponds to the 10th and 11th thoracic vertebrae.

The samples are weighed, packed in plastic bags and sent 300 km by rail in 30 litre containers to the Danish Meat Research Institute. Ice in cans ensures that the temperature in the samples can be kept under 5° C during the transportation. On arrival at the Institute the samples are put on shelves in a chilling room at 4° C. and then aged to 7 or 9 days post mortem for calves and young bulls, respectively.

Jointing and Tissue separation

Jointing and Tissue separation are carried out on the right carcass side. Figure 3 shows the joints and the grouping after value. The forequarter is cut from the hindquarter between the 1st and 2nd lumbar vertebrae and divided into shoulder, neck, forerib, primerib, flatrib + brisket and shin.

a. The shoulder is removed by cutting through the natural seam up against and along the blade bone.

b. The shin is removed from the shoulder.

c. The flatribs + brisket are cut/sawn from the prime rib, forerib and neck on a straight line from the edge of M. long. dorsi to the lateral parts of the neck bones.

d. The primerib is cut from the forerib between the 6th and 7th thoracic vertebrae.

e. The forerib and the neck are divided between the last cervical and the 1st thoracic vertebrae.

The hindquarter is divided into flank, sirloin and rump, rumpsteak, top round, tip muscle, eye of round, bottom round, heel of round, round bone and hindshank.

a. The flank is removed by following the natural seam along the tip muscle down to the hip bone and then parallel to the back.

b. The rumpsteak and the sirloin + rump are cut/sawn free along the symphysis pubis down to and across the head of the round bone.

c. The sirloin and rump comprise 5 lumbar and 3 sacral vertebrae and are sawn/cut from the rumpsteak along a straight line between the 3rd and 4th sacral vertebrae and 2 cm from the anterior edge of symphysis pubis.

d. The top round is cut free along the natural seam.

e. The eye of round is removed from the bottom round.

f. The tip muscle and the bottom round are cut off and separated along the natural seam.

g. The heel of round is cut off the hindshank.

h. Round bone and hindshank are separated.

The joints are then placed in three different groups (see figure 3) and separated into lean, fat and bone and weighed separately.

Figure 2.

Samples + measuring carcass length

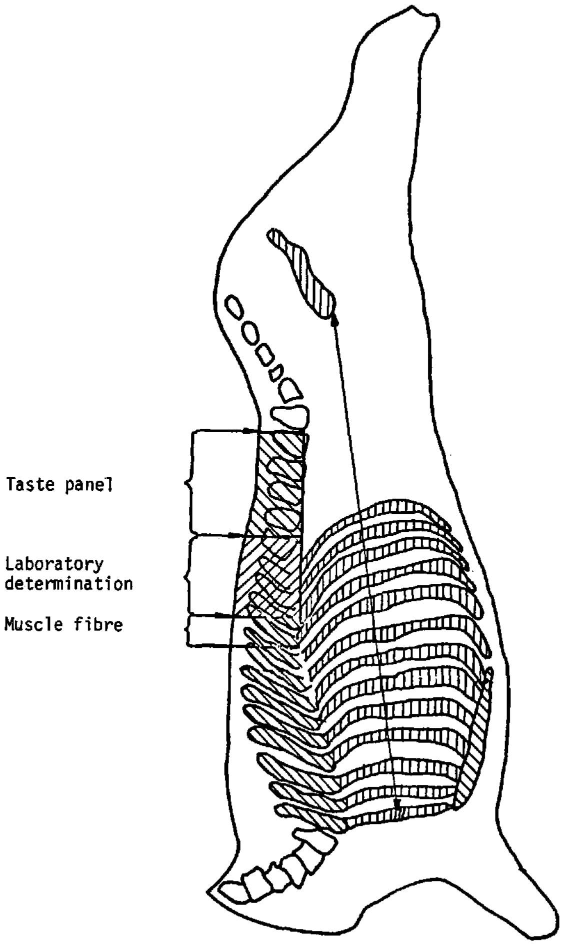
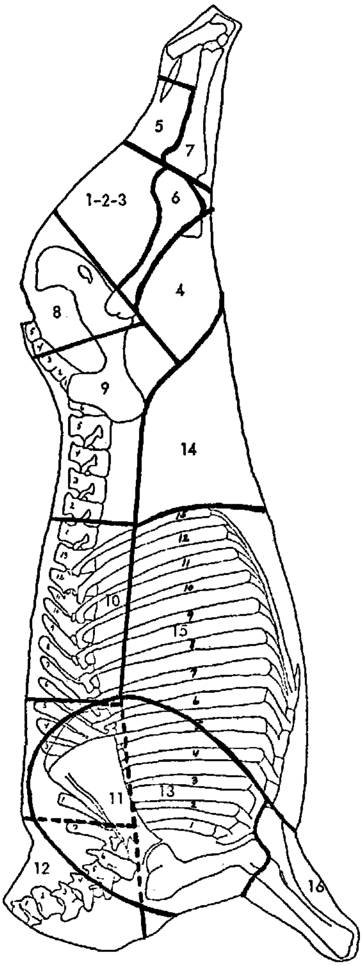


Figure 3.

Method of cutting



Group III (pistol)

1 Top round
2 Bottom round
3 Eye of round
4 Tip muscle
5 Heel of round
6 Round bone
7 Hindshank
8 Rump steak
9 Sirloin and rump
10 Primerib

Group II

11 Forerib
12 Neck
13 Shoulder

Group I

14 Flank
15 Flatribs + brisket
16 Shin

The carcass quality traits are calculated as follows:

$$\text{Dressing percentage} = 100 \times \frac{\text{Cold carcass weight (kg)}}{\text{Final weight at the station (kg)}}$$

$$\text{\% lean} = 100 \times \frac{\text{Kg lean in side}^{x)}}{\text{Kg lean, fat and bone in side}}$$

$$\text{\% fat} = 100 \times \frac{\text{Kg fat in side}}{\text{Kg lean, fat and bone in side}}$$

$$\text{\% bone} = 100 \times \frac{\text{Kg bone in side}}{\text{Kg lean, fat and bone in side}}$$

$$\text{\% pistollean} = 100 \times \frac{\text{Kg lean in pistolcut}}{\text{Kg lean, fat and bone in side}}$$

$$\text{Lean/fat} = \frac{\text{Kg lean in side}}{\text{Kg fat in side}}$$

$$\text{Lean/bone} = \frac{\text{Kg lean in side}}{\text{Kg bone in side}}$$

$$\text{LP/LT} = \frac{\text{Kg lean in pistolcut}}{\text{Kg lean in side}}$$

$$\text{FP/FT} = \frac{\text{Kg fat in pistolcut}}{\text{Kg fat in side}}$$

$$\text{BP/BT} = \frac{\text{Kg bone in pistolcut}}{\text{Kg bone in side}}$$

x) All tissue weights are obtained from the right side of the carcass.

IV.2. RESULTS

In tables 11, 12 and 13 are given the least squares means for the individual categories and breeds as well as the component of interaction for Final Weight x Breed. The results are calculated on the basis of model (1), page 20. In table 14 the coefficients of heritability, which are calculated on the basis of model (2), page 20, are presented. From table 15a the coefficients of correlation between the traits within test year, breed and final weight appear.

IV.2.1. Dressing Percentage, Evaluation of Carcass and Commercial Grading.

The results appear from Table 11. It should be noticed that the results concerning commercial grading are only calculated on 1052 veal calves and 973 young bulls.

IV.2.1.1. Effect of Final Weight

With the exception of scores for loin, there is an effect of final weight, when the weight is increased from 250 kg to 450 kg. The dressing percentage is increased by 2 percentage units, which is equivalent to 1 percentage unit for each 100 kg increase of the final weight. An important improvement can also be noticed in the evaluation of back and thigh as well as in the commercial grading, when the weight is increased from 250 kg to 450 kg. The fact that no effect of final weight has been found at evaluation of the loin is due to difficulties with subjective evaluations especially in this part of the carcass, and furthermore to the circumstance that the evaluation for calves is carried out on whole carcasses, while it is carried out on split carcasses for young bulls.

IV.2.1.2. Effect of Breed

Both concerning dressing percentage, evaluation of the individual parts of the carcasses and commercial grading there are significant differences between the breeds, RDM being the poorest and DRK the best.

IV.2.1.3. Effect of interaction between Final Weight and Breed.

A significant interaction has been found for the evaluation of back. This can be explained by the fact that a greater improvement from 250 kg to 450 kg takes place in the RDM breed than in the two other breeds.

IV.2.2. Area of M. long. dorsi and Percentage of Lean, Fat, Bone and Pistollean.

IV.2.2.1. Effect of Final Weight

All the traits appearing in Table 12 demonstrate a significant effect, when the weight is increased from 250 kg to 450 kg. For % lean there is a relatively small decrease, while the % pistollean drops considerably more. This means that from 250 kg to 450 kg there is an increase of the relative lean content in the forequarters, and it indicates that the muscles of the forequarters are developed later than the muscles in the hindquarters. The relative fat content in the whole carcass increases considerably, being 47%, while the relative content of bone drops by 16%. For the area of M. long. dorsi there is an increase of 17.6 cm^2 or 37% from 250 kg to 450 kg live-weight.

IV.2.2.2. Effect of Breed

Significant differences between breeds have been found for all the traits stated in Table 12.

The area of M. long. dorsi and the percentage of lean, fat, bone and pistollean show that the DRK breed has the highest relative content of lean, the best muscle distribution, the lowest content of fat and bone and the biggest area of the M. long. dorsi. The RDM breed has the least content of lean, the least favourable distribution of the muscles and the highest content of fat, while the content of bone and the area of M. long. dorsi are at the same level as in the SDM breed.

IV.2.2.3. Effect of Interaction between Weight and Breed

A significant interaction is found for % lean, % fat, % pistollean and area of M. long. dorsi.

As regards both % lean, % fat and % pistollean, the change from calves to young bulls is relatively smaller in RDM than in the two other breeds. This effect is due to the fact that the RDM is later developed than the two other breeds.

For the area of M. long. dorsi there is an increase of 38% from calves to young bulls in the RDM breed. In the SDM breed the increase is 35%, while it is 39% in the DRK breed.

IV.2.3. Lean/Bone and Lean/Fat Ratios and Distribution of Lean, Fat and Bone

IV.2.3.1. Effect of Final Weight

For all the traits there is a significant effect of final weight as demonstrated in Table 13. The lean/fat ratio drops by 35% in carcasses from calves to young bulls, while the lean/bone ratio rises by 17%. For the other three traits, in spite of significant differences, there are modest changes from 3-6%. The results show that when the weight at slaughter is increased, the relative content of lean, fat and bone in the pistolcut decreases. In other words, both lean, fat and bone in the forequarters are developed later than in the hindquarters.

IV.2.3.2. Effect of Breed

For all five traits in Table 13 a significant effect of breed is found.

The DRK breed has the highest lean/fat ratio followed by SDM and RDM. The lean/bone ratio is also highest for the DRK breed, while it is equal for SDM and RDM. As regards the ratio between lean, fat and bone the pistolcut and the whole carcass the SDM breed has the highest figure for all three components and RDM has the lowest.

IV.2.3.3. Interaction between Final Weight and Breed

Significant interaction is only found in the lean/fat ratio and in the distribution of fat tissue.

The lean/fat ratio for the RDM breed decreases only by 29% from calves to young bulls, while it decreases by 36% both for SDM and DRK. This difference supports the above mentioned fact that the RDM breed is developing later than the two other breeds. As regards the ratio between fat in the pistol and total content of fat, there is a much greater development from calves to young bulls in the RDM and SDM breeds than in the DRK breed. Both in RDM and SDM the decrease is 4-5%, while it is only 1.6% in the DRK.

IV.2.4. Coefficient of Heritability

The coefficients of heritability for the carcass quality traits are calculated by means of model (2), page 20 . The results will appear from Table 14.

With the exception of the classification and the LP/LT, FP/FT and BP/BT ratios, the h^2-value for the other traits is between 0.4 and 0.6. Apart from the dressing percentage and % lean an important phenotypic variation has also been found and so the conditions of improvement of the carcass quality traits through breeding is greatly forthcoming.

IV.2.5. The interrelation between the Traits

As it appears from Table 15a ,several carcass quality traits are so strongly correlated that selection for one of these traits would result in improvement of one or more of the others.

The dressing percentage is positively correlated to the subjective evaluation of the individual parts of the carcass, to the classification, % lean, lean/bone ratio, LD-area and % pistollean, and negatively correlated to % bone.

Percentage of lean is strongly negatively correlated to % fat and strongly positively correlated to lean/fat, lean/bone, LD-area and % pistollean, while the % fat is strongly negatively correlated to the lean/fat ratio and % pistollean.

The positive correlation between LD-area and % pistollean as well as the correlation between these traits and the other carcass quality traits, including the LP/LT ratio, show that if selection is based on % pistollean and/or LD-area, both carcass conformation and carcass composition may be favourably influenced.

Table 11. Effects of final weight, breed and interaction on carcass quality traits (least squares means).

	No. of animals	Dressing percentage	Back[1)]	Loin[1)]	Thigh[1)]	Classification[2)]
Effect of final weight						
250 kg	1308	53.8	6.77	7.32	7.18	7.19
450 "	973	55.8	7.28	7.23	7.68	8.01
Level of significance		x x x	x x x	N.S.	x x x	x x x
Effect of breed						
RDM	1298	53.9	6.07	6.56	5.77	5.83
SDM	872	54.8	7.26	7.38	7.85	8.10
DRK	120	55.7	7.74	7.89	8.66	8.87
Level of significance		x x x	x x x	x x x	x x x	x x x
Weight x breed interaction						
250 kg RDM	742	53.0	5.72	6.63	5.55	5.37
250 kg SDM	498	53.9	7.05	7.43	7.69	7.68
250 kg DRK	68	54.5	7.56	7.92	8.30	8.51
450 kg RDM	547	54.7	6.43	6.50	5.99	6.30
450 kg SDM	374	55.7	7.47	7.34	8.01	8.52
450 kg DRK	52	56.9	7.93	7.87	9.02	9.22
Level of significance		N.S.	x x	N.S.	N.S.	N.S.

1) Scale 1-10.

2) A^1 = 10, A+ = 9, A = 8, A- = 7, B+ = 6, B = 5 etc.

Table 12. Effect of final weight, breed and interaction on carcass quality traits (least squares means).

	No. of animals	% lean	% fat	% bone	% pistollean	Area of M.long.d. cm^2
Effect of final weight						
250 kg	1308	70.6	9.7	19.7	34.2	47.2
450 kg	973	69.1	14.3	16.6	31.5	64.8
Level of significance		x x x	x x x	x x x	x x x	x x x
Effect of breed						
RDM	1289	69.0	12.5	18.5	32.0	55.5
SDM	872	69.7	11.9	18.3	33.2	55.6
DRK	120	70.8	11.5	17.6	33.4	56.9
Level of significance		x x x	x x x	x x x	x x x	x
Weight x breed interaction						
250 kg RDM	742	69.5	10.4	20.0	33.2	46.7
250 kg SDM	498	70.7	9.5	19.9	34.7	47.4
250 kg DRK	68	71.7	9.2	19.1	34.9	47.6
450 kg RDM	547	68.5	14.6	16.9	30.8	64.3
450 kg SDM	374	68.8	14.4	16.8	31.8	63.8
450 kg DRK	52	70.0	13.9	16.2	32.0	66.2
Level of significance		x x x	x x x	N.S.	x x x	x

Table 13. Effect of final weight, breed and interaction on carcass quality traits (least squares means).

	No. of animals	Lean/ fat	Lean/ bone	LP/LT	FP/FT	BP/BT
Effect of final weight						
250 kg	1308	7.5	3.6	0.480	0.408	0.475
450 kg	973	4.9	4.2	0.451	0.393	0.463
Level of significance		x x x	x x x	x x x	x x x	x x x
Effect of breed						
RDM	1289	5.8	3.8	0.459	0.395	0.467
SDM	872	6.3	3.8	0.472	0.404	0.472
DRK	120	6.6	4.0	0.467	0.401	0.469
Level of significance		x x x	x x x	x x x	x x x	x x x
Weight x breed interaction						
250 kg RDM	742	6.8	3.5	0.472	0.404	0.473
250 kg SDM	498	7.7	3.6	0.485	0.414	0.478
250 kg DRK	68	8.0	3.8	0.482	0.405	0.475
450 kg RDM	547	4.8	4.0	0.445	0.387	0.461
450 kg SDM	374	4.9	4.1	0.458	0.394	0.465
450 kg DRK	52	5.1	4.3	0.452	0.398	0.463
Level of significance		x x x	N.S.	N.S.	x	N.S.

Table 14. Coefficients of heritability and coefficients of variation for carcass quality traits.

Trait	Coefficient of heritability	Phenotypic coefficient of variation %	Variation among progeny groups	Variation within progeny groups
Dressing percentage	0.60 ± 0.09	2.7	0.31	1.78
S-back	0.55 ± 0.09	16.8	0.17	1.06
S-loin	0.45 ± 0.08	15.1	0.12	0.98
S-thigh	0.47 ± 0.08	14.2	0.11	0.80
Classification	0.26 ± 0.06	15.7	0.08	1.10
% lean	0.52 ± 0.08	2.5	0.38	2.56
% fat	0.44 ± 0.08	13.4	0.28	2.28
% bone	0.50 ± 0.08	5.0	0.11	0.76
Lean/fat	0.50 ± 0.08	16.2	0.13	0.89
Lean/bone	0.53 ± 0.08	6.3	0.008	0.051
LD-area, cm^2	0.58 ± 0.09	9.1	3.58	21.10
% pistollean	0.54 ± 0.08	3.3	0.16	1.02
LP/LT	0.24 ± 0.06	2.2	6.2×10^{-6}	95.5×10^{-6}
FP/FT	0.19 ± 0.05	7.6	43.3×10^{-6}	875×10^{-6}
BP/BT	0.09 ± 0.04	3.0	4.3×10^{-6}	199×10^{-6}

Table 15a. Phenotypic and genetic correlation coefficients for carcass quality traits.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Dressing %		0.59	0.45	0.72	0.71	0.55	-0.32	-0.51	0.34	0.57	0.71	0.49	0.28	-0.16	-0.13
2. S-back	0.48		0.71	0.78	0.83	0.39	-0.09	-0.58	0.15	0.57	0.67	0.28	-0.04	-0.18	-0.17
3. S-loin	0.34	0.54		0.70	0.65	0.05	0.20	-0.40	-0.16	0.33	0.48	0.11	0.20	-0.23	-0.15
4. S-thigh	0.46	0.56	0.42		1.15	0.52	-0.21	-0.65	0.28	0.66	0.68	0.45	0.18	-0.11	-0.34
5. Classif.	0.44	0.41	0.32	0.66		0.72	-0.37	-0.75	0.50	0.81	0.89	0.68	0.38	-0.08	-0.49
6. % lean	0.35	0.24	0.05	0.36	0.35		-0.85	-0.51	0.96	0.78	0.60	0.92	0.45	0.02	-0.16
7. % fat	-0.12	-0.02	0.12	-0.15	-0.14	-0.85		-0.03	-1.05	-0.33	-0.38	-0.81	-0.45	-0.19	0.11
8. % bone	-0.43	-0.40	-0.31	-0.40	-0.41	-0.38	-0.17		-0.10	-0.95	-0.52	-0.41	-0.12	0.27	0.13
9. Lean/fat	0.17	0.07	-0.10	0.17	0.18	0.82	-0.91	0.06		0.48	0.50	0.88	0.44	0.22	-0.01
10. Lean/bone	0.48	0.40	0.25	0.45	0.46	0.68	-0.20	-0.92	0.27		0.62	0.70	0.31	-0.24	-0.13
11. LD-area	0.48	0.41	0.29	0.39	0.42	0.43	-0.27	-0.34	0.29	0.44		0.67	0.51	-0.22	-0.28
12. %pistollean	0.27	0.18	0.07	0.32	0.34	0.78	-0.68	-0.27	0.68	0.51	0.48		0.77	0.08	0.03
13. LP/LT	0.02	0.00	0.05	0.08	0.11	0.06	-0.08	0.02	0.10	0.00	0.25	0.64		0.12	0.27
14. FP/FT	0.00	0.02	0.00	0.05	0.03	0.08	-0.10	0.01	0.06	0.03	0.03	0.01	-0.08		-0.36
15. BP/BT	0.00	0.02	0.03	0.03	0.03	0.02	-0.01	-0.03	0.01	0.03	0.05	0.15	0.20	-0.12	

Phenotypic correlations under the diagonal (coefficients $\geq$ 0.05 are significant on the 0.05 level).
Genetic correlations above the diagonal (for standard errors, see tabel 15b).

Table 15b. Standard errors for genetic correlation coefficients.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Dressing %		0.08	0.10	0.07	0.09	0.09	0.12	0.12	0.11	0.09	0.07	0.10	0.14	0.16	0.20
2. S-back			0.07	0.06	0.07	0.11	0.13	0.12	0.12	0.09	0.08	0.12	0.15	0.16	0.21
3. S-loin				0.08	0.11	0.13	0.13	0.13	0.13	0.12	0.10	0.13	0.15	0.16	0.21
4. S-thigh					0.04	0.10	0.13	0.12	0.12	0.08	0.08	0.11	0.15	0.16	0.21
5. Classif.						0.10	0.16	0.16	0.13	0.08	0.07	0.10	0.18	0.19	0.27
6. % lean							0.13	0.12	0.02	0.05	0.08	0.03	0.13	0.16	0.21
7. % fat								0.13	0.12	0.13	0.12	0.12	0.14	0.17	0.21
8. % bone									0.13	0.12	0.12	0.12	0.15	0.16	0.21
9. Lean/fat										0.10	0.10	0.04	0.13	0.16	0.21
10. Lean/bone											0.08	0.07	0.14	0.16	0.21
11. LD-area												0.07	0.12	0.15	0.20
12. % pistollean													0.07	0.16	0.21
13. LP/LT														0.19	0.23
14. FP/FT															0.27
15. BP/BT															

CHAPTER V

MEAT QUALITY

The examinations of meat quality are carried out in order

1. to estimate the progeny group average for the most important meat quality traits,
2. to give an exact registration of the level of the meat quality traits and their variation, heritability and correlation to other traits,
3. to permit more detailed studies of the methods applied.

According to the method applied, the examinations of the meat quality can be divided into three groups:

Physical-chemical measurements, taste panel evaluations and fiber measurements.

V.1. PHYSICAL-CHEMICAL MEASUREMENTS AND TASTE-PANEL EVALUATIONS

V.1.1. Methods.

The sampling as well as the ageing conditions for the samples are described in chapter IV, page 33.

7 or 9 days post mortem for calves and young bulls respectively, determinations of Volodkewich shear-force value, colour, chemical composition and pH are carried out on the samples for analyses (LD 12th thoracic to 1st lumbar vertebrae). At the same time samples for taste testing (LD 2nd to 5th lumbar vertebrae) are frozen and stored at -40^{o} C.

Shear-force value (consistency)

A 6 cm thick slice positioned at the 1st lumbar vertebrae is used for consistency measurements. After removal of outer sheets of connective tissue and after insertion of a thermo-couple in the centre, the sample is placed in a bath of boiling water. When the temperature in the centre shows 71 $\pm$ 1^{o} C the sample is removed from the bath and chilled in running water. Six fiber parallel strips with 10 x 20 mm^2 cross sections are cut from each sample with a scalpel. In 1967 and 1968 the shear-force was measured on a Volodkewich apparatus (Grünewald, 1957). In 1969 this apparatus was replaced by an Instron Universal Testing Machine simulating the Volodkewich principle, i.e. that the meat is sheared across by squeezing it between two rounded steel bars. The dimensions of the set of bars used are 4 mm in diameter and 20 mm long. Measurements are taken by shearing each of the six strips once across the middle perpendicular to the fiber direction. The shear-force value is then calculated from the recorded time-force diagrams and the average of the six values taken. Instead of using the maximum force required to shear completely through a meat strip it is arbitrarily chosen to calculate the shear-force value as the maximum force required to bite 8 mm into the 10 mm high sample.

Colour

Colour measurements are carried out on a Zeiss "Elrepho" reflectance meter at a wave length band at 535 mm. A freshly cut 20 mm thick slice (13th lumbar vertebrae) is vacuum packed and left for one hour before measurement in order to obtain complete reduction of oxymyoglobin to myoglobin. The reflectance of the vacuum packed sample is measured on 6 positions (3 on each side) and the average taken.

Water holding capacity (WHC)

Determinations of the waterholding capacity are carried out according to a modification of Grau & Hamm (1953). Four peasized samples (0.7 g) are cut out from the interior of the muscle. They are weighed individually on weighing paper before and after being pressed for 3 minutes at 7-8 kg/cm^2 between filter paper by means of an oil press with two 16 x 16 cm^2 steel plates. The WHC is calculated as the average of mg weight loss /g meat.

Chemical analyses

The rest of the sample (8-10 cm positioned at 13th and 12th vertebrae) is minced after removal of outer layers of connective tissue and fat. Double determinations of percentage dry matter, percentage N after Kjeldahl and percentage fat after Schmid-Bondzynski-Ratslaff are carried out as described by Nordic Committee on Food Analysis.

pH

5 g of minced meat is stirred with 5 ml destilled water and the pH is measured with a stationary pH-meter (Radiometer). pH-measurements are taken to ensure that the meat has normal pH (pH = 5.50). In cases where the pH of the meat is 5.80 or in excess of that, all results from meat quality and taste panel determinations are omitted from the calculations.

Taste panel

Samples from calves and young bulls are tested in separate series.

Thus, samples from calves are evaluated in the autumn and samples from young bulls are evaluated in the spring.

The testing is performed by an experienced panel of 9 housewives. Samples of beef steaks are judged for colour, flavour, tenderness, juiciness and total impression on an 11 point hedonic scale, where -5 is extremely bad, 0 is neither good nor bad and + 5 is ideal. Each day an average of 10 samples is tested.

The preparation of the samples is as follows:

Four 23 mm thick slices are sawed from each frozen sample (positioned at 2nd and 3rd lumbar vertebrae).The slices are allowed to thaw for two hours at room temperature before being fried on a griddle plate without addition of fat. The temperature of the griddle plate is 170° C, when the meat is placed on it, whereafter it slowly falls to 125° C. The steaks are turned over every third minute and fried for a total of 12 minutes. This cooking time corresponds to the degree of doneness being "just done" and an internal temperature in the steaks of approximately 70° C.

V.1.2. Results

In tables 16 and 17 are presented the least squares' means for the effect of final weight, breed and interaction between final weight and breed. The results are calculated on the basis of model (1) page 20 .

V.1.2.1. Effect of Final Weight

It appears from table 16 that there is a strongly significant difference between final weight groups for meat colour, % fat, % dry matter, % N and WHC. The calves have the palest meat and the lowest fat content in the meat. The young bulls have the highest content of dry matter and the best waterholding capacity.

For the shear-force value (Volodkewich) a strongly significant difference between the weight groups is registered, but contrary to other examinations the shear-force value in the young bulls is lower than it is in the veal calves. This result is probably caused by a tendency to cold shortening, which can occur especially in very young animals even at chilling temperaturs of 6° C.

Concerning the taste-panel evaluation of the meat quality traits analysis of the effect of final weight is prohibited due to experimental design.

1.2.2. Effect of Breed

For all traits significant breed differences are registered with the exception of taste panel scores for colour. Both in the shear-force value and subjective evaluation of the tenderness, the RDM breed is the best,followed by SDM and DRK. As regards scores for flavour and scores for total impression,the range of the three breeds is the same.

RDM has a higher fat content in the meat than SDM and DRK. In general, the fat content is low, and none of the breeds have more intramuscular fat than desirable.

V.1.2.3. Interaction between Final Weight and Breed

For meat colour and % fat there is a strongly significant interaction. The young bulls, but not the calves, of DRK, have a meat colour, which is more pale than in RDM, while SDM in both categories has the darkest meat. As far as the fat content is concerned, DRK has a low content, especially as young bulls, while RDM has the highest content both as calves and young bulls.

V.1.2.4. Coefficients of Heritability.

The coefficients of heritability for the traits, which are shown in table 18, are calculated on the basis of model (2), page 20.

It appears from table 18 that relatively high coefficients of heritability are found for the objectively estimated meat colour and shear force as well as for the taste-panel's scores for tenderness and total impression. As there is a considerable phenotypic variation for the same traits, the prospects of genetic improvement are good.

For the other meat quality traits the coefficients of heritability are between 0.04 and 0.21, and with the exception of % fat in the meat, they also have a fairly low phenotypic variation.

V.1.2.5. Interrelation between the Traits.

Phenotypic correlation coefficients among the traits within test years, breeds and final weight groups are calculated on the basis of model (1), page 20. The genetic correlation coefficients are calculated on the basis of model (2).

It appears from table 19a, that there is a strongly significant negative correlation between the objectively measured shear-force value and the scores for tenderness and total impression. This indicates that meat samples, which require much force for the cutting, obtain low scores from the taste-panel. Scores for flavour, tenderness and total impression have a close relationship.

The fat content of the meat is important for the content of dry matter. In this investigation the fat content had no correlation to flavour, tenderness and shear-force value.

Table 16. Effect on final weight, breed and interaction on objective meat quality traits (least squares means).

	No. of animals	Colour	Volodkevich shear force	% fat	% dry matter	% nitrogen	Water-holding capacity
Effect of final weight							
250 kg	1236	16.4	12.8	0.84	23.6	3.47	501.7
450 "	995	13.8	12.0	1.61	24.5	3.52	481.0
Level of significance		x x x	x x	x x x	x x x	x x x	x x x
Effect of breed							
RDM	1278	15.3	11.0	1.40	24.1	3.48	493.1
SDM	835	14.7	12.6	1.17	24.1	3.51	487.0
DRK	118	15.3	13.7	1.11	23.9	3.49	493.9
Level of significance		x x x	x x x	x x x	x x x	x x x	x x x
Weight x breed interaction							
250 kg RDM	709	16.8	11.0	0.95	23.5	3.45	504.2
250 kg SDM	461	15.9	13.3	0.77	23.6	3.49	499.4
250 kg DRK	66	16.5	14.1	0.79	23.5	3.47	501.4
450 kg RDM	569	13.8	10.9	1.85	24.6	3.50	482.0
450 kg SDM	374	13.4	11.9	1.56	24.6	3.54	474.5
450 kg DRK	52	14.2	13.3	1.43	24.3	3.51	486.4
Level of significance		x x x	x x	x x x	x	N.S.	x x

Table 17. Effect of breed on taste panel evaluation of meat quality traits (least squares means)

	No. of animals	Scores for colour	Scores for flavour	Scores for tenderness	Scores for juiciness	Scores for total impression
Effect of breed at constant weight						
RDM	1278	2.82	2.27	1.89	2.49	1.74
SDM	835	2.81	2.22	1.63	2.57	1.53
DRK	118	2.85	2.22	1.43	2.58	1.41
Level of significance		N.S.	x	x x x	x x	x x x
Effect of breed at different weight						
250 kg RDM	799	2.80	2.25	1.92	2.41	1.75
250 kg SDM	461	2.80	2.15	1.63	2.49	1.51
250 kg DRK	66	2.81	2.24	1.64	2.58	1.57
Level of significance		N.S.	x x	x x	x x	x x x
450 kg RDM	569	2.84	2.29	1.85	2.57	1.73
450 kg SDM	374	2.82	2.28	1.63	2.65	1.55
450 kg DRK	52	2.88	2.20	1.24	2.59	1.27
Level of significance		N.S.	N.S.	x x	N.S.	x x

Table 18. Coefficients of heritability and coefficients of variation for meat quality traits.

Trait	Coefficient of heritability	Phenotypic coefficient of variation	Variation among progeny groups	Variation within progeny groups
Colour	0.41±0.07	6.8	0.11	0.95
Shear-force value	0.36±0.07	35.8	1.60	16.11
% fat	0.20±0.05	32.4	0.008	0.157
% dry matter	0.21±0.05	2.2	0.015	0.268
% nitrogen	0.15±0.05	2.0	0.0002	0.0047
Waterholding capacity	0.20±0.05	3.2	12.3	240.9
Scores for colour	0.10±0.04	5.3	0.004	0.166
" " flavour	0.09±0.04	6.5	0.005	0.219
" " tenderness	0.38±0.07	20.2	0.18	1.69
" " juiciness	0.04±0.04	7.5	0.003	0.316
" " total impression	0.30±0.06	15.5	0.08	0.99

Table 19a. Phenotypic and genetic correlation coefficients for meat quality traits.

	1	2	3	4	5	6	7	8	9	10	11
1. Meat colour		-0.22	-0.38	-0.29	0.07	0.41	1.11	0.32	0.26	-0.24	0.27
2. Shear-force value	-0.19		-0.09	-0.30	0.09	-0.51	-0.08	-0.82	-0.90	-0.31	-0.87
3. % fat	-0.10	-0.14		0.62	0.05	-0.13	-0.53	0.30	0.05	0.11	0.04
4. % dry matter	-0.22	-0.15	0.55		0.77	-0.53	-0.51	0.32	0.23	-0.30	0.24
5. % nitrogen	-0.11	-0.01	-0.02	0.57		-0.66	-0.10	-0.33	-0.20	-0.75	-0.21
6. LV	0.22	-0.18	-0.02	-0.26	-0.17		0.43	0.57	0.40	0.72	0.44
7. S-colour	0.33	-0.13	-0.05	0.00	0.04	0.05		0.31	0.30	-0.43	0.26
8. S-flavour	0.09	-0.32	0.05	0.17	0.05	0.02	0.48		0.82	0.89	0.79
9. S-tenderness	0.20	-0.68	0.09	0.13	0.01	0.16	0.32	0.53		0.68	1.00
10. S-juiciness	-0.04	-0.06	0.05	0.00	-0.14	0.01	0.39	0.33	0.22		0.71
11. S-total impression	0.19	-0.65	0.08	0.13	0.01	0.14	0.40	0.63	0.96	0.30	

Phenotypic correlations under the diagonal (coefficients ≥ 0,05 are significant on the 0.05 level)

Genetic correlations above the diagonal (for standard errors see table 19b).

Table 19b. Standard errors for genetic correlation coefficients.

	1	2	3	4	5	6	7	8	9	10	11
1. Meat colour		0.14	0.16	0.17	0.18	0.15	0.14	0.20	0.13	0.33	0.14
2. Shear-force value			0.17	0.17	0.18	0.17	0.21	0.26	0.15	0.35	0.16
3. % fat				0.12	0.21	0.20	0.25	0.25	0.17	0.37	0.18
4. % dry matter					0.11	0.21	0.23	0.23	0.16	0.39	0.17
5. % nitrogen						0.23	0.26	0.27	0.18	0.54	0.19
6. L.V.							0.24	0.25	0.15	0.46	0.16
7. S-colour								0.28	0.19	0.40	0.20
8. S-flavour									0.13	0.41	0.12
9. S-tenderness										0.35	0.01
10. S.juiciness											0.35
11. S-total impression											

V.2. ESTIMATION OF TYPES OF FIBERS AND MEASUREMENT OF FIBER DIAMETER

Within a muscle there may be variation in number, appearance and diameter of the muscle fibers; the variation in appearance applies for instance to colour and sensitivity to histochemical colour reaction, which reflects composition and activity of various systems of enzymes. Normally, a distinction is made between 1) red fibers, 2) intermediary fibers and 3) white fibers. The charateristic feature of the red fibers is a high content of myoglobin and mitochondries. The white fibers have a high content of glycolytic enzymes. The intermediary fibers have a dual position.

Interest attaches to the examinations of the muscle fibers in the muscles, which are most important from an economic point of view, especially concerning the elucidation of the causes of variation in the meat quality, but also in order to explore the growth mechanism of the muscles. In this investigation, measurements of the average diameter of the muscle fibers in M. longissimus dorsi in calves and young bulls have been made during the whole 5 years' period. For the young bulls of 1970, and both for the calves and young bulls of 1971, 629 animals in all, a grading of the muscle fibers into red, white and intermediary fibers was furthermore carried out, and the diameters of these fibers were measured separately.

V.2.1. Methods

As described in chapter IV, page 33, the examinations are carried out on a sample of M. longissimus dorsi, cut out between 10th and 12th ribs.

A test piece, which is cut out of the middle of the sample, is fixed in 10% formalin. After complete fixation, 20 μ thick slices are cut out with freezing microtone and coloured with Sudan Black B as described by Chiffelle and Putt (1951).

The Sudan Black B is particularly absorbed by the red fibers and to a small extent by the intermediary fibers. The average diameter of the muscle fibers is measured on 100 muscle fibers chosen at random, which at the same time are graded into the categories red, medium and white on an evaluation of the colour intensity.

V.2.2. Results

In table 20 are presented the results of the measurements of fiber diameters without grading into colour-categories. From the table will appear the importance of breed, final weight and interaction for the average fiber diameter, for the standard-deviation of the diameters of the hundred individual fibers around the average and for the coefficient of skewness and the coefficient of kurtosis, which are the two parameters describing the shape of the distribution curve of the individual fiber diameters around the average.

In table 21 is presented the relative proportion of red, white and intermediary fibers as well as the average diameter of the three fiber types. The parameters in tables 20 and 21 are calculated by means of model (3), page 20.

V.2.2.1. Effect of Final Weight

It appears from table 20 that the diameter of the fiber is larger in young bulls than in calves.

The standard deviation of fiber-diameters and the coefficient of kurtosis are also greatest in the young bulls. All three results are very strongly significant. There is no significant difference between the categories as regards the coefficient of skewness, but for both categories the figures show a right skew distribution, which indicates a relatively greater variation among the fiber diameters above the average than below the average.

From table 21 appears that there is almost the same number of red fibers in the musculature of calves and young bulls, while the young bulls have relatively more intermediary fibers and fewer white fibers than the calves.

V.2.2.2. Effect of Breed

The results show that there are differences among breeds, as both the calves and the young bulls of RDM have smaller fiber diameter than the SDM.

The diameters of fibers in SDM have a distribution,that is more right skew than in RDM. This means,that there are relatively many fibers having very large diameter in the muscles of SDM cattle. DRK is intermediate between SDM and RDM as regards average fiber diameter, but the variation among the fibers above the average is greater,than it is in SDM.

RDM has relatively fewer red fibers than SDM and DRK, while the difference in the content of the two other fiber types is less distinct in the three breeds. As the average fiber diameter is less for RDM than for the two other breeds, the results show that thediameters of the fibers in the musculature of RDM are more uniform than in the two other breeds.

V.2.2.3. Interaction between Final Weight and Breed

As appears from tables 20 and 21 no significant effects of interaction have been found for the muscle fiber characteristics.

V.2.2.4. Coefficient of Heritability

The coefficients of heritability for the fiber traits are calculated on the basis of model (4), page 20. The results are calculated exclusively on the basis of data from 1971.

As appears from table 22, both average fiber diameter and the diameters of the three colour groups have a relatively high heritability as well as considerable phenotypic variation. The relative proportion of red, medium and white has also a high heritability and phenotypic variation.On the other hand, neither the standard-deviation of the individual fiber diameter, the coefficient of skewness nor the coefficient of kurtosis have a genetic determined variation.

V.2.2.5. The Interrelation among the Traits

In table 23a the phenotypic and the genetic correlation coefficients of the traits are presented. These coefficients are only calculated on the data from the last test year, including 433 animals. The phenotypic correlation coefficients are calculated on the basis of model (3), page 20, thus within breed and final weight group. The genetic correlation coefficients are calculated on the basis of model (4), page 20.

It appears from the table that the average fiber diameter is highly correlated to the average diameters of the red, white and intermediary fibers. The greatest correlation is found for the diameter of the intermediary fibers, which is also the fiber category having the largest diameter. The standard deviation of the individual fiber diameter is strongly positively correlated to the average diameters of white and intermediary fibers.

Table 20. Effect of final weight, breed and interaction on muscle fiber traits (least squares means).

	Number	Av. fiber diameter μ	Standard deviation of fiber diameters	Coefficient of skewness for fiber diameters	Coefficient of kurtosis for fiber diameters
Effect of final weight					
250 kg	246	32.82	8.81	0.86	2.39
450 kg	984	42.85	11.56	0.81	2.64
Level of significance		xxx	xxx	N.S.	xxx
Effect of breed					
RDM	678	36.29	9.06	0.71	2.72
SDM	480	39.15	10.71	0.88	2.44
DRK	72	38.08	10.78	0.93	2.38
Level of significance		xxx	xxx	xxx	xxx
Weight x breed interaction					
250 kg RDM	120	31.48	7.57	0.72	2.67
250 kg SDM	106	33.90	9.32	0.91	2.26
250 kg DRK	20	33.09	9.53	0.96	2.24
450 kg RDM	558	41.09	10.56	0.70	2.77
450 kg SDM	374	44.41	12.09	0.85	2.63
450 kg DRK	52	43.06	12.04	0.89	2.52
Level of significance		N.S.	N.S.	N.S.	xx

Table 21. Effect of final weight, breed and interaction on muscle fiber type and fiber diameter (least squares means).

	Number	% red fibers	% white fibers	% intermedium fibers	Av. diam. of red fibers	Av. diam. of white fibers	Av. diam. of intermedium fibers
Effect of final weight							
250 kg	246	30.91	31.97	37.12	24.52	35.33	36.50
450 kg	383	29.07	25.05	45.87	34.20	45.50	46.30
Level of significance		xx	xxx	xxx	xxx	xxx	xxx
Effect of breed							
RDM	324	27.10	29.56	43.34	29.62	37.54	38.81
SDM	264	31.63	28.33	40.04	29.85	42.26	43.05
DRK	41	31.24	27.64	41.11	28.62	41.45	42.35
Level of significance		xxx	N.S.	xxx	N.S.	xxx	xxx
Weight x breed interaction							
250 kg RDM	120	28.32	32.70	38.98	24.79	33.20	34.13
250 kg SDM	106	32.17	33.41	34.42	24.83	37.28	37.95
250 kg DRK	20	32.23	29.79	37.97	23.96	35.51	37.43
450 kg RDM	204	25.88	26.42	47.70	34.45	41.88	43.49
450 kg SDM	158	31.09	23.24	45.67	34.87	47.23	48.15
450 kg DRK	21	30.25	25.49	44.26	33.29	47.40	47.26
Level of significance		N.S.	xx	N.S.	N.S.	N.S.	N.S.

Table 22. Coefficients of heritability and coefficients of variation for muscle fiber observations.

Trait	Coefficient of heritability	Phenotypic coefficient of variation %	Variation among progeny groups	Variation within progeny groups
Av. muscle fiber diameter	0.39±0.17	9.7	1.28	11.98
Standard deviation of muscle fiber diameter	0.00±0.07	16.6	0.001	2.93
Coefficient of skewness for muscle fiber diameter	0.04±0.08	32.4	0.001	0.060
Coefficient of kurtosis for muscle fiber diameter	-0.04±0.06	16.9	-0.002	0.195
% red fibers	0.24±0.13	18.7	1.44	23.01
% white fibers	0.22±0.13	33.3	3.06	52.31
% intermedium fibers	0.38±0.16	17.8	7.98	75.11
Av. diameter of red fibers	0.38±0.16	11.3	1.04	9.97
Av. diameter of white fibers	0.26±0.14	13.2	1.82	26.18
Av. diameter of intermedium fibers	0.24±0.13	10.1	1.04	16.26

Table 23a Phenotypic and genetic correlation coefficients for muscle fiber traits.

	1	2	3	4	5	6	7	8	9	10
1. Av. fiber diameter					-0.47	-1.10	0.88	1.23	1.30	1.22
2. Standard deviation of fiber diameter	0.52									
3. Skewness of fiber diameter	0.03	0.21								
4. Kurtosis of fiber diameter	0.05	-0.27	-0.32							
5. % red fibers	-0.05	0.14	0.25	-0.22		0.69	-0.98	-0.25	-0.29	-0.35
6. % white fibers	-0.30	-0.22	-0.02	0.01	0.03		-0.95	-1.28	-1.31	-0.86
7. % medium fibers	0.27	0.10	-0.12	0.11	-0.57	-0.84		0.90	0.93	0.68
8. Diameter of red fibers	0.79	0.18	-0.02	0.22	-0.02	-0.22	0.19		1.19	1.23
9. Diameter of white fibers	0.76	0.55	0.15	-0.01	0.14	-0.16	0.06	0.54		1.37
10. Diameter of intermedium fibers	0.94	0.57	0.07	-0.06	0.14	-0.27	0.14	0.64	0.68	

Phenotypic correlations under the diagonal (coefficients $\geq$ 0.10 significant on the 0.05 level).

Genetic correlations above the diagonal (for standard errors, see Table 23b).

Table 23b Standard errors for genetic coefficients of correlations.

	1	2	3	4	5	6	7	8	9	10
1. Av. fiber diameter					0.34	0.32	0.16	0.11	0.16	0.13
2. Standard deviation of fiber diameter										
3. Skewness of fiber diameter										
4. Kurtosis of fiber diameter										
5. % red fibers						0.35	0.38	0.36	0.38	0.38
6. % white fibers							0.46	0.29	0.33	0.41
7. % medium fibers								0.17	0.23	0.27
8. Diameter of red fibers									0.11	0.12
9. Diameter of white fibers										0.21
10. Diameter of medium fibers										

CHAPTER VI

RELATIONSHIPS BETWEEN SELECTED TRAITS REGARDING GROWTH, FEED UTILIZATION, CARCASS QUALITY AND MEAT QUALITY.

An important requirement in the construction of an optimal breeding plan is knowledge of the interrelation among the traits. In this chapter the phenotypic and genetic correlation coefficients are introduced. (Table 24a). For the traits Nos. 1 to 19 the correlation coefficients are calculated within test year, breed and final weight groups on the basis of model (1), page 20 , and the genetic coefficients are calculated by use of model (2). For traits Nos. 20 to 22 the calculations include 427 animals, and they are carried out by use of models (3) and (4) respectively.

The results demonstate that a genetic improvement of the growth capacity indirectly will result in a strong reduction of the feed consumption per kg gain, as well as some reduction of the % fat in the carcass and % intramuscular fat, and a slight increase of the % lean and % pistollean. A genetic improvement of the growth capacity will result in an unchanged LD-area, but a slight reduction in the fiber-diameter, so that the fastest growing bulls will tend to have the greatest total number of muscle fibers.

Bulls with a high dressing percentage also have a high carcass gain and a good muscularity. On the other hand, there is no relationship between dressing percentage and fatness in the present data concerning animals reared under uniform feeding intensity and conditions and slaughtered at the same live weight.

The % pistollean is strongly positively correlated to the lean/fat ratio, the lean/bone ratio and the % lean, and strongly negatively correlated to the % fat.

The scores for back and thigh are positively correlated to the lean/bone ratio and only slightly correlated to % lean and % pistollean.

The LD-area is rather strongly positively correlated to both lean/bone ratio and % lean and % pistollean.

The shear-force value and taste panel scores for tenderness are rather strongly negatively correlated, which indicates that meat samples requiring much force for the cutting obtain low scores from the taste panel. Furthermore there is a tendency towards thick muscle fibers giving relatively tough meat. Shear-force value and scores for tenderness are unaffected by all the other production characteristics.

The meat colour is slightly positively correlated to the rate of gain, which indicates that the fastest growing bulls tend to have the palest meat. This may be due to the fact, that the fastest growing bulls at a constant weight basis are slaughtered at an earlier age.

Percent intramuscular fat is slightly negatively correlated to the rate of gain, positively correlated to the fatty content of the carcass and correspondingly negatively correlated to the % lean and the lean/fat ratio.

Table 24a. Phenotypic and genetic correlations concerning growth, feed utilization, carcass quality and meat quality.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. Daily gain		0.78	-0.94	-0.74	-0.21	0.39	0.39	-0.14	0.24	-0.50	0.34	-0.02	-0.02	0.08	0.23	0.43	-0.91	-0.40	-0.07	-0.99	-0.15	-0.58
2. Carcass gain	0.86		-0.80	-0.95	0.46	0.66	0.57	0.23	0.56	-0.65	-0.02	0.35	0.43	0.52	0.48	0.23	-0.97	-0.18	0.13	-1.01	-0.40	-0.65
3. F.u./kg gain	-0.89	-0.75		0.85	0.10	-0.49	-0.50	0.08	-0.34	0.61	-0.33	0.02	-0.03	-0.20	-0.30	-0.43	0.94	0.39	0.28	1.21	0.51	0.90
4. F.u./carcass gain	-0.81	-0.90	0.90		-0.44	-0.70	-0.62	-0.22	-0.59	0.70	-0.03	-0.30	-0.40	-0.54	-0.48	-0.25	0.96	0.20	0.10	1.23	0.68	0.95
5. Dressing percentage	-0.17	0.36	0.20	-0.24		0.47	0.32	0.56	0.53	-0.28	-0.51	0.60	0.71	0.71	0.41	-0.27	-0.22	0.28	0.30	0.13	-0.32	0.02
6. % pistollean	0.22	0.35	-0.30	-0.41	0.26		0.87	0.69	0.91	-0.80	-0.41	0.28	0.43	0.67	0.42	0.27	-0.72	-0.14	-0.02	-0.80	-0.66	-0.63
7. Lean/fat	0.18	0.27	-0.27	-0.35	0.18	0.68		0.48	0.96	-1.05	-0.10	0.15	0.28	0.50	0.35	0.31	-0.87	-0.19	-0.09	-0.97	-0.29	-0.91
8. Lean/bone	0.04	0.29	-0.05	-0.26	0.48	0.51	0.27		0.78	-0.30	-0.95	0.59	0.67	0.62	0.36	-0.06	-0.16	0.00	0.25	-0.51	-0.15	-0.51
9. % lean	0.20	0.37	-0.28	-0.43	0.35	0.78	0.82	0.68		-0.83	-0.51	0.39	0.53	0.61	0.38	0.17	-0.58	-0.12	0.08	-0.96	-0.21	-0.87
10. % fat	-0.23	-0.29	0.33	0.39	-0.12	-0.68	-0.91	-0.20	-0.85		-0.05	-0.08	-0.19	-0.38	-0.30	-0.31	0.74	0.19	0,12	0.74	0.16	0.63
11. % bone	0.03	-0.19	-0.06	0.12	-0.43	-0.27	0.06	-0.92	-0.38	-0.17		-0.59	-0.65	-0.51	-0.23	0.17	-0.10	-0.07	-0.33	0.19	0.04	0.25
12. P-back	0.02	0.26	0.00	-0.20	0.47	0.18	0.07	0.40	0.24	-0.03	-0.40		0.78	0.67	0.28	-0.08	-0.01	0.04	0.41	0.03	-0.06	0.27
13. P-thigh	0.09	0.33	-0.10	-0.29	0.45	0.32	0.18	0.45	0.36	-0.15	-0.40	0.56		0.67	0.31	-0.07	-0.17	0.11	0.36	-0.23	0.03	-0.29
14. LD-area	0.06	0.31	-0.06	-0.27	0.48	0.49	0.29	0.45	0.44	-0.28	-0.34	0.41	0.39		0.58	-0.05	-0.42	0.10	0.24	-0.31	-0.50	-0.20
15. Meat colour	0.22	0.25	-0.27	-0.29	0.05	0.16	0.11	0.10	0.11	-0.08	-0.07	0.10	0.14	0.14		-0.15	-0.30	0.18	-0.42	-0.89	-0.63	-0.18
16. Shear-force	0.05	0.06	-0.08	-0.08	0.01	0.08	0.09	0.01	0.08	-0.10	0.02	0.01	0.03	0.06	-0.19		-0.23	-0.90	0.35	-0.09	0.26	0,38
17. % intramusc. fat	-0.25	-0.25	0.34	0.34	-0.01	-0.30	-0.29	-0.10	-0.35	0.39	-0.04	0.03	-0.09	-0.14	-0.09	-0.13		0.14	0.03	0.38	-0.13	-0.16
18. P-tenderness	0.01	0.00	0.00	0.01	-0.02	-0.03	-0.05	0.02	-0.04	0.06	-0.04	0.01	-0.01	-0.01	0.21	-0.68	0.08		-0.51	-0.49	-1.03	-1.11
19. Av. Fiber diameter	-0.11	0.01	0.13	0.03	0.23	0.06	0.00	0.15	0.08	0.01	-0.16	0.16	0.15	0.17	-0.20	0.20	0.03	-0.22		1.28	1.41	1.34
20. Diam. of red fibers	-0.16	-0.10	0.21	0.17	0.12	-0.07	-0.10	-0.02	-0.07	0.09	-0.03	0.07	-0.01	0.01	-0.20	0.04	0.12	-0.05	0.79		1.24	1.36
21. Diam. of white fibers	-0.10	-0.04	0.12	0.07	0.12	0.03	0.05	0.02	0.07	-0.07	0.00	0.10	0.11	0.06	-0.19	0.18	-0.03	-0.18	0.75	0.53		1.53
22. Diam. of medium fibers	-0.11	0.00	0.11	0.04	0.21	0.07	0.04	0.04	0.07	-0.05	-0.03	0.15	0.14	0.13	-0.16	0.16	0.01	-0.14	0.94	0.63	0.65	

Phenotypic correlations under the diagonal (for traits 1-19 are coefficients ≥ 0.06 and for traits 20-22 are coefficient ≥ 0.09 significant on the 0.05 level).
Genetic correlations above the diagonal (for standard errors, see Table 24b).

Table 24b Standard errors for genetic coefficients of correlation.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. Daily gain		0.05	0.17	0.15	0.13	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.14	0.13	0.13	0.13	0.16	0.13	0.17	0.28	0.43	0.44
2. Carcass gain			0.15	0.14	0.10	0.09	0.10	0.12	0.10	0.12	0.13	0.12	0.11	0.10	0.11	0.14	0.15	0.14	0.17	0.28	0.43	0.42
3. F.u./kg gain				0.04	0.13	0.13	0.14	0.14	0.14	0.10	0.13	0.14	0.14	0.13	0.15	0.14	0.09	0.14	0.17	0.14	0.34	0.30
4. F.u./carcass gain					0.12	0.12	0.12	0.13	0.13	0.08	0.13	0.13	0.13	0.12	0.13	0.14	0.09	0.14	0.17	0.15	0.32	0.32
5. Dressing percentage						0.10	0.12	0.09	0.09	0.13	0.12	0.08	0.07	0.07	0.12	0.13	0.16	0.13	0.15	0.34	0.38	0.43
6. % pistollean							0.04	0.07	0.03	0.12	0.12	0.12	0.11	0.07	0.12	0.13	0.16	0.14	0.16	0.22	0.31	0.33
7. Lean/fat								0.10	0.02	0.13	0.13	0.13	0.12	0.10	0.12	0.13	0.15	0.14	0.17	0.19	0.35	0.29
8. Lean/bone									0.05	0.13	0.12	0.09	0.08	0.08	0.12	0.14	0.16	0.14	0.16	0.28	0.37	0.36
9. % lean										0.13	0.12	0.11	0.10	0.08	0.12	0.13	0.17	0.14	0.16	0.22	0.38	0.32
10. % fat											0.13	0.13	0.14	0.13	0.13	0.14	0.10	0.14	0.17	0.21	0.37	0.35
11. % bone												0.12	0.12	0.12	0.13	0.13	0.16	0.14	0.16	0.31	0.36	0.38
12. P-back													0.06	0.08	0.13	0.13	0.16	0.14	0.14	0.32	0.38	0.38
13. P-thigh														0.08	0.13	0.14	0.17	0.14	0.15	0.31	0.38	0.38
14. LD-area															0.10	0.13	0.15	0.13	0.15	0.29	0.32	0.37
15. Meat colour																0.14	0.17	0.14	0.17	0.25	0.38	0.42
16. Shear-force																	0.17	0.15	0.16	0.36	0.40	0.41
17. % intramusc. fat																		0.17	0.21	0.30	0.39	0.41
18. P-tenderness																			0.18	0.35	0.42	0.44
19. Av. Fiber diameter																				0.15	0.25	0.25
20. Diam. of red fibers																					0.16	0.23
21. Diam. of white fibers																						0.37
22. Diam. of medium fibers																						

CHAPTER VII

DISCUSSION AND CONCLUSION

In this report the beef production traits are organized and treated in three main groups: 1) Gain and Feed Utilization, 2) Carcass Quality, and 3) Meat Quality.

GAIN AND FEED UTILIZATION

Under homogeneous and controlled environmental conditions the phenotypic standard deviation of average daily gain is 60-70 grammes. The variance of this trait is strongly hereditarily determined giving a heritability of 0.43. A genetic improvement of the growth capacity will indirectly entail a strongly reduced feed consumption per kg gain as well as slightly later developed animals with consequent lower fatness, higher % lean and better muscle distribution. On the other hand the rate of gain has only a small influence on the most important meat quality traits.

CARCASS QUALITY

The phenotypic variation for the carcass quality traits is generally on a fairly low level, but for most of the traits the existing variation is strongly genetic determined having coefficients of heritability of around 0.5 to 0.6. Low coefficients of heritability have only been found for the subjective evaluation and for the distribution of lean, fat and bone. The % pistollean is a compound quality trait, which is influenced by the % lean, the lean/bone ratio and the distribution of lean (LP/LT). The correlation analyses carried out show that all these traits will be favourably influenced, when % pistollean is applied as criterion of selection. Furthermore it has been demonstrated that the LD-area of the carcass is rather strongly correlated to the most important carcass quality traits. As this area at the same time has a coefficient of variation of around 9% and a h^2-value of 0.58, it makes up an important trait for selection. Also the carcass quality is only slightly correlated to the most important meat quality trait.

MEAT QUALITY

Most of the meat quality traits have a low genetic variation. For the shear-force value, however, the h^2-values are at a fairly high level. Consequently, it is possible to improve this trait through selection on basis of progeny tests.

GENOTYPE x WEIGHT AT SLAUGHTER INTERACTION

A significant effect of interaction between breed and weight at slaughter has been demonstrated for carcass gain, the most important carcass quality traits and shear-force value. Although a corresponding effect of interaction has not been found between progeny groups and weight at slaughter, the results indicate that progeny and performance tests should be carried out at a final weight that is not too much different from the weight at slaughter used in practice.

PERFORMANCE AND PROGENY TESTS

In the light of the results presented, the following test procedure for the beef production in the Danish dual-purpose cattle has been established:

The high coefficients of heritability for average daily gain show that it is possible on the animal itself to determine the breeding value for growth capacity with relatively high accuracy.

Therefore performance tests are now carried out on about 500 potential AI bulls each year. The test covers the age period from 1½ to 11 months, and the breeding value for daily gain is expressed as a T-index composed as follows:

$T = h^2 \ (P_x - \overline{P}) \times \overline{P}$, where

h^2 = coefficient of heritability

P_x = the daily gain of the bulls in percentage of the breed's average at the station

$\overline{P}$ = 100 = Average for T-index.

The cross-sectional area of M.long.dorsi is determined at the end of the test by use of ultrasonic measurements (Andersen, 1975). The ultrasonic muscle area is adjusted into a constant 11 months' weight and is presented as percentage of the breed's average at the station.

In the progeny test for beef production the number of progenies per group is reduced from 18 to 10 as a result of the high coefficients of heritability for the traits involved. Only one weight group is tested, and the final weight is now 300 kg. The breeding value of an AI bull for beef production ability is comprised in one K-index, composed as follows:

$K = b_1 \cdot CG + b_2 \cdot PL + b_3 \cdot TEND$, where

CG = the average carcass gain of the progeny group - measured as deviation from the breed's average at the station.

TL = the average percentage of pistollean of the progeny group - measured as deviation from the breed's average at the station.

TEND = the average shear-force of M.long.dorsi of the progeny group - measured as deviation from the breed's average at the station.

b_1, b_2 and b_3 = weighing factors for the three traits - calculated on the basis of the heritability of the traits, their correlations and their relative economic importance.

By including the performance tests and the progeny tests for beef production in the breeding work with the dual-purpose cattle, it is possible to improve the dairy traits as well as the daily gain and carcass quality of the breed simultaneously. Thus the costs for feed, labour and investment of the young stock and the fattening bulls will be reduced, and at the same time the carcass value of fattening bulls and culled cows will increase.

REFERENCES

Andersen, B.B., 1970. Individprøve for slagtekvalitet. Licentiatafhandling, K.V.L., København. 110 pp.

Andersen, B.B. 1975. Recent experimental development in ultrasonic measurement of cattle. Livestock Prod. Sci. 2, 137-146.

Andersen, B.B. og G.S. Andersen, 1975. Sammenhæng mellem mælkeproduktionsevne, kødproduktionsevne og kropsmål hos RDM og SDM. Statens Husdyrbrugsforsøg. Meddelelse nr. 71. København. 4 pp.

Andersen, H.R., 1974. Slagtevægtens og foderstyrkens indflydelse på vækst, foderudnyttelse og slagtekvalitet hos RDM-ungtyre. Licentiatafhandling, K.V.L., København. 154 pp.

Averdunk, G., 1969. Ergebnisse und Problematik der Eigenleistungs- und Nachkommenprüfung auf Fleischleistung beim Rind. Züchtungskunde 41, 152-161.

Buchter, L., 1970). Development of a standardized procedure for the slaughter of experimental beef animals from the Danish progeny testing station "Egtved", 16th European Meeting of Meat Research Workers, Varna, Bulgaria Vol. 1, 45-56.

Callow, E.H., 1944. The food value of beef from steers and heifers and its relation to dressing cut percentage. J. Agr. Sci. 34, 177-

Callow, E.H., 1947. Comparative studies of meat. I. The chemical composition of fatty and muscular tissue in relation to growth and fattening. J. Agr. Sci. 37, 113-124.

Callow, E.H., 1961. Comparative studies of meat. VII. A comparison between Hereford, Dairy Shorthorn and Friesian steers on four levels of nutrition. J. Agr. Sci. 56, 265-282.

Chiffelle, T.L. og F.A. Putt, 1951. Propylene and ethylene glycol as solvents for Sudan IV and Sudan Black B. Stain Technology 26, 51-56.

Cole, J.W., L.E. Orme and C.M. Kincaid, 1960. Relationship of Loin Eye Area, Separable Lean of Various Beef Cuts and Carcass Measurements to toal Carcass Lean in Beef. J. An. Sci. 19, 89-100.

Cole, J.W., C.B. Ramsey and R.H. Epley, 1962. Simplified Method for predicting Pounds of Lean in Beef Carcasses. J. An. Sci. 21, 355-361.

Cundiff, L.V., Chambers, D., Stephens, D.F. and Willham, R.L., 1964. Genetic analysis of some growth and carcass traits in beef cattle. J. An. Sci. 23, 1133-1138.

Cunningham, E.P. and T. Broderick, 1969. Genetic and environmental parameters of growth and carcass traits in dual-purpose cattle. Ir. J. Agric. Res. 8, 397-416.

Dietert, W., J.H. Weniger und U. Pfleiderer, 1970. Untersuchungen über verschiedene Prüfungsverfahren auf Mastleistung und Schlachtkörperwert beim Rind. Züchtungskunde 42, 349-361.

Fimland, E.A., 1973. Estimates of Phenotypic and Genetic Parameters for Growth Characteristics of Young Potential AI Bulls. Acta Agr. Scand. 23, 209-216.

Gallagher, R.M., 1963. The influence of growth rate selection on some carcass characteristics of beef cattle. In symposium on carcass composition and appraisal of meat animals (Ed. Tribe, D.E.). C.S.I.R.O., Melbourne, Australia. 9-1 - 9-9.

Grau R. und R. Hamm, 1953. Eine einfache Methode zur Bestimmung der Wasserbindung in Fleisch. Naturwissenschaften 40, 29-30.

Gravert, H.O. 1962. Untersuchungen über die Erblichkeit von Fleischeigenschaften beim Rind. Z. f. Tierz. Zuchtbiol. 78, 43-74.

Gravert, H.O., E. Rosenhahn, E. Ernst und P. Feddersen, 1971. Entwicklung und Bedeutung der Nachkommenschaftsprüfungen auf Fleischleistung beim Rind in Schleswig-Holstein. Züchtungskunde 43, 155-161.

Grünewald, Th. 1957. Ein Festigkeitsprüfgerät für Lbensmittel nach N. Wolodkewitsch. Z. Lebensm. Untersuch. - Forsch., 105, 1-12.

Harvey, W.R., 1972. Instructions for use of LSMLMM. Ohio State University, Ohio. 30 pp.

Hertrampf, J., 1960. Untersuchungen zur Erkennung der Schlachtqualität von Jungbullen bei der Nachkommenprüfung auf Fleischleistung von Zweinutzungsrindern. Diss., Göttingen. 55 pp.

Hinks, C.J.M. and B. Bech Andersen, 1968. Phenotypic aspects of growth and carcass quality in veal calves. Anim. Prod. 10, 331-340.

Hinks, C.J.M. and B. Bech Andersen, 1969. Genetic aspects of growth and carcass quality in veal calves. Anim. Prod. 11, 43-45.

Kaufmann, R.G., M.D. von Ess and R.H. Long, 1976. Bovine compositional interrelationships. J. An. Sci., 43, 102-107.

La Chevallerie, Manfred v., 1968. Untersuchungen über Methoden zur Erfassung der Schlachtskörperzusammensetzung am lebenden Rind. Diss. Göttingen. 131 pp.

Langholz, H.-J., 1964. Die Nachkommenprüfung auf Station als züchterischer Weg zur Verbessung der Rindfleischerzeugung. Diss. Göttingen. 136 pp.

Langholz, H.-J. und C. Jongeling, 1972. Untersuchungen zum genetischen Aussagewert der stationären Nachkommenprüfung auf Mastleistung und Schlachtkörperwert beim Rind. Züchtungskunde 44, 368-384.

Langlet, J., 1965. Review of existing knowledge of genetic relationship of meat and milk production with special emphasis on experimental techniques and design. Wld. Rev. Anim. Prod. 1, 31-36.

Lettner, F., 1965. Vergleichende Untersuchungen an Dreirippenstücken und Schalchtkörpern bei österreichischen Höhenviehrassen. Die Bodenkultur 16, 340-355.

Lindström, U. and K. Maijala, 1970. Evaluation of Performance Test Results for AI Bulls. Acta Agric. Scand. 20, 207-218.

Linner, J.L.M., 1973. Beziehung zwischen Merkmalen der Milchleistung und der Mast- und Schlachtleistung beim deutschen Fleckvieh. Diss. München. 1973. 79 pp.

Malsburg, K.v.d., 1911. Die Zellengrösse als Form und Leitungsfaktor der Landwirtschaftlichen Nutztiere. Arb.d.Dtsche Ges.f. Züchtgskde 10, 353 pp.

Miller, J.C., H.B. Hedrick, G.B. Thompson, R.R. Freitag, W.E. Meyer, A.J. Dyer and H.D. Naumann, 1965. Factors Affecting Longissimus Dorsi and Subcutaneous Fat Measurements and Indices of Beef Carcass Cut-Out. Mo. Agri. Exp. Sta. Res. Bul. 880, 44 pp.

Ovesen, E.B., 1970. Undersøgelser over malkeorganernes morfologiske egenskaber hos køer i 1. laktation. Licentiatafhandling. KVL. København. 148 pp.

Palmer, A.Z. Relation of age, breed, sex and feeding practices on beef and pork tenderness. Proc. Meat Tenderness Symposium, 1963, 163-179. Campbell Soup Company.

Rittmannsperger, F., 1966. Schätzung phänotypischer und genetischer Parameter von Masteigenschaften bei Jungbullen des österreichischen Fleck- und Branviehs. Züchtungskunde 38, 346-353.

Shelby, C.E., R.T. Clark and R.R. Woodward, 1955. The heritability of some economic characteristics of beef cattle. J. Anim. Sci. 14, 372-385.

Shelby, C.E., W.R. Harvey, R.T. Clark, J.R. Quesenberry and R.R. Woodward, 1963. Estimates in ten years of miles city R.O.P. steer data. J. Anim. Sci. 22, 346-353.

Skjervold, H., 1958. Registrering av kjøttproduksjonsegenskapene hos storfe. Norges Landbrukshøgskole. Institut for avls- og ra-celære. Melding nr. 123, Ås. 144 pp.

Torreele, G. and T. Slawinski, 1970. A study about the relationship between growth rate, dressing percentage and carcass composition for intensively fattened young bulls. Med. Facult. Landbouwwetensch. Rijksuniversiteit 35, Gent, Belgien. 401-408.

Trappmann, W., 1972. Schätzung phänotypischer und genetischer Parameter der Fleischleistung von Jungbullen bei Stations- und Feldprüfung. Züchtungskunde 44, 17-27.

APPENDIX I

COEFFICIENT OF SKEWNESS AND COEFFICIENT OF KURTOSIS FOR SOME MEAT PRODUCTION TRAITS.

Trait	Calves		Young bulls	
	Coefficient of skewness	Coefficient of kurtosis	Coefficient of skewness	Coefficient of kurtosis
Weight at 15 days	0.08	3.00	0.27	3.15
Age in days	0.39	3.24	0.35	3.40
Daily carcass gain	-0.11	3.20	0.12	3.31
Daily gain	-0.19	3.30	0.03	3.02
F.u./kg carcass gain	0.29	3.42	0.24	3.52
F.u./kg gain	0.35	3.37	0.31	3.35
Dressing %	0.14	3.50	0.02	3.05
Scores for back	-0.20	3.06	-0.58	3.68
Scores for loin	-0.01	3.03	-0.06	3.07
Scores for thigh	0.11	2.44	-0.05	2.51
Classification	0.36	2.37	-0.09	1.94
% lean	0.04	3.10	0.11	3.16
% tallow	0.22	2.96	0.10	2.99
% bone	0.12	3.06	0.15	3.04
Lean/tallow	0.70	3.69	0.87	4.49
Lean/bone	0,35	3.28	0.35	3.20
Area of m.long.dorsi	0.50	3.48	0.26	2.90
% pistollean	0.15	2.98	0.22	3.22
Lean in pistol/lean in total	-0.02	3.36	-0.04	2.94
Tallow in pistol/ tallow in total	-0.03	3.27	0.02	3.12
Bone in pistol/bone in total	0.12	3.19	-0.27	3.27
Meat colour	0.39	3.50	0.34	3.42
Tenderness	0.96	4.04	1.04	4.13
% intramusc. fat	0.90	4.21	0.97	4.03
% dry matter	-0.45	4.19	0.28	4.35

Trait	Calves: Coefficient of skewness	Calves: Coefficient of kurtosis	Young bulls: Coefficient of skewness	Young bulls: Coefficient of kurtosis
% nitrogen	-0.17	3.78	-0.28	3.07
Waterholding capacity	0.20	3.56	0.02	3.43
Scores for colour	-0.34	3.07	-0.50	4.55
Scores for flavour	-0.31	3.32	-0.15	3.02
Scores for tenderness	-0.48	2.92	-0.55	2.98
Scores for juiciness	-0.37	3.09	-0.20	3.23
Scores for total impression	-0.62	3.22	-0.73	3.36
Average fiberdiam.	0.52	3.83	0.05	3.06
Standard dev. of fiberdiam.	0.40^x	2.86^x	0.67	4.19
Coeff. of skewness for fiberdiameter	-3.01	13.95	-0.15	3.45
Coeff. of kurtosis for fiberdiameter	0.97^x	3.95^x	1.08	4.52
% red fibers	-0.19^x	2.86^x	0.07^x	2.63^x
% white fibers	0.13^x	2.70^x	0.05^x	2.55^x
% intermed. fibers	0.07^x	2.68^x	0.13^x	2.21^x
Av. diam. of red fibers	0.33^x	3.31^x	0.05^x	3.14^x
Av. diam. of white fibers	0.61^x	3.66^x	1.00^x	6.70^x
Av. diam. of interm. fibers	0.46^x	3.31^x	0.43^x	3.36^x

The coefficients in the table are significant at the 5% level, if the deviations from 0 and 3 for coefficient of skewness and coefficient of kurtosis, respectively, are greater than the deviations listed below.

	Calves	Young bulls
Coefficients of skewness (without x)	± 0.111	± 0.127
" " " (with x)	± 0.251	± 0.197
Coefficients of kurtosis (without x)	± 0.23	± 0.26
" " " (with x)	± 0.52	± 0.41

APPENDIX II

Oversættelsesliste vedrørende tabeller

ad libitum	efter ædelyst
age	alder
area of M.long.dorsi	muskelareal
authors	forfattere
av.	gennemsnit
back	ryg
breed	race
bone	knogler
BP/BT	knogler i pistol/knogler i slagtekrop
bulls	tyre
calves	kalve
categorie	kategori
colour	kødfarve
concentrates	kraftfoder
consistency	konsistens
culled cows	udsætterkøer
daily gain	daglig tilvækst
daily carcass gain	nettotilvækst
dressing percentage	slagteprocent
dried sugarbeet pulp	tørret sukkerroeaffald
dry matter	tørstof

fat	talg
FP/FT	talg i pistol/talg i slagtekrop
final weight	slutvægt
hay	hø
head	stk.
heifers	kvier
LP/LT	kød i pistol/kød i slagtekrop
lean	kød
loin	lænd
molasses	melasse
nitrogen	kvælstof
No. of progenies	antal afkom
No. of progeny groups	antal afkomsgrupper
numbers	antal
percentage	procent
pistollean	pistolkød
skimmilk	skummetmælk
slaughter	slagtning
standard deviation	spredning
steers	stude
straw	halm
thigh	lår
total	total
waterholding capacity	vandbindingsevne
weight	vægt
whole milk	sødmælk
young bulls	ungtyre