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# ESTIMATION OF CARCASS CHARACTERISTICS IN YOUNG BEEF CATTLE

Selostus: Nuoren lihanaudan teurasominaisuuksien arvioimisesta

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**Abstract.** In the present study the main objectives were to determine whether sufficiently accurate estimation of live weight, carcass weight and carcass composition with live measurements is possible, and whether an accurate estimation of carcass composition with any other procedure than total carcass dissection is possible. The material consisted of 205 1-year old steers and bulls and 174 bull calves. Within experiment each trait of each animal was corrected for age, breed and feeding with a correction factor obtained with the least squares method. In the stepwise regression analysis the results for both age groups were analysed separately. From live measurements the best estimators in both age groups were width of chest, heart girth and natural length. The most reliable predictor of meat quantity was carcass weight, $R^2$-value was 96 % for both age groups. In estimation of meat percentage the $R^2$-value obtained for the ½-year olds with cutting results of fore shanks was 56 %, the respective value for the 1-year olds was considerably lower. With 1-year olds the carcass weight and some by-products gave the highest estimations for the quantity and percentage of fat, $R^2$ were 62 % and 50 % respectively, and for the ½-year olds the kidney fats and the cutting results of flanks gave the highest estimations, $R^2$ were 70 % and 59 % respectively. For the quantity and percentage of bone the $R^2$ for the 1-year olds obtained with cutting results of shanks were 68 % and 55 % respectively, and for the ½-year olds 82 % and 70 % respectively. When the cutting results of the fore and hind quarters were used as estimators the $R^2$ obtained for all the traits were higher in both age groups than with any other estimator, $R^2$ obtained with carcass quality scores remained lower.

# Introduction

Methods to increase meat production and improve carcass quality have been objects of intensive research since World War II. This is true especially in the developed countries where meat consumption together with requirements on meat quality have increased by both the consumers and the industry.

The main purpose of research is to discover methods for the economical production of carcasses with large deposits of high-quality meat, sufficiently fats and as little as possible uneatable tissues such as bone and tendons.

Increase in weight and size, i.e. growth, and feed consumption are the only information available during the growth of beef cattle. On the economic point of view these are the most important factors in beef cattle production. Under the prevailing circumstances, however, it is not always possible to verify the weight and growth by any other means but measuring, because only a few farmers have an animal scale at their disposal.

No sufficiently accurate information can be obtained of carcass weight and composition — quantities and percentages of meat, fat and bone — of an animal during its growth. The quantities of meat, fat and bone can only be determined through dissection of the whole carcass and partition of different types of tissue. The accuracy required by scientific research can only be obtained if the different types of tissue are separated anatomically, where, for example, the intermuscular fasciae and fat can be removed from the muscle.

As partition of carcasses into different tissues is very expensive and time-consuming even in research, other methods to determine carcass composition are being examined. Estimation of carcass composition has always been started from visual evaluation and live measurements, continued to carcass measurements and quality scores, up to the inspection of different types of tissue in some small parts of a carcass.

As fat content strongly affects the rations between different types of tissue in a carcass, several techniques and devices have been developed for measuring fat, of which the ultrasonic measuring device is the most delicate and the most widely used one. In measuring the thickness of back fat in pigs some very prominent results have been obtained. In cattle, however, no equally reliable results have been obtained especially when the fat cover has been thin.

The use of different techniques and devices is no further discussed here, but it can be observed that the further the measurement and study technique develope, the more reliable information on live animal and carcass composition is obtained.

## Purpose of present study

Although foreign results on the subject matter are relatively abundantly available, they are in their original form mostly unapplicable for Finnish conditions. Materials consist of foreign breeds, feeding is different, carcass classification methods differ from each other and from ours, etc. The greatest handicaps for comparison are, however, in the different cutting methods and quality requirements which vary between countries and seasons and which production finally has to adapt to.

The purpose of the present study is to determine whether adequately accurate estimation of live weight, carcass weight and carcass composition with live measurements on young beef cattle is possible, and whether carcass composition — quantities and percentages of meat, fat and bone — can be estimated without decreasing the commercial value of the carcass at all or only slightly.

## Material and methods

### *Material*

The material comprised results of 10 separate experiments. Eight of them were conducted at the S. W. Finland Agricultural Experiment Station in 1963—70, and two at the North Ostrobothnia Agricultural Experiment Station in 1969—70. In experiments I—VI there were 205 about 1-year old steers and bulls, and in the experiments VII—X 174 bull calves reared till age of 165 days. In the present study the former are called 1 - y e a r o l d s and the latter ½ - y e a r o l d s.

The experiments were planned and supervised by the Institutes of Animal Breeding and Animal Husbandry of the Agricultural Research Centre.

In the experiments for the 1-year olds the initial feeding was roughly taking equal, but thereafter the animals were arranged to several feeding groups, except in experiment I. The differencies in feeding were mainly based on the unequal portions of concentrates, the varying levels of nitrogen content on pasture and in green silage fodder, and on the various methods the silage fodder had been prepared. In experiments VII—IX feeding remained uniform, in experiment X the effect of different portions of animal protein on the development of an animal was also studied.

The calves were delivered for the experiments by the local A. I. Society and co-operative slaughterhouse. The attempt was to obtain the calves at 1—2 weeks' age which, however, did not always succeed especially with the crossbreds.

In the experiments I and V the calves were born in spring and slaughtered the following spring. In the other experiments with 1-year olds the calves were born in autumn and slaughtered the following autumn at the end of pasture season, except in experiment IV where half of the animals stayed in the cow stable on indoor feeding over the summer. Calves in the experiments with ½-years olds were all born in autumn.

The purpose was that all the animals were sent for slaughter at the same age within experiment. Age differencies were levelled by gradating the slaughters. The slaughter age for ½-year olds was predetermined to 165 days and that of the others to about one year.

Rearing till one year was justifiable especially in experiments IV, V and VI where there were progeny groups of phenotype tested bulls which had been tested at rearing stations at the age of one year. In some experiments also other criteria could have been considered for determining the moment of slaughter. Some of the most noteworthy being slaughter at same weight or at the same fatness degree, like in the study by Lindhé and Henningsson (1968). However, an accurate determination of fatness degree would have been impossible. On the other hand the circumstances favoured slaughter at same age, as the number of stalls available in the cow stable was quite restricted, and the calves for the following experiments could only be taken in after the animals in the previous experiments had been removed. In addition carcass dissection would have spread over a much longer period which would have been quite difficult to arrange in the slaughterhouses.

The distribution of material by breed and experiment is presented in Tables 1 and 2.

Table 1. Distribution of material by experiment and breed. 1-year olds.

| | S. W. Finland Experiment Station | | | | N. Ostrobothnia Experiment Station | | No. of animals |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | |
| *Breed* | | | | | | | |
| Ay.Ay | 6 | 12 | 12 | 47 | – | 32 | 109 |
| Fc.Fc | 6 | 12 | 12 | – | 16 | – | 46 |
| Ch.Ay | 6 | – | – | – | – | – | 6 |
| Ch.Fc | 6 | – | 11 | – | – | – | 17 |
| Fr.Fc | – | – | 12 | – | 15 | – | 27 |
| Total | 24 | 24 | 47 | 47 | 31 | 32 | 205 |
| Initial age, days | 11 | 9 | 12 | 11 | 23 | 22 | 14.5 |
| Deviation » | 4.5 | 3.3 | 3.4 | 4.0 | 16.7 | 7.5 | – |
| Slaughter age, days | 340 | 356 | 366 | 357 | 338 | 339 | 351.3 |
| Deviation » | 2.4 | 10.1 | 3.7 | 6.2 | 23.0 | 10.6 | – |
| Feeding group | 1 | 2 | 5 | 2 | 6 | 4 | – |

In experiment II the animals were castrated at approx. 8 months and in experiment III at approx. 4 months.

Breeds: Ay = Ayrshire, Fc = Finncattle, Ch = Charolais, Fr = Friesian.

Table 2. Distribution of material by experiment and breed. $^1/_2$-year olds.

| | S. W. Finland Experiment Station | | | | No. of animals |
|---|---|---|---|---|---|
| | VII | VIII | IX | X | |
| *Breed* | | | | | |
| Ay.Ay | 6 | 14 | 10 | 14 | 44 |
| Fc.Fc | 6 | 14 | 10 | 14 | 44 |
| Ch.Ay | 6 | 14 | 10 | 13 | 43 |
| Ch.Fc | 6 | 14 | 10 | 13 | 43 |
| Total | 24 | 56 | 40 | 54 | 174 |
| Initial age, days | 15 | 11 | 10 | 8 | 10.4 |
| Deviation » | 6.6 | 5.8 | 8.8 | 2.2 | |
| Slaughter age, days | 165 | 166 | 166 | 165 | 165.6 |
| Deviation » | 2.2 | 2.5 | 3.1 | 6.8 | – |
| Feeding group | 1 | 1 | 1 | 4 | – |

Breeds: Ay = Ayrshire, Fc = Finncattle, Ch = Charolais, Fr = Friesian.

## *Estimated traits and estimators*

Estimated traits:

1. Live weight
2. Carcass weight
3. Quantities and percentages of carcass meat, fat and bone.

Estimators:

I Live measurements

II Initial weight and daily gain during experiment

III Carcass quality scores

IV Live weight, carcass weight, dressing-%, by-products and, only for the ½-years olds, cutting results of flanks

V Cutting results of shanks

VI Cutting results of fore and hind quarters

VII Detailed cutting results of the carcasses

*Presentation of the results*

Because there are eight estimated traits and seven trait groups act as estimators the results are presented in the following order:

1. Definition and mean results of the estimated traits
2. Results obtained by each estimator (I—VII) are presented separately in the following order:

   a) Definition and mean results of the traits b) results of the stepwise regression analysis and discussion.

*Statistical analysis*

In order to minimize the errors caused by spurious correlations between traits, all the traits of each animal were corrected within experiment for age, feeding and breed.

In order to estimate the correction factors and to examine the statistical significance of the variation caused by different factors — age, feeding and breed — the results of each experiment were first analysed with the least squares method (HARVEY 1966).

In the analysis the slaughter age is the independent variant and the breeds and feeding groups form the levels. With the regression coefficient each trait was corrected for age thus obtained to correspond the average age in the experiment. In the same way each trait was corrected for breed (or sire) and feeding deviation within experiment.

All the corrections were made for each trait irrespective of whether the variation caused by the above mentioned factors was statistically significant or not.

Corrections were made according to the following equation:

$$y_0 = x_0 - b(a_0 - \bar{a}) - x_1 - x_2,$$

where: $y_0$ = corrected value of a trait

$x_0$ = original, uncorrected value of a trait

$b$ = regression coefficient of age for the trait

$a_0$ = slaughter age

$\bar{a}$ = mean slaughter age in the experiment

$x_1$ = breed (or sire) deviation for the trait

$x_2$ = feeding deviation for the trait

In the stepwise regression analysis corrected values were used with which the best estimators (groups I—VII, page 393) to estimate the traits — live weight, carcass weight and carcass composition.

The steps were followed till the standard error of estimate started to increase, but only those steps (traits) are retained in the results which had a statistically significant value for the partial regression coefficient (b).

With stepwise regression analysis the correlations between different traits (r), multiple correlations (R), partial regression coefficients (b) and standardised partial regression coefficients (beta) could be calculated.

In discussion on the results it has to be considered that they were not analysed by breeds but the difference between breeds and also feedings are eliminated as carefully as possible with the correction factors obtained with the least squares method. It is impossible to check whether all the corrections are correct. Expecially the effect of age on different traits within a certain time period can not be determined because the deviation of age has been relatively large as in experiment V.

## Estimated traits

*Live weight*

In most experiments the live weight has been registered at the experiment station on the previous evening or the morning of transport to slaughterhouse. If the animals had been weighed on two or three consequent days before slaughter, mean of these has been used in the results. In all experiments the animals were transported to the slaughterhouse in the morning and slaughtered the same day. The animals were not on fast before slaughter.

*Carcass weight*

At the slaughterhouse the carcasses are weighed immediately after slaughter. An automatic scale reduces from this so called warm carcass weight 3 % to compensate for possible evaporation and drying losses. The weight thus obtained is carcass weight (= cold carcass weight) according to which the producer price is determined. All by-products, including kidney fats which in some countries remain in the carcass, are removed.

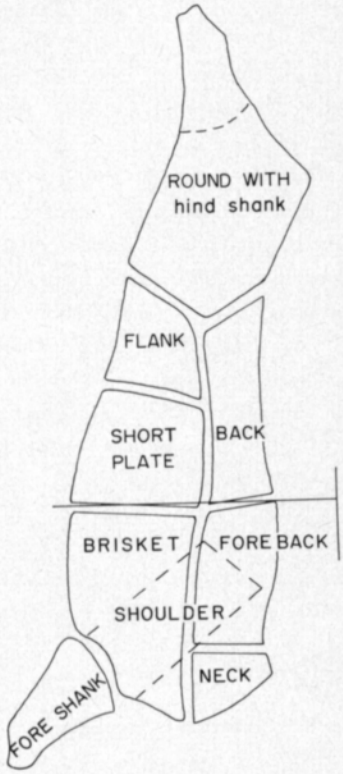
*Quantities and percentages of carcass meat, fat and bone*
*Partition of different types of tissue*

Carcass weight is registered before dissection. In average, the registered weight lies between warm and cold carcass weight, the first ones dissected closer to the warm carcass weight. The percentages for the cutting results were calculated from this so called actual weight. If calculated from carcass weight the first ones would have received cutting gain, and the latter ones cutting loss. In the results, however, only cold carcass weight is presented because presenting several weights for one carcass would disturb further treatment of the results, especially as the percentage for by-products and the dressing-% are calculated from carcass weight according to present practice.

Dissection was performed according to the routine, the so called commercial cutting scheme, practised by the co-operative slaughterhouses. Carcasses from the S.W. Finland Experiment Station were dissected at the S.W. Finland Co-operative Slaughterhouse (LSO) in Turku and the ones from N. Ostrobothnian Experiment Station in slaughterhouse Lihakunta in Oulu.

Carcass cutting scheme is presented in Figure 1.

Fig. 1.
CUTTING SCHEME OF A NEAT CARCASS




Carcasses in experiment VII and VIII were not dissected. In experiments I, IX and X the carcasses were dissected according to Figure 1., where the carcasses were cut into fore and hind quarters between the seventh and the eighth rib. Hereafter the fore quarters was partitioned into briskets, fore back, shoulders, neck and fore shanks, and the hind quarters into the rounds with hind shanks, back, flanks and short plates. All parts were cut into meat, fat, bone and tendon selections. The outer and inner fillets[1]) and steaks separately including and excluding bones were weighed.

Carcasses in experiments II—VI were also cut into fore and hind quarters as shown in Figure 1, but the quarters were partitioned no further but cut separately into tissue selections. However, in the hind quarters the outer fillets and the steaks including and excluding bones were weighed separately.

In experiments II—VI the fore and hind shank on the right hand side, and in experiments I, IX and X both fore shanks but neither hind shank were removed from the carcass. (An accurate description of shank dissection is presented in Chapter V.)

Although the cutting scheme is the same within the Co-operative Slaughterhouse Organisation, some differencies appear in dissection technique. Except for shanks, dissection of the main cuts from the carcasses was the same in both slaughterhouses. In LSO meat was classified into Ist and IInd grades where the Ist one consisted almost entirely of meat and the IInd one included also some fats and fasciae. In Lihakunta, however, Ist, IInd and IIIrd grades were dissected.

In the present results all meat selections are combined making no distinction between grades.

[1]) outer fillet = Musculus longissimus dorsi — MLD

*Means of estimated traits by experiment*

The means and standard deviations of live weight, carcass weight and carcass cutting results are presented by experiment in Tables 3, 4 and 5. In case all the animals represent the same breed or have a similar diet, no remark about the statistical significance of breed or feeding is made. Only in those experiments where sons of several sires are tested and the difference between sires has been statistically significant, a remark is made. In tables 3–7, 11, 14, 19, 23, 26 and 27 the means and standard deviations are calculated from corrected values. The statistical significance of variation caused by breed, feeding and age are calculated from original values.

With 1-year olds (Table 3) the differencies between live weight and carcass weight between breeds were significant in all experiments. Instead, with ½-year olds (Table 3) in experiments VIII and IX no statistically significant differencies in live weight appeared between breeds, therefore the differencies in carcass weights are due to the higher dressing-% of the crossbreds.

In quantities of meat and bone the differencies between breeds (Table 4) were statistically significant with 1-year olds, whereas differencies in percentages were significant only in a few cases. Also differencies caused by age affected more clearly the quantities than the percentages.

In experiment IV (Tables 3 and 4) the difference caused by feeding was statistically significant with almost all the traits. During the indoor feeding season half of the animals were on abundant concentrate diet and the other half on silage fodder diet. During summertime one half were continuously

Table 3. Means and standard deviations of live and carcass weights by experiment.

| Exp. No. | Mean | SD | Statistical significance | | | Mean | SD | Statistical significance | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Breed | Feed. | Age | | | Breed | Feed. | Age |
| | 1-year olds, n = 205 | | | | | | | | | |
| | Live weight kg | | | | | Carcass weight kg | | | | |
| I | 328 | 23.1 | * | | — | 168 | 12.3 | *** | | — |
| II | 298 | 17.8 | *** | — | — | 140 | 10.5 | *** | — | — |
| III | 336 | 23.9 | ** | *** | ** | 158 | 12.2 | ** | *** | ** |
| IV | 346 | 33.9 sires | * | *** | — | 158 | 18.0 | | *** | — |
| V | 289 | 28.0 | * | — | ** | 134 | 14.2 | * | — | * |
| VI | 273 | 18.1 | | — | * | 123 | 8.5 | | — | — |
| | ½-year olds, n = 174 | | | | | | | | | |
| | Live weight kg | | | | | Carcass weight kg | | | | |
| VII | 203 | 16.4 | ** | | — | 100 | 8.1 | *** | | — |
| VIII | 200 | 16.2 | — | | * | 98 | 9.1 | * | | * |
| IX | 188 | 17.1 | — | | ** | 93 | 9.5 | * | | * |
| X | 216 | 14.3 | *** | *** | ** | 109 | 7.9 | *** | *** | ** |

Statistical significance: *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

indoor receiving abundantly concentrates and the other half were on mere pasture. During that period the growth rate of the two groups remained the same, difference in live weight had been gained already during indoor feeding period. However, animals in the first half carried about twice as much fats as in the second one.

With ½-year olds (Table 5) the differencies were statistically significant in quantities and percentages of meat and bone. In these experiments there were in addition to the purebred Ay- and Fc-calves also Charolais crossbreds which in earlier experiments usually were thicker fleshed and less bony than the purebreds (Ruohomäki and Varo 1967).

Table 4. Cutting results of whole carcass. Means and standard deviations by experiment. 1-year olds

n=205

| Exp. No. | Mean | SD | Statistical significance | | | Mean | SD | Statistical significance | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Breed | Feed. | Age | | | Breed | Feed. | Age |
| | Meat-kg | | | | | Meat-% | | | | |
| I | 129.7 | 10.3 | *** | | — | 76.3 | 1.2 | — | | — |
| II | 104.8 | 8.5 | *** | — | — | 73.8 | 0.9 | — | — | — |
| III | 118.2 | 10.1 | ** | *** | ** | 73.7 | 1.5 | — | — | — |
| IV | 114.2 | 14.1 | | *** | — | 71.5 | 1.4 | | *** | — |
| V | 91.8 | 10.4 | * | — | * | 68.0 | 1.0 | ** | * | — |
| VI | 93.2 | 6.9 | | — | — | 75.4 | 1.0 | | — | — |
| | Fat-kg | | | | | Fat-% | | | | |
| I | 6.3 | 1.4 | — | | — | 3.7 | 0.8 | — | | — |
| II | 3.7 | 1.1 | — | — | — | 2.6 | 0.7 | — | — | — |
| III | 5.4 | 2.0 | — | * | — | 3.4 | 1.3 | — | — | — |
| IV | 9.6 | 2.8 | | *** | — | 5.6 | 1.2 | | *** | — |
| V | 13.6 | 2.1 | — | * | * | 10.1 | 1.3 | * | * | — |
| VI | 0.5 | 0.3 | | — | * | 0.4 | 0.2 | | — | * |
| | Bone-kg | | | | | Bone-% | | | | |
| I | 30.9 | 2.3 | * | | — | 18.2 | 0.8 | ** | | — |
| II | 32.6 | 3.3 | *** | — | — | 21.1 | 0.8 | — | — | — |
| III | 32.5 | 2.9 | — | — | ** | 20.3 | 1.4 | — | — | — |
| IV | 31.8 | 2.7 sires | ** | — | — | 20.2 | 1.6 | | *** | — |
| V | 27.9 | 2.9 | — | — | * | 20.7 | 0.9 | — | ** | — |
| VI | 28.7 | 1.9 | | — | * | 23.2 | 1.1 | | — | — |
| | Tendons % | | | | | Meat/Bone-ratio | | | | |
| I | 1.3 | 0.3 | — | | — | 4.20 | 0.18 | * | | — |
| II | 2.4 | 0.7 | — | — | — | 3.49 | 0.15 | — | — | — |
| III | 2.4 | 0.4 | * | — | — | 3.64 | 0.29 | — | — | — |
| IV | 2.5 | 0.3 | | — | — | 3.57 | 0.31 | | *** | — |
| V | 1.0 | 0.1 | — | * | — | 3.25 | 0.22 | * | ** | — |
| VI | 0.8 | 0.1 | | — | — | 3.26 | 0.22 | | — | — |

In all the tables the *quantities* are indicated: meat-kg, fat-kg, bone-kg and the *percentages:* meat-%, fat-% and bone-%.

Table 5. Cutting results of whole carcass. Means and standard deviations by experiment.
$^1/_2$-year olds
n = 94

| Exp. No. | Mean | SD | Statistical significance Breed | Feed. | Age | Mean | SD | Statistical significance Breed | Feed. | Age |
|---|---|---|---|---|---|---|---|---|---|---|
| | Meat-kg | | | | | Meat-% | | | | |
| IX | 68.6 | 7.6 | * | | * | 72.7 | 1.3 | ** | | — |
| X | 82.6 | 6.4 | *** | *** | ** | 74.8 | 1.2 | *** | — | * |
| | Fat-kg | | | | | Fat-% | | | | |
| IX | 3.4 | 0.8 | — | | — | 3.6 | 0.6 | ** | | — |
| X | 3.4 | 1.0 | — | — | — | 3.1 | 0.8 | — | — | — |
| | Bone-kg | | | | | Bone-% | | | | |
| IX | 20.0 | 1.8 | * | | — | 21.3 | 1.2 | *** | | — |
| X | 22.1 | 1.5 | *** | *** | — | 20.2 | 1.1 | *** | — | * |
| | Tendons % | | | | | Meat/Bone-ratio | | | | |
| IX | 2.3 | 0.4 | — | | — | 3.43 | 0.30 | ** | | — |
| X | 1.7 | 0.4 | — | — | — | 3.74 | 0.23 | *** | — | — |

## Ist estimator: *live measurements*

*Measuring technique*

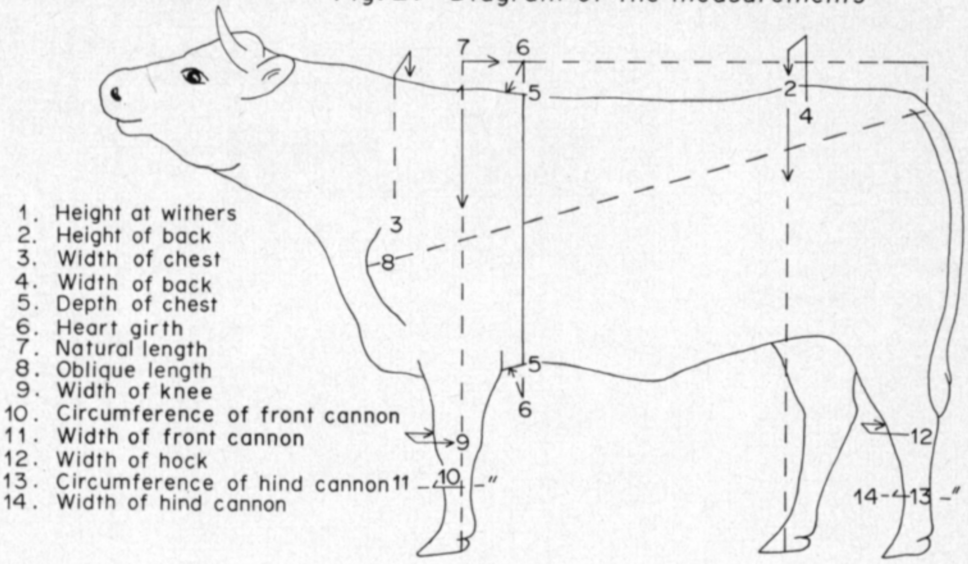
Before the measuring technique and results are presented some observations on the technique and errors by other researchers are explained.

According to Weber (1957) the basic requirement for the measurements is that they are biologically reasonable. Regardless this were true, also the following sources of error were possible by Weber: 1) differencies between animals, 2) differencies between persons who perform the measuring, 3) differencies between animals and persons and 4) errors in the measurements by one person. It was observed that no errors occur provided the head and feet remain in one position. The greatest difficulties and inaccuracies under the practical circumstances are caused by the movements of the animal.

In a study by Mather et al. (1959) 99 heifers and 52 cows were measured twice and the differencies in the measurements were compared. The difference was lowest in hip width, 0.5 % and the highest in the paunch girth, 5.8 %, except the body length of the heifers, 8.2 %. In a study by Touchberry and Lush (1950) the greatest errors occurred in the measurements of length and the smallest in the depth of chest.

In the present study the measurements were taken of all the animals except the ones in experiments V and VI. Measurements were normally taken on

Fig. 2. Diagram of the measurements




the day of live weight determination, or, if the animal was weighed on several consequent days, on one of these occasions. All the measurements were performed by the same person who also during the growth of the animals had measured them several times. Thus it can be supposed that there appears a minimum of measurement errors in this material. Live animal measurements are presented in Figure 2.

Measurements 1—5 are taken with a measuring stick and 6, 7, 8, 10 and 13 with a measuring tape. Width of chest (3) has been measured on the back as the distance between the tips of the humerii and the width of back (4) as the distance between the hooks. Depth of chest (5) has been measured quite behind the front legs at the same point as the heart girth (6). Natural length (7) has been measured along the spine from withers till tail head, in the same way the oblique length (8) from the tip of humerus till tail head. The circumferencies of front and hind cannon (10 and 13) are taken with a measuring tape at the narrowest part of the cannon (metacarpus and metatarsus). The widths of the cannons (11 and 14) are taken at the same point with a sliding gauge with which also the widths of knee (9) and hock (12) are measured.

*Means of live measurements by experiment*

In Tables 6 and 7 means and standard deviations of live measurements are presented by experiment.

The differencies in the widths of chest and back between breeds were statistically significant with both the 1-year olds (Table 6) and the ½-year olds (Table 7). On the other hand no equally distinct differencies in measurements of length and height appeared between breeds. Almost all differencies between breeds on measurements of legs were statistically significant, some of them even between sires.

Table 6. Means and standard deviations of live measurements by experiment.
1-year olds

n = 142

| Epx. No. | Mean cm | SD cm | Statistical significance | | | Mean cm | SD cm | Statistical significance | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Breed | Feed. | Age | | | Breed | Feed. | Age |
| | 1. Height at withers | | | | | 2. Height of back | | | | |
| I | 111.1 | 3.4 | — | | — | 116.0 | 3.8 | — | | — |
| II | 114.5 | 3.0 | — | — | — | 118.4 | 3.1 | — | — | — |
| III | 118.0 | 2.9 | — | * | ** | 123.8 | 2.9 | — | * | * |
| IV | 115.0 | 3.2 | | * | — | 119.2 | 3.5 sires | ** | — | — |
| | 3. Width of chest | | | | | 4. Width of back | | | | |
| I | 45.7 | 3.3 | * | | — | 42.0 | 2.0 | *** | | — |
| II | 38.3 | 2.8 | *** | — | — | 38.0 | 2.4 | *** | — | — |
| III | 40.5 | 2.7 | *** | * | * | 38.9 | 2.0 | *** | ** | ** |
| IV | 42.2 | 3.2 | | *** | — | 40.5 | 2.4 | | *** | — |
| | 5. Depth of chest | | | | | 6. Heart girth | | | | |
| I | 59.5 | 1.7 | — | | — | 162.8 | 5.5 | * | | — |
| II | 59.3 | 1.5 | — | — | — | 155.7 | 4.1 | * | — | — |
| III | 60.5 | 1.1 | — | ** | ** | 161.9 | 3.5 | * | *** | ** |
| IV | 60.6 | 2.6 sires | * | ** | — | 162.5 | 6.6 | | *** | — |
| | 7. Natural length | | | | | 8. Oblique length | | | | |
| I | 114.6 | 5.0 | — | | — | 129.7 | 4.7 | — | | — |
| II | 117.4 | 3.9 | — | — | — | 130.9 | 3.1 | ** | — | — |
| III | 117.9 | 4.0 | — | * | ** | 131.4 | 4.1 | — | — | ** |
| IV | 116.6 | 3.1 sires | ** | *** | — | 130.7 | 4.8 | | *** | — |
| | 9. Width of knee | | | | | 12. Width of hock | | | | |
| I | 9.4 | 0.4 | * | | — | 8.7 | 0.3 | ** | | — |
| II | 9.3 | 0.5 | * | — | — | 8.5 | 0.3 | *** | — | — |
| III | 9.7 | 0.4 | * | *** | *** | 8.9 | 0.3 | *** | — | * |
| IV | 9.6 | 0.4 sires | *** | *** | — | 8.8 | 0.4 sires | *** | — | — |
| | 10. Circumf. of front cannon | | | | | 11. Width of front cannon | | | | |
| I | 17.2 | 0.9 | * | | — | 6.0 | 0.2 | *** | | — |
| II | 17.3 | 0.6 | *** | ** | * | 5.9 | 0.2 | *** | — | — |
| III | 18.4 | 0.8 | *** | ** | * | 6.1 | 0.2 | ** | * | ** |
| IV | 18.1 | 0.8 sires | ** | * | * | 6.1 | 0.3 sires | *** | ** | — |
| | 13. Circumf. of hind cannon | | | | | 14. Width of hind cannon | | | | |
| I | 19.3 | 0.8 | * | | — | 7.3 | 0.3 | ** | | — |
| II | 19.3 | 0.6 | *** | — | — | 7.3 | 0.3 | *** | — | — |
| III | 20.3 | 0.9 | *** | ** | * | 7.5 | 0.3 | *** | ** | ** |
| IV | 19.9 | 0.8 sires | ** | — | — | 7.4 | 0.3 sires | *** | — | — |

Table 7. Means and standard deviations of live measurements by experiment.
$^1/_2$-year olds
n = 174

| Exp. No | Mean cm | SD cm | Statistical significance | | | Mean cm | SD cm | Statistical significance | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Breed | Feed. | Age | | | Breed | Feed. | Age |
| | 1. Height at withers | | | | | 2. Height of back | | | | |
| VII | 101.6 | 2.5 | — | | — | 105.1 | 3.3 | — | | — |
| VIII | 98.9 | 2.8 | — | | — | 102.0 | 2.9 | ** | | — |
| IX | 98.2 | 3.2 | — | | — | 103.0 | 3.5 | — | | — |
| X | 100.9 | 2.8 | * | * | * | 106.0 | 3.2 | * | ** | — |
| | 3. Width of chest | | | | | 4. Width of back | | | | |
| VII | 33.0 | 1.8 | ** | | — | 30.8 | 0.9 | *** | | — |
| VIII | 31.7 | 1.9 | *** | | — | 31.0 | 1.6 | *** | | — |
| IX | 31.9 | 2.8 | * | | — | 31.3 | 2.5 | ** | | — |
| X | 36.0 | 2.5 | *** | *** | — | 33.6 | 2.1 | ** | *** | * |
| | 5. Depth of chest | | | | | 6. Heart girth | | | | |
| VII | 47.7 | 1.6 | — | | — | 131.6 | 4.6 | — | | — |
| VIII | 48.1 | 1.6 | — | | — | 131.4 | 4.3 | ** | | * |
| IX | 49.0 | 1.9 | — | | — | 131.5 | 4.4 | — | | * |
| X | 50.1 | 2.1 | — | *** | * | 137.5 | 4.7 | * | *** | * |
| | 7. Natural length | | | | | 8. Oblique length | | | | |
| VII | 101.5 | 3.0 | — | | — | 115.1 | 2.6 | — | | — |
| VIII | 100.6 | 4.1 | *** | | — | 112.2 | 4.3 | *** | | — |
| IX | 98.2 | 3.8 | — | | — | 110.2 | 4.3 | — | | — |
| X | 102.9 | 4.6 | — | *** | * | 115.0 | 3.7 | — | *** | ** |
| | 9. Width of knee | | | | | 12. Width of hock | | | | |
| VIII | 8.5 | 0.3 | *** | | — | 8.5 | 0.3 | *** | | — |
| VIII | 8.4 | 0.3 | *** | | — | 8.3 | 0.3 | *** | | ** |
| IX | 8.4 | 0.4 | ** | | — | 8.2 | 0.3 | *** | | — |
| X | 8.8 | 0.4 | *** | * | — | 8.3 | 0.4 | *** | ** | — |
| | 10. Circumf. of front cannon | | | | | 11. Width of front cannon | | | | |
| VII | 15.5 | 0.7 | ** | | — | 5.2 | 0.2 | ** | | — |
| VIII | 15.4 | 0.7 | *** | | — | 5.1 | 0.2 | *** | | — |
| IX | 15.4 | 0.8 | *** | | — | 5.1 | 0.3 | * | | — |
| X | 15.7 | 0.8 | *** | ** | — | 5.3 | 0.3 | *** | — | — |
| | 13. Circumf. of hind cannon | | | | | 14. Width of hind cannon | | | | |
| VII | 16.8 | 0.5 | *** | | * | 6.3 | 0.2 | *** | | — |
| VIII | 16.6 | 0.5 | *** | | — | 6.1 | 0.2 | *** | | — |
| IX | 17.1 | 0.9 | *** | | — | 6.2 | 0.3 | — | | — |
| X | 17.6 | 0.8 | *** | *** | — | 6.5 | 0.3 | *** | ** | — |

According to a study by LINDSTRÖM and MAIJALA (1970) the following means of live measurements are presented of animals in a young bull rearing station:

| Age 365 days | Ay<br>395 animals | Fc<br>179 animals |
|---|---|---|
| Heart girth | 178 cm | 173 cm |
| Natural length | 133 » | 128 » |
| Height at withers | 119 » | 118 » |

As these figures are compared with the ones of the 1-year olds presented in Table 6 it can be seen that the mean of the heart girth is here about 15 cm and the length about 14 cm larger than in the present study. Difference in height was only 3 cm.

*Stepwise regression analysis, results and discussion*

Estimation of live weight, carcass weight and carcass composition with live measurements.

In Tables 8, 9 and 10 also live weight has been one of the estimating factors (part b.). Where no additional information is obtained with live measurements, the results are omitted from the tables.

L i v e w e i g h t. The $R^2$ [1]) obtained for live weight with live measurements was 87 % for the 1-year olds and 82 % for the $^1/_2$-year olds (Table 8, a). The most reliable estimators of live measurements for both age groups were the width of chest and the heart girth. With 1-year olds the second step was natural length but the value of its standardized regression coefficient was, however, lower than that of the heart girth and width of chest. With ½-year olds the natural length was replaced by the oblique length, and the height of back with height at withers.

The correlation of natural length on live weight was 0.659, and that of the oblique length 0.619 with the 1-year olds, with the $^1/_2$-year olds the correlations were 0.510 and 0.546 respectively. The correlations of the height at withers and the height of back on live weight with 1-year olds were 0.542 and 0.598 and with $^1/_2$-year olds 0.548 and 0.562 respectively. As the correlations of these measurements on live weight are almost equal, the reliability of the estimation would hardly decrease if the natural length was used instead of the oblique length and the height at withers instead of height of back. Appli cation of fewer measurements would simplify the work and reduce errors.

Interrelationships between live weight and live measurements have been investigated in several studies. The most common measurements taken have been heart girth, width of chest, depth of chest, height at withers, height of back and natural length. In the more accurate definition of the measurement points, however, differencies exist between different studies, which sometimes makes them incomparable. As materials consist of animals of different breeds and ages this naturally also reduces the possibilities of comparison.

[1]) $R^2$ = Coefficient of Determination, (%)

The $R^2$ obtained for live weight with heart girth and natural length was 79 % which is very close to the one obtained in the study by LINDSTRÖM and MAIJALA (1970) where the average $R^2$-value obtained with the same traits was 81 % for both Ayrshire and Finncattle.

Table 8. Result of stepwise regression analysis.
a) Live measurements — live weight and carcass weight.
b) Live measurements and live weight — carcass weight.

| Step | x | r | R | $R^2$ | b | $\beta$ |
|---|---|---|---|---|---|---|
| | 1-year olds, n = 142 | | | | | |
| | y = Live weight, $\bar{y}$ = 331 kg | | | | | |
| a) 1. | Heart girth | .823 | .823 | 67.7 | 1.928*** | 0.370 |
| 2. | Natural length | .659 | .889 | 79.0 | 1.720*** | 0.250 |
| 3. | Width of chest | .790 | .923 | 85.2 | 2.925*** | 0.325 |
| 4. | Width of hind cannon | .665 | .929 | 86.3 | 12.066** | 0.131 |
| 5. | Height of back | .598 | .932 | 86.9 | 0.748* | 0.091 |
| | y = Carcass weight, $\bar{y}$ = 156 kg | | | | | |
| a) 1. | Heart girth | .806 | .806 | 65.0 | 0.999*** | 0.360 |
| 2. | Width of chest | .797 | .871 | 75.9 | 1.729*** | 0.361 |
| 3. | Natural length | .638 | .910 | 82.8 | 0.933*** | 0.255 |
| 4. | Width of hind cannon | .660 | .918 | 84.3 | 7.448*** | 0.152 |
| b) 1. | Live weight | .938 | .938 | 88.0 | 0.390*** | 0.734 |
| 2. | Width of back | .742 | .943 | 88.9 | 0.823** | 0.127 |
| 3. | Width of hock | .380 | .947 | 89.7 | 3.661** | 0.092 |
| 4. | Heart girth | .806 | .948 | 89.9 | 0.280* | 0.101 |
| | 1/2-year olds, n = 174 | | | | | |
| | y = Live weight, $\bar{y}$ = 203 kg | | | | | |
| a) 1. | Heart girth | .778 | .778 | 60.5 | 0.973*** | 0.275 |
| 2. | Width of chest | .752 | .849 | 72.1 | 2.157*** | 0.317 |
| 3. | Height at withers | .548 | .884 | 78.1 | 1.011*** | 0.181 |
| 4. | Width of hind cannon | .621 | .895 | 80.1 | 9.402*** | 0.160 |
| 5. | Oblique length | .546 | .903 | 81.5 | 0.585*** | 0.145 |
| 6. | Width of back | .681 | .908 | 82.4 | 1.112** | 0.135 |
| | y = Carcass weight, $\bar{y}$ = 100 kg | | | | | |
| a) 1. | Heart girth | .779 | .779 | 60.7 | 0.614*** | 0.318 |
| 2. | Width of chest | .764 | .856 | 73.3 | 1.431*** | 0.385 |
| 3. | Natural length | .486 | .878 | 77.1 | 0.305*** | 0.143 |
| 4. | Height at withers | .492 | .885 | 78.3 | 0.349** | 0.114 |
| 5. | Width of back | .687 | .890 | 79.2 | 0.557* | 0.123 |
| 6. | Width of knee | .514 | .893 | 79.7 | 2.039* | 0.086 |
| b) 1. | Live weight | .922 | .922 | 85.0 | 0.383*** | 0.700 |
| 2. | Width of chest | .764 | .928 | 86.1 | 0.556*** | 0.149 |
| 3. | Heart girth | .779 | .932 | 86.9 | 0.270** | 0.140 |

Statistical significance: *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

Table 9. Result of stepwise regression analysis.
1-year olds a) Live measurements — carcass composition.
n = 142 b) Live measurements and live weight — carcass composition.

| Step | x | r | R | $R^2$ | b | $\beta$ |
|---|---|---|---|---|---|---|
| | $y$ = Meat-kg, $\bar{y}$ = 116.6 kg | | | | | |
| a) 1. | Width of chest | .796 | .796 | 63.4 | 1.655*** | 0.431 |
| 2. | Heart girth | .783 | .858 | 73.6 | 0.832*** | 0.374 |
| 3. | Natural length | .593 | .886 | 78.5 | 0.732*** | 0.250 |
| b) 1. | Live weight | .906 | .906 | 82.1 | 0.345*** | 0.809 |
| 2. | Width of chest | .796 | .915 | 83.7 | 0.687** | 0.179 |
| 3. | Height of back | .459 | .919 | 84.5 | −0.394** | −0.113 |
| 4. | Width of hock | .357 | .921 | 84.8 | 2.259* | 0.070 |
| | $y$ = Fat-kg, $\bar{y}$ = 6.6 kg | | | | | |
| b) 1. | Depth of chest | .506 | .506 | 25.6 | 0.288** | 0.260 |
| 2. | Width of hock | −.182 | .555 | 30.8 | −1.999*** | −0.338 |
| 3. | Live weight | .478 | .625 | 39.1 | 0.032*** | 0.414 |
| | $y$ = Bone-kg, $\bar{y}$ = 32.0 kg | | | | | |
| a) 1. | Width of hind cannon | .643 | .643 | 41.3 | 2.154** | 0.220 |
| 2. | Natural length | .626 | .735 | 54.0 | 0.183*** | 0.252 |
| 3. | Width of hock | .562 | .768 | 59.0 | 2.044*** | 0.257 |
| 4. | Height of back | .574 | .792 | 62.7 | 0.189*** | 0.219 |
| 5. | Heart girth | .518 | .799 | 63.8 | 0.126* | 0.132 |
| b) 1. | Live weight | .671 | .671 | 45.0 | 0.027** | 0.262 |
| 2. | Width of hock | .562 | .764 | 58.4 | 2.260*** | 0.284 |
| 3. | Height at withers | .560 | .788 | 62.1 | 0.164** | 0.179 |
| 4. | Width of hind cannon | .643 | .797 | 63.5 | 1.665* | 0.170 |
| 5. | Natural length | .626 | .804 | 64.6 | 0.117* | 0.161 |
| | $y$ = Meat-%, $\bar{y}$ = 73.4 % | | | | | |
| a) 1. | Width of chest | .337 | .337 | 11.4 | 0.136** | 0.302 |
| 2. | Height of back | −.117 | .432 | 18.7 | −0.139*** | −0.340 |
| 3. | Heart girth | .319 | .489 | 23.9 | 0.102*** | 0.394 |
| 4. | Width of hind cannon | .008 | .515 | 26.5 | −0.949* | −0.205 |
| | $y$ = Fat-%, $\bar{y}$ = 4.0 % | | | | | |
| a) 1. | Width of hock | −.294 | .294 | 8.6 | −0.965*** | −0.319 |
| 2. | Depth of chest | .253 | .406 | 16.5 | 0.159*** | 0.280 |
| | $y$ = Bone-%, $\bar{y}$ = 20.1 % | | | | | |
| a) 1. | Heart girth | −.455 | .455 | 20.7 | −0.108*** | −0.430 |
| 2. | Width of hock | .273 | .587 | 34.5 | 1.423*** | 0.394 |
| 3. | Width of chest | −.410 | .631 | 39.8 | −0.145*** | −0.336 |
| 4. | Height of back | .014 | .668 | 44.6 | 0.101*** | 0.258 |

Table 10. Result of stepwise regression analysis.
1/2-year olds a) Live measurements — carcass composition.
n = 94 b) Live measurements and live weight — carcass composition.

| Step | x | r | R | $R^2$ | b | $\beta$ |
|---|---|---|---|---|---|---|
| | $y$ = Meat-kg, $\bar{y}$ = 76.6 kg | | | | | |
| a) 1. | Width of chest | .795 | .795 | 63.2 | 1.057*** | 0.406 |
| 2. | Heart girth | .740 | .843 | 71.1 | 0.439*** | 0.288 |
| 3. | Natural length | .401 | .871 | 75.9 | 0.288** | 0.177 |
| 4. | Width of back | .748 | .885 | 78.3 | 0.724** | 0.236 |
| b) 1. | Live weight | .882 | .882 | 77.8 | 0.269*** | 0.602 |
| 2. | Width of chest | .795 | .898 | 80.6 | 0.442* | 0.170 |
| 3. | Width of hock | .333 | .905 | 81.9 | −2.736** | −0.140 |
| 4. | Heart girth | .740 | .912 | 83.2 | 0.226* | 0.148 |
| 5. | Width of back | .748 | .917 | 84.1 | 0.461* | 0.150 |
| | $y$ = Fat-kg, $\bar{y}$ = 3.4 kg | | | | | |
| a) 1. | Heart girth | .507 | .507 | 25.7 | 0.064** | 0.319 |
| 2. | Width of chest | .501 | .556 | 30.9 | 0.108** | 0.313 |
| 3. | Height at withers | .263 | .572 | 32.7 | 0.102** | 0.330 |
| 4. | Height of back | .128 | .607 | 36.8 | −0.080* | −0.289 |
| | $y$ = Bone-kg, $\bar{y}$ = 21.2 kg | | | | | |
| a) 1. | Width of knee | .730 | .730 | 53.3 | 1.015** | 0.249 |
| 2. | Depth of chest | .614 | .801 | 64.2 | 0.169** | 0.206 |
| 3. | Circumf. of hind cannon | .605 | .832 | 69.2 | 0.389** | 0.200 |
| 4. | Width of back | .581 | .857 | 73.4 | 0.142** | 0.196 |
| 5. | Width of hock | .692 | .875 | 76.6 | 1.074** | 0.233 |
| 6. | Oblique length | .508 | .885 | 78.3 | 0.063** | 0.153 |
| b) 1. | Live weight | .796 | .796 | 63.4 | 0.046*** | 0.440 |
| 2. | Width of knee | .730 | .867 | 75.2 | 0.819** | 0.201 |
| 3. | Width of hock | .692 | .881 | 77.6 | 0.993** | 0.216 |
| 4. | Height of back | .568 | .892 | 79.6 | 0.068* | 0.137 |
| 5. | Circumf. of hind cannon | .605 | .898 | 80.6 | 0.263** | 0.135 |
| | $y$ = Meat-%, $\bar{y}$ = 73.9 % | | | | | |
| a) 1. | Width of chest | .284 | .284 | 8.1 | 0.188*** | 0.399 |
| 2. | Width of hock | −.232 | .444 | 19.7 | −1.270*** | −0.360 |
| | $y$ = Fat-%, $\bar{y}$ = 3.3 % | | | | | |
| a) 1. | Heart girth | .305 | .305 | 9.3 | 0.049** | 0.305 |
| | $y$ = Bone-%, $\bar{y}$ = 20.6 % | | | | | |
| b) 1. | Width of chest | −.449 | .449 | 20.2 | −0.185*** | −0.442 |
| 2. | Width of hock | .280 | .635 | 40.3 | 1.482*** | 0.474 |
| 3. | Circumf. of hind cannon | .153 | .668 | 44.6 | 0.397** | 0.299 |
| 4. | Live weight | −.298 | .694 | 48.2 | −0.025* | −0.347 |

GRAVIR (1967) obtained an $R^2$ of 69 % for live weight with seven live measurements on 360-days old bulls, 57 % of this value was determined by heart girth alone.

In the study be SKJERVOLD (1958) several live measurements were taken. The correlations between six live measurements and live weight varied within 0.70—0.75.

In the last two studies the $R^2$ and the correlations remained somewhat lower than in the present study.

On the other hand, the results obtained in this study were on the same level as in the study by HUTH (1965), where the material consisted of 211 1-year old bulls. The following correlations were obtained:

| | | |
|---|---|---|
| Live weight | — height of back and withers, mean | r = 0.631 |
| | — depth of chest | r = 0.751 |
| | — heart girth | r = 0.859 |
| | — width of back | r = 0.836 |

Correlations on the measurements of width are higher than on those of height.

In the study by JOHANSSON and HILDEMAN (1953) the heart girth, width of hips, height at withers, natural length and hind girth were measured on 10 000 animals. For 1175 $^1/_2$-year olds and 171 young steers the correlations heart girth by live weight were 0.892—0.951. No additional information was obtained with other measurements.

The values varied even within one breed depending on the material, for the big animals the values were higher than for the small. In estimation of weight by heart girth the standard error was ±6 % in live weight and ±9 % in carcass weight. In weighing of live animals the standard error varied between ± 1 and ± 2 %.

For carcass weight (Table 8, a) the $R^2$ remained nearly 3 % lower for both age groups than for live weight. In both age groups the highest estimates were provided by width of chest, heart girth and natural length.

In the earlier mentioned study by GRAVIR an $R^2$ of 65 % for carcass weight was obtained with several live measurements. In the study by JOHANSSON and HILDEMAN the correlation between heart girth and carcass weight varied between 0.857—0.945.

In a study by BUSS (1968) the correlations of heart girth and carcass weight laid between 0.661 and 0.325.

In a study by LINDHÉ (1968) the material consisted of 218 animals, steers of six different breeds and crossbreds. The regression between heart girth and carcass weight varied by breed between 2.67 and 3.36 (SE 9.3—16.1 kg), and between heart girth and live weight from 4.83 to 6.46 (SE 19.5—29.3 kg).

In several studies the correlations between live weight and carcass weight have been estimated. The correlations obtained by JOHANSSON and HILDEMAN were from 0.880 to 0.968 with $^1/_2$-year olds and with young steers. BUSS obtained correlations of 0.783, 0.664 and 0.636 for the three breeds respectively. SEEBECK and TULLOH (1966) also observed in their study that carcass weight was directly dependent on live weight, and that dressing-% increases with the live weight.

In the present study the correlations between live weight and carcass weight were with the measured 1-year olds 0.938 (with all the 1-year olds 0.940) and with $^1/_2$-year olds 0.922 (with the dissected $^1/_2$-year olds 0.924).

If it is possible to determine live weight through weighing, this alone provides a higher $R^2$ for carcass weight than live measurements. An $R^2$ of 88 % was obtained for 1-year olds and 85 % for ½-year olds (Table 8, b). In both age groups the live measurements increased the $R^2$ obtained with live weight only by about 2 %-units.

When carcass weight was estimated with mere live weight, the value of the regression coefficient (b) for both age groups was 0.50, thus if the live weight increases by one kilo, the carcass weight increases by 500 grams.

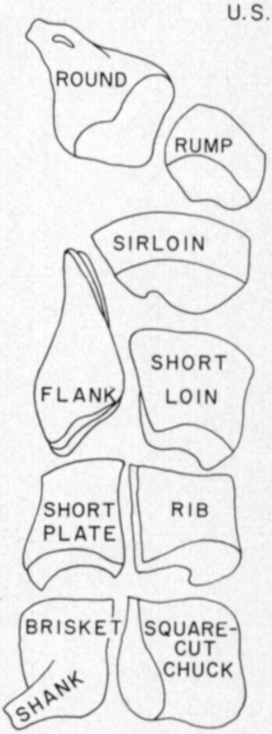
Like in the estimation of carcass weight the first three estimators for meat-kg were heart girth, width of chest and natural length for the 1-year olds (Table 9, a). The same value for $R^2$ for the $^1/_2$-year olds, 78 %, was obtained with the above mentioned measurements and with the width of back (Table 10, a).

If the live weight is known in the estimation of meat-kg this alone provides an $R^2$ of 82 % for the 1-year olds (Table 9, b) and 78 % for the $^1/_2$-year olds (Table 10, b). If the measurements are also included this gives additional information from 3 to 6 %-units.

In the study by VARO (1969) the material consisted of purebred Ayrshire and Finncattle of varying ages together with Charolais crosses. Among young animals the carcass meat quantity was best estimated by the ratio of carcass weight and size (= total of 10 measurements), the R was 0.949. When the older animals were concerned the best estimator of meat quantity was carcass weight, r = 0.97.

Foreign results are seldom comparable to the present ones because cutting practices in different countries differ from each other. Differencies are apparent in comparison of the Finnish (Fig. 1) and the American (Fig. 3) carcass cutting schemes (LAINE 1971). Also other cutting schemes from other countries could be included as all of them differ from each other, and from the one used in Finland, to an extent which makes comparison almost impossible.

Fig. 3.
WHOLESALE CUTS IN THE U.S.A.




In several studies the quantities and percentages of the primal cuts in the whole carcass are investigated. In comparison of the results the differencies in partitioning are of no significance when the quantities and percentages of meat, fat and bone of the whole carcass are compared.

Of the other results should also be mentioned those by SKJERVOLD (1958). With height over hips and width of rounds a correlation of R = 0.68 was obtained for the hind quarter, which was separated from the right hand side half between the 13th rib and the 1st lumbar vertebra. In addition to this when six measurements were included the correlation rose to R = 0.71. On the weight of the fore quarter the correlations were lower than the ones mentioned above.

The material by BUSCH et al. (1969) consisted of 181 steers. The mean yield of edible meat from one half of a carcass was 85.6 kg. The correlations of girth measurements on the quantity of edible meat remained between 0.41 and 0.81, and on the measurements of width 0.42—0.70, and on the measurements of length, 0.62 respectively. The correlation on carcass weight was 0.94. In the whole material (745 animals) carcass weight estimated the quantity of edible meat till 75—88 %, the measurements increased the coefficient by 2—4 %-units.

In the present study the $R^2$ for fat-kg of 39 % was obtained for the 1-year olds (Table 9, b) and of 37 % for the $^1/_2$-year olds (Table 10, a).

In estimation of bone-kg the $R^2$ of 78 % was obtained for the $^1/_2$-year olds (Table 10, a) and 64 % for the 1-year olds (Table 9, a).

For both the age groups several measurements were required to obtain the above mentioned values for $R^2$. An accurate determination of the measuring sites cause difficulties in practice.

In both age groups rather low values were obtained for $R^2$ on meat-% and fat-% (Tables 9 and 10). For bone-% an $R^2$ of 45 % was obtained for both age groups.

In the study by NEIMAN—SØRENSEN et al. (1965) eight live measurements were taken. The results are presented together with those by NIELSEN (1962) obtained with 243 calves of the same breed.

| | Meat-% | Fat-% | Bone-% |
|---|---|---|---|
| Neiman—Sørensen: | | | |
| $R^2$ (%) | 6 | 2.5 | 13 |
| Nielsen: | | | |
| Width of back, r = | —0.038 | 0.081 | —0.041 |
| Width of rounds r = | 0.046 | —0.011 | —0.050 |

The correlations above are considerably lower than the ones obtained in the present study.

In the study by TALLIS et al. (1959) the obtained correlations for edible meat-% were: weight/height r = 0.45 and weight/width r = —0.43.

In the study by ORME et al. (1959 c) the correlations between carcass girths and the percentages of the primal cuts varied between —0.42 — —0.53.

## IInd estimator: *initial weight and daily gain*

*Initial weight* (weight at the beginning of the experiment)

The calves were weighed the day they were brought to the experiment station. Weights at birth are not known. Initial weights have been corrected by experiment for initial age unlike the other traits which were corrected for slaughter age.

*Daily gain during experiment gr./day.*

Daily gain was calculated according to the following model:

$$\frac{\text{Live weight at the end of exp.} - \text{Initial weight}}{\text{Slaughter age} - \text{Initial age}}$$

In calculations, no other figures for growth have been employed but the one for growth during experiment, because some calves were born in spring and the others in autumn. In the experiments the calves were of different ages at the first indoor feeding and pasture period. The calves born in spring started pasturing at about 3 months and the ones born in autumn at about 8 months.

*Means of initial weights and daily gains by experiment*

Table 11 presents the means and standard deviations of initial weights and daily gains by experiment.

Daily gain of the $^1/_2$-year olds was 200 gr. higher than that of the 1-year olds. In the experiments for the $^1/_2$-year olds all the calves were born in autumn

Table 11. Means and standard deviations of initial weight and daily gain by experiment.

| Exp. No. | Mean | SD | Statistical significance | | | Mean | SD | Statistical significance | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Breed | Feed. | Age | | | Breed | Feed. | Age |
| | 1-year olds, n = 205 Initial weight kg. | | | | | Daily gain during experiment gr./day | | | | |
| I | 42.1 | 4.7 | — | | — | 873 | 69 | — | | — |
| II | 38.1 | 2.8 | ** | — | — | 749 | 47 | *** | — | — |
| III | 39.7 | 3.9 | — | — | *** | 840 | 62 | * | *** | * |
| IV | 42.1 | 4.4 sires | *** | — | ** | 877 | 96 | | *** | — |
| V | 43.3 | 8.7 | — | — | * | 779 | 83 | * | — | — |
| VI | 43.2 | 4.6 | | — | * | 728 | 60 | | — | — |
| | $^1/_2$-year olds, n = 94 Initial weight kg. | | | | | Daily gain during experiment gr./day | | | | |
| IX | 40.1 | 4.0 | *** | | *** | 940 | 96 | — | | — |
| X | 41.7 | 4.5 | *** | — | — | 1104 | 95 | * | *** | — |

and received ample portions of fodder under almost uniform circumstances at the S.W. Finland Experiment Station. The experiments for the 1-year olds consisted of both steers and bulls. In several of them growth during the pasture period was low.

*Stepwise regression analysis, results and discussion*

Estimation of carcass weight and carcass composition with initial weight and daily gain.

For carcass weight the $R^2$ obtained was 86 % for the 1-year olds and 77 % for the $^1/_2$-year olds. The respective values for meat-kg were 79 % and 71 % (Table 12). The $R^2$ obtained for fat-kg was 24 % for the 1-year olds and 29 % for the $^1/_2$-year olds. The $R^2$ for bone-kg were 52 % and 56 % respectively. (Table 12).

Table. 12. Result of stepwise regression analysis. Initial weight and daily gain during experiment — carcass weight and carcass composition.

| Step | x | r | R | $R^2$ | b | $\beta$ |
|---|---|---|---|---|---|---|
| | 1-year olds, n = 205 | | | | | |
| | y = Carcass weight[1]), $\bar{y}$ = 156 kg. | | | | | |
| 1. | Daily gain, gr./day | .907 | .907 | 82.3 | 0.163*** | 0.857 |
| 2. | Initial weight, kg. | .410 | .929 | 86.3 | 0.735*** | 0.208 |
| | y = Meat-kg, $\bar{y}$ = 109 kg | | | | | |
| 1. | Daily gain, gr./day | .884 | .884 | 78.1 | 0.125*** | 0.864 |
| 2. | Initial weight, kg | .277 | .889 | 79.0 | 0.206** | 0.098 |
| | y = Fat-kg, $\bar{y}$ = 6.7 kg | | | | | |
| 1. | Daily gain, gr./day | .492 | .492 | 24.1 | 0.012*** | 0.492 |
| | y = Bone-kg, $\bar{y}$ = 30.9 kg | | | | | |
| 1. | Daily gain, gr./day | .667 | .667 | 44.5 | 0.022*** | 0.610 |
| 2. | Initial weight, kg | .401 | .719 | 51.7 | 0.146*** | 0.275 |
| | $^1/_2$-year olds, n = 94 | | | | | |
| | y = Carcass weight, $\bar{y}$ = 102 kg. | | | | | |
| 1. | Daily gain, gr./day | .840 | .840 | 70.6 | 0.071*** | 0.786 |
| 2. | Initial weight, kg | .428 | .880 | 77.4 | 0.537*** | 0.263 |
| | y = Meat-kg, $\bar{y}$ = 76.6 kg | | | | | |
| 1. | Daily gain, gr./day | .802 | .802 | 64.3 | 0.055*** | 0.749 |
| 2. | Initial weight, kg. | .417 | .843 | 71.1 | 0.429*** | 0.263 |
| | y = Fat-kg, $\bar{y}$ = 3.4 kg | | | | | |
| 1. | Daily gain, gr./day | .542 | .542 | 29.4 | 0.005*** | 0.542 |
| | y = Bone-kg, $\bar{y}$ = 21.2 kg | | | | | |
| 1. | Daily gain, gr./day | .707 | .707 | 50.0 | 0.012*** | 0.656 |
| 2. | Initial weight, kg | .383 | .748 | 56.0 | 0.096*** | 0.249 |

[1]) n = 142

The correlations and regressions on the percentages of meat, fat and bone were quite low and therefore excluded from the calculations.

Daily gain was the first step in the estimation of all the traits. The correlations of initial age on all the traits was low and negative.

The different stages of growth have been abundantly studied in studies on both breeding and management. Determination of optimal growth is in key position considering the profitability of rearing beef cattle, as differencies between breeds and management and the genetic variation have a decisive effect on the final result.

Only a few results of interrelations between the traits in question are presented here, as in the present study no other measurements for growth have been used but daily gain during experiment.

In the study by LINDSTRÖM and MAIJALA (1970) the following correlations were obtained between the weight at birth, at 180 days and at 365 days.

| | Ay | | Fc | |
|---|---|---|---|---|
| | 335 animals | | 200 animals | |
| Weight at birth | r | $r^2$ | r | $r^2$ |
| — 180 days .................. | 0.608 | 37 % | 0.588 | 34 % |
| — 365 days .................. | 0.537 | 29 % | 0.413 | 17 % |
| | 301 animals | | 142 animals | |

The relation between birth weight and 180-day weight is considerably stronger than between birth weight and 365-day weight. The correlation between growth from 60-days to 180-days, and from 180-days to 365-days is nonsignificant.

In the present study the correlations between initial weights and live weights are considerably lower than the ones obtained by LINDSTRÖM and MAIJALA between weight at birth and live weight. With initial weight an $R^2$ of only 16 % on 165-day age, and of 11 % on 1-year were obtained. The mean initial age for the 1-year olds was 11 days and for the $^1/_2$-year olds 9 days.

In Table 13 some results on the interrelation between growth and various carcass traits found in the literature are presented with the results of present study.

When the correlations between growth and the other traits from present study are compared to the ones presented in other studies it can be noticed that the correlations for growth found in this study especially on quantities are higher than the ones found in literature.

## IIIrd estimator: *carcass quality scores*

### *Evaluation technique*

The carcasses were evaluated after ca. 24 hours from slaughter. One person, who was uninformed of the breed or feeding group of the carcass, evaluated all the carcasses. The estimation was performed according to the practice in the slaughterhouse organisation. The procedure has been applied since 1960, and the Meat Industrial Research Centre takes care of its further

Table 13. The correlations of daily gain on live and carcass weight and carcass composition found in the literature.

| | Blackwell et al. 1962 | du Bose et al. 1967 | Brackelsberg & Willham 1968 | Dietert 1969 | Hinks & Bech Andersen 1968 | Martin & Starkenburg 1965 | Nielsen 1962 | Swiger et al. 1965 | Wismer-Pedersen 1969 | Present study 1-yr. | Present study ½-yr. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Live weight | .76 | .35 | — | — | — | — | — | 75 | — | .976 | .925 |
| Carcass weight | .72 | .44 | — | — | — | — | — | — | — | .907 | .840 |
| Boneless steak and roast kg | — | .45 | — | — | — | — | — | — | — | — | — |
| Boneless steak and roast % | — | .11 | — | — | — | — | — | — | — | — | — |
| Primal yield % | — | — | — | .15 | — | — | — | — | — | — | — |
| Boneless retail cut kg | — | — | — | — | — | — | — | .65 | — | — | — |
| Boneless retail cut % | — | — | — | — | — | — | — | −.35 | — | — | — |
| Meat-kg | — | — | — | — | — | — | — | — | — | .884 | .802 |
| Meat-% | — | — | −.21 | — | .0 | −.04 | .136 | — | .0−<br>.23 | .287 | .182 |
| Fat-kg | — | — | — | — | — | — | — | .36 | — | .492 | .542 |
| Fat-% | — | — | .23 | — | .06 | — | .058 | — | −.37<br>−.10 | .127 | .321 |
| Bone-kg | — | — | — | — | — | — | — | — | — | .667 | .707 |
| Bone-% | — | — | −.21 | — | −.05 | — | −.252 | — | — | −.395 | −.305 |

development. The last slight changes were made in 1969. Since 1972 a new evaluation technique has been employed which partly differs from the one described here.

In evaluation of carcass fleshiness attention is paid to the following parts: outer, inner and overall steak lines, rump, sirloin, fore back, neck, shoulders, brisket + flanks and hind shanks. The mean of the points given to these ten parts is presented as fleshiness scores graded from 1 to 15, like each individual score of fleshiness given to an evaluated part in a carcass.

The scale for fat content and distribution was from − 7 till + 4, where points below one indicated a too high fat content.

The colours of meat and fat are estimated both separately from − 3 to + 5. Colour points are means of colour points for fat and meat.

Fleshiness scores + fat content + colour points build up the total score according to which the carcass quality class is determined.

The total scores correspond to the carcass quality classes as follows:

| | | | | |
|---|---|---|---|---|
| 22 | points | class | E | (10) |
| 20 | » | » | I + | ( 9) |
| 18 | » | » | I | ( 8) |
| 16 | » | » | I − | ( 7) |
| 14 | » | » | II + | ( 6) |
| 12 | » | » | II | ( 5) |
| 10 | » | » | II − | ( 4) |

In brakets is given the numerical value used in punch cards, which are also used in tables to indicate carcass quality class.

Steers, young bulls and ½-year olds are evaluated according to the same scale. Some carcasses, however, were so scarce in fat that fat colour could not be evaluated, thus it was excluded from all results. Still, it is included in colour points as the mean of fat and meat colour.

### *Means of carcass quality scores by experiment*

Table 14 presents the means and standard deviations of carcass quality scores by experiment.

The carcass evaluation system has been especially critisized as it follows the shape of the carcass but provides no information of the quantities and percentages of different types of tissue. Also in the present material, differencies between breeds are largely caused by differencies in shape as carcasses of crossbred animals differ from the purebreds to an extent which affects especially the evaluation of the hind quarters. On the other hand crossbred carcasses contained more meat than purebreds, but the Finncattle carcasses generally obtained the lowest scores because of the narrow shape of their hind quarters, although their meat content usually was as high as that of the Ayrshires (Ruohomäki 1967, Ruohomäki and Varo 1967).

### *Stepwise regression analysis, results and discussion*

Estimation of carcass composition with carcass quality scores.

In addition to quality scores also carcass weight has acted as one estimator of other carcass traits (Tables 15 and 16).

With carcass quality scores for m e a t - k g the $R^2$ obtained was 47 % for the 1-year olds (Table 15, a) and 59 % for the ½-year olds (Table 16, a).

When carcass weight was taken as an estimator of m e a t - k g in addition to the carcass quality scores this alone improved the value of $R^2$ up to 96 % in both age groups. Quality scores increased the $R^2$ by only 0.6 %-units for the 1-year olds (Table 15, b), and 1% -unit for the ½-year olds (Table 16, b). The standardized regression coefficient was for the 1-year olds about 20 times and for the ½-year olds about 10 times as high as that of the scores.

When carcass weight alone estimated the m e a t - k g, the value of the regression coefficient (b) was 0.7757*** for the 1-year olds, and 0.7960*** for the ½-year olds. It can be seen that i f c a r c a s s w e i g h t i n c r e a s e s b y o n e k i l o t h e m e a t - k g i n c r e a s e s b y a b o u t 8 0 0 g r a m s. C a r c a s s q u a l i t y s c o r e s h a v e n o s i g n i f i c a n c e i n e s t i m a t i o n o f m e a t - k g i f c a r c a s s w e i g h t i s k n o w n.

Table 17 presents the results of the stepwise regression analysis for the 1-year olds by steps when meat-kg has been estimated with carcass weight and carcass quality scores.

The $R^2$ increases only by 0.6 % with the scores of shoulders and not at all with the fleshiness scores. The standard error of the estimates (SE ± 2.053)

Table 14. Means and standard deviations of carcass quality scores by experiment.

| Exp. No. | Mean | SD | Statistical significance | | | Mean | SD | Statistical significance | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Breed | Feed. | Age | | | Breed | Feed. | Age |
| | 1-year olds, n = 205 | | | | | | | | | |
| | Fleshiness scores | | | | | Fat content and distribution | | | | |
| I | 13.4 | 0.5 | *** | | — | 3.8 | 0.4 | — | | — |
| II | 9.9 | 1.2 | ** | — | — | 2.8 | 0.6 | * | — | — |
| III | 10.6 | 1.0 | *** | ** | — | 3.4 | 0.5 | — | — | — |
| IV | 11.6 | 1.0 | | *** | — | 3.0 | 0.7 | | — | — |
| V | 10.0 | 1.1 | ** | * | — | 3.5 | 0.4 | — | — | — |
| VI | 10.2 | 1.1 | | — | — | 2.9 | 0.3 | | — | — |
| | Colour of meat | | | | | Colour points total | | | | |
| I | 4.0 | 0.8 | * | | — | 4.4 | 0.7 | — | | — |
| II | 3.3 | 0.7 | * | — | — | 3.3 | 0.7 | * | — | — |
| III | 4.0 | 0.8 | — | — | — | 4.1 | 0.8 | — | — | — |
| IV | 3.7 | 0.6 | | *** | — | 3.8 | 0.5 | | *** | — |
| V | 3.9 | 0.6 | — | — | — | 4.5 | 0.3 | — | — | — |
| VI | 3.0 | 0.3 | | — | — | 3.1 | 0.3 | | — | — |
| | Points total | | | | | [1]) Carcass class | | | | |
| I | 21.6 | 1.0 | *** | | — | 9.5 | 0.4 | *** | | — |
| II | 16.0 | 2.2 | ** | — | — | 7.0 | 1.1 | ** | — | — |
| III | 18.1 | 1.8 | *** | * | — | 8.1 | 0.9 | *** | — | — |
| IV | 18.3 | 1.7 | | *** | — | 8.3 | 0.8 | | *** | — |
| V | 18.0 | 1.2 | *** | ** | — | 7.9 | 0.7 | ** | * | — |
| VI | 16.1 | 1.4 | | — | — | 7.4 | 0.8 | | — | — |
| | $^1/_2$-year olds, n = 94 | | | | | | | | | |
| | Fleshiness scores | | | | | Fat content and distribution | | | | |
| IX | 10.9 | 1.2 | *** | | — | 3.7 | 0.5 | — | | — |
| X | 12.2 | 1.1 | *** | — | — | 3.7 | 0.5 | — | — | — |
| | Colour of meat | | | | | Colour points total | | | | |
| IX | 4.7 | 0.5 | — | | — | 4.8 | 0.5 | — | | — |
| X | 4.7 | 0.7 | — | — | — | 4.8 | 0.4 | — | — | * |
| | Points total | | | | | [1]) Carcass class | | | | |
| IX | 19.3 | 1.7 | *** | | — | 8.5 | 0.9 | *** | | — |
| X | 20.8 | 1.5 | *** | — | * | 9.1 | 0.8 | *** | — | * |

[1]) Value 7 corresponds to carcass class I−, value 8 to carcass class I and value 9 to carcass class I+.

Table 15. Result of stepwise regression analysis.
1-year olds a) Carcass quality scores — carcass composition.
n = 205 b) Carcass quality scores and carcass weight — carcass composition.

| Step | | x | r | R | $R^2$ | b | $\beta$ |
|---|---|---|---|---|---|---|---|
| | | y = Meat-kg, $\bar{y}$ = 109 kg | | | | | |
| a) | 1. | Fleshiness scores | .686 | .686 | 47.1 | 7.158*** | 0.686 |
| b) | 1. | Carcass weight | .980 | .980 | 96.0 | 0.738*** | 0.933 |
| | 2. | Shoulders | .430 | .983 | 96.6 | 0.312* | 0.045 |
| | 3. | Fleshiness scores | .686 | .983 | 96.6 | 0.474* | 0.045 |
| | | y = Fat-kg, $\bar{y}$ = 6.7 kg | | | | | |
| a) | 1. | Colour of meat | .290 | .290 | 8.4 | 0.742*** | 0.259 |
| | 2. | Fleshiness scores | .266 | .370 | 13.7 | 1.029*** | 0.542 |
| | 3. | Hind shanks | .116 | .391 | 15.3 | −0.307* | −0.234 |
| | 4. | Shoulders | .103 | .415 | 17.2 | −0.240* | −0.193 |
| b) | 1. | Carcass weight | .484 | .484 | 23.4 | 0.084*** | 0.586 |
| | 2. | Colour of meat | .290 | .556 | 30.9 | 0.831*** | 0.290 |
| | 3. | Hind shanks | .116 | .585 | 34.2 | −0.283** | −0.215 |
| | | y = Bone-kg, $\bar{y}$ = 30.9 kg | | | | | |
| a) | 1. | Hind shanks | .342 | .342 | 11.7 | 0.490*** | 0.267 |
| | 2. | Outer steak line | .341 | .386 | 14.9 | 0.553*** | 0.298 |
| | 3. | Colour of meat | −.141 | .430 | 18.5 | −0.735** | −0.183 |
| | 4. | Shoulders | .083 | .432 | 18.7 | −0.294* | −0.168 |
| b) | 1. | Carcass weight | .731 | .731 | 53.4 | 0.177*** | 0.884 |
| | 2. | Fleshiness scores | .314 | .762 | 58.1 | −1.453*** | −0.548 |
| | 3. | Colour of meat | −.141 | .774 | 59.9 | −0.562** | −0.140 |
| | 4. | Hind shanks | .342 | .784 | 61.5 | 0.373** | 0.203 |
| | 5. | Outer steak line | .341 | .793 | 62.9 | 0.360** | 0.193 |
| | | y = Meat-%, $\bar{y}$ = 72.9 % | | | | | |
| a) | 1. | Fleshiness scores | .499 | .499 | 24.9 | 0.455*** | 0.374 |
| | 2. | Shoulders | .451 | .520 | 27.0 | 0.167* | 0.210 |
| | 3. | Colour points total | −.075 | .541 | 29.3 | −0.313* | −0.150 |
| | | y = Fat-%, $\bar{y}$ = 4.4 % | | | | | |
| b) | 1. | Colour points total | .332 | .332 | 11.0 | 0.604*** | 0.350 |
| | 2. | Hind shanks | −.085 | .352 | 12.4 | −0.154** | −0.222 |
| | 3. | Carcass weight | .088 | .390 | 15.2 | 0.014* | 0.196 |
| | | y = Bone-%, $\bar{y}$ = 20.7 % | | | | | |
| b) | 1. | Fleshiness scores | −.555 | .555 | 30.8 | −1.084*** | −0.916 |
| | 2. | Colour of meat | −.300 | .599 | 35.9 | −0.414*** | −0.232 |
| | 3. | Hind shanks | −.319 | .619 | 38.3 | 0.232*** | 0.283 |
| | 4. | Outer steak line | −.342 | .637 | 40.6 | 0.245*** | 0.296 |
| | 5. | Carcass weight | −.446 | .654 | 42.8 | −0.018** | −0.204 |
| | 6. | Brisket and flank | −.261 | .663 | 44.0 | 0.122* | 0.140 |

Table 16. Result of stepwise regression analysis.

½-year olds a) Carcass quality scores — carcass composition.

n = 94 b) Carcass quality scores and carcass weight — carcass composition.

| Step | | x | r | R | $R^2$ | b | $\beta$ |
|---|---|---|---|---|---|---|---|
| | | $y$ = Meat-kg, $\bar{y}$ = 76.6 kg | | | | | |
| a) | 1. | Fleshiness scores | .718 | .718 | 51.6 | 4.714*** | 0.763 |
| | 2. | Overall steak line | .635 | .738 | 54.5 | 0.989* | 0.208 |
| | 3. | Sirloin | .222 | .753 | 56.7 | −1.055* | −0.178 |
| | 4. | Rump | .314 | .765 | 58.5 | −0.862* | −0.177 |
| b) | 1. | Carcass weight | .982 | .982 | 96.4 | 0.734*** | 0.917 |
| | 2. | Fleshiness scores | .718 | .985 | 97.0 | 0.649** | 0.105 |
| | 3. | Neck | .528 | .986 | 97.2 | 0.239* | 0.055 |
| | 4. | Carcass quality class | .585 | .987 | 97.4 | −0.466* | −0.055 |
| | | $y$ = Fat-kg, $\bar{y}$ = 3.4 kg | | | | | |
| a) | 1. | Points total | .435 | .435 | 18.9 | 0.559*** | 0.945 |
| | 2. | Carcass quality class | .308 | .490 | 24.0 | −0.621* | −0.556 |
| | | $y$ = Bone-kg, $\bar{y}$ = 21.2 kg | | | | | |
| a) | 1. | Hind shanks | .337 | .337 | 11.4 | 0.415** | 0.337 |
| b) | 1. | Carcass weight | .773 | .773 | 59.8 | 0.199*** | 1.041 |
| | 2. | Fore back | .089 | .844 | 71.2 | −0.326*** | −0.283 |
| | 3. | Shoulders | .199 | .858 | 73.6 | −0.197** | −0.218 |
| | | $y$ = Meat-%, $\bar{y}$ = 73.9 % | | | | | |
| a) | 1. | Fleshiness scores | .560 | .560 | 31.4 | 0.431** | 0.385 |
| | 2. | Overall steak line | .519 | .585 | 34.2 | 0.210* | 0.243 |
| | | $y$ = Fat-%, $\bar{y}$ = 3.3 % | | | | | |
| a) | 1. | Points total | .274 | .274 | 7.5 | 0.352** | 0.748 |
| | 2. | Carcass quality class | .167 | .344 | 11.8 | −0.460* | −0.518 |
| | | $y$ = Bone-%, $\bar{y}$ = 20.6 % | | | | | |
| a) | 1. | Fleshiness scores | −.676 | .676 | 45.7 | −0.277* | −0.279 |
| | 2. | Fore back | −.675 | .720 | 51.8 | −0.243** | −0.310 |
| | 3. | Neck | −.636 | .735 | 54.0 | −0.154* | −0.222 |

is in the first step (3 × SE) 12.318 kg and in the third step correspondingly 11.562 kg. The remaining difference is only about 0.750 kg, therefore no significant improvement appears in carcass evaluation when carcass quality scores are included (Table 17).

In estimation of fat-kg the significance of the scores was quite low (Tables 15 and 16). The correlation of fat content scores on fat-kg was 0.065 for the 1-year olds and 0.308 for the ½-year olds.

With carcass quality scores an $R^2$ of 11—19 % was obtained on bone-kg (Tables 15, a and 16, a). When the carcass weight was included the value

Table 17. Result of stepwise regression analysis.
1-year olds Carcass quality scores and carcass weight — meat-kg.
n = 205

| Step | x | r | R | $R^2$ | b | $\beta$ |
|---|---|---|---|---|---|---|
| | y = Meat-kg, $\bar{y}$ = 109 kg | | | | | |
| 1. | Carcass weight ............................ | .980 | .980 | 96.0 | 0.7757*** | 0.9809 |
| | standard error of estimation ± 2.053 kg | | | | | |
| 1. | Carcass weight ............................ | .980 | .980 | 96.0 | 0.7750*** | 0.9547 |
| 2. | Shoulders ................................... | .430 | .983 | 96.6 | 0.4741*** | 0.0961 |
| | standard error of estimation ± 1.943 kg | | | | | |
| 1. | Carcass weight ............................ | .980 | .980 | 96.0 | 0.7385*** | 0.9339 |
| 2. | Shoulders ................................... | .430 | .983 | 96.6 | 0.3125** | 0.0455 |
| 3. | Fleshiness scores .......................... | .686 | .983 | 96.6 | 0.4740* | 0.0455 |
| | standard error of estimation ± 1.927 kg | | | | | |

increased to 63 % with the 1-year olds (Table 15, b) and to 74 % with the ½-year olds (Table 16, b).

In estimation of meat-% an $R^2$ of 19 % was obtained with 1-year olds and 34 % with ½-year olds (Tables 15 and 16). In estimation of fat-% $R^2$-values of 12 % and 15 % were obtained respectively (Tables 15 and 16). For bone % an $R^2$ of 44 % for the 1-year olds and 54 % for the ½-year olds were obtained (Tables 15 and 16).

Carcass quality scores are particularly developed to serve commercial purposes. The price for meat is in each country determined by consumption habits which are different from country to country and in different times. For this reason the evaluation methods differ to such a great extent from each other. The common factor among them is, however, that they take into consideration carcass weight, the age and sex of the animal, meat and fat content and often also the colour of meat and fat.

As several weaknesses have been found in the evaluation methods they are being developed to meet their purpose better. Evaluation is sense-dependent and therefore also the possibility of misevaluation is greater than in methods based on measurements and weights. During the last few years in the newly applied methods also some measurements are included together with the scores. For example, measurement of the thickness of fat cover area of the MLD and weight of the intestinal fats.

It is found in several investigations that carcass evaluation based on mere sense-dependent evaluation meets the requirements of scientific study no better than live animal evaluation.

Correlations collected from the literature between carcass quality scores and different carcass traits are presented in Table 18. Also correlations obtained in present study are included.

Table 18. Correlations between carcass quality scores and carcass weight and composition found in the literature.

| | | Fleshiness scores | | Fat content and distribution | Points total |
|---|---|---|---|---|---|
| | | 1) | 2) | | |
| Carcass weight | | | | | |
| Brännäng 1966 .................... | | .42– | .45 | | .42 |
| Cundiff et al. 1964 ............... | | | | | .16 |
| Wilson et al. 1964 ............... | | | | | .15 |
| Present study ........................ | 1-yr. | | .652 | .141 | .478 |
| | 1/2-yr. | | .628 | .289 | .593 |
| Fat-kg | | | | | |
| Gottsch et al. 1961 ............... | | | | .75 | |
| Swiger et al. 1965 ................ | | | | | .31 |
| Varo 1969 ............................ | R = | | | .518 | |
| Present study ........................ | 1-yr. | | .266 | .065 | .284 |
| | 1/2-yr. | | .360 | .308 | .435 |
| Boneless steak and roast % | | | | | |
| du Bose et al. 1967 .............. | | | | | –.16 |
| Primal yield % | | | | | |
| Dietert 1969 ....................... | | | | | .15 |
| Retail cut % | | | | | |
| Cundiff et al. 1964 ............... | | | | | –.34 |
| Swiger at al. 1965 ................ | | | | | –.44 |
| Meat-% | | | | | |
| Hinks & Bech Andersen 1968 | | .28 | .44 | –.24 | .35 |
| Martin & Starkenburg 1965 . | | | | | –.26 |
| Neiman-Sørensen et al. 1965 ... | | .36 | .34 | –.13 | .29 |
| Nielsen 1962 ........................ | | .359 | .341 | | .291 |
| Present study ........................ | 1-yr. | | .499 | .062 | .318 |
| | 1/2-yr. | | .560 | .123 | .467 |
| Fat-% | | | | | |
| Martin & Starkenburg 1965 ... | | | | | –.16 |
| Neiman-Sørensen et al. 1965 ... | | .07 | –.09 | .35 | .002 |
| Nielsen 1962 ........................ | | –.069 | –.094 | | .014 |
| Present study ........................ | 1-yr. | | .036 | .070 | .158 |
| | 1/2-yr. | | .176 | .262 | .274 |
| Bone-% | | | | | |
| Neiman-Sørensen et al. 1965 ... | | –.41 | –.36 | –.23 | –.37 |
| Nielsen 1962 ........................ | | –.408 | –.360 | | –.414 |
| Present study ........................ | 1-yr. | | –.555 | –.145 | –.499 |
| | 1/2-yr. | | –.676 | –.225 | –.622 |

1) for the fore quarter, 2) for the hind quarter except in present study for both quarters.

When the correlations in Table 18 are compared with each other it can be found that they largely vary between studies and even within present study. Especially correlations on fat content with 1-year olds are dissimilar to the ones with ½-year olds.

Generally taking interrelations are weak, according to some studies even nonsignificant, as the most accurate information on meat-kg is provided by carcass weight and in estimation of other traits the scores provide only low accuracies. As already stated one of the weakest points in evaluation is that it follows the shape of the carcass. The shape is also affected by the dimensions of skeleton as SKJERVOLD (1958) mentions in his study.

According to a study by HAMMOND (1958) the short and plump animals have thicker muscles than the long and narrow ones. Thickly fleshed carcasses endure keeping better and processed meat is also tastier than meat obtained from thinly fleshed carcasses.

Also WITT (1965) in his study presents that the smaller surface area compared to the volume of the muscle the more economical and tastier the meat is after processing. Also de BOER et al. (1969) and PIRCHNER (1965) have expressed similar opinions. Meat-kg is not only a quantitative but also a qualitative trait as with the increase in meat content the bone content decreases and larger muscles are more valuable than the small ones.

Also results of the present study and earlier ones with Charolais crossbreds have shown that they comprise more meat and less bone than purebreds. They obtain higher quality scores, too, which proves that at least in these breed comparisons the plump shape of the carcass has indicated higher meat content (RUOHOMÄKI 1967, RUOHOMÄKI and VARO 1967).

As a conclusion it can be stated that information of carcass traits obtained with carcass quality scores is inadequate and that beside sense-dependent evaluation or instead of that an evaluation method which is entirely based on measurements and weights should be developed.

The evaluation method applied since the beginning of 1972 can not be compared to the present one as no carcass dissection was performed in the last experiments.

## IVth estimator: *live weight, carcass weight, dressing-%, by-products and, only for the 1/2-year olds, cutting results of flanks*

Determination of live weight and carcass weight has already been explained with the estimated traits. In the present chapter they act as estimators with dressing-%, by-products and flank cutting results.

### *Dressing-%*

Dressing-% (carcass yield) is calculated as the ratio of carcass weight to live weight. In several studies the dressing-% has been calculated of the warm carcass weight which often makes it higher in foreign studies. Kidney fats which remain in the carcass for their part also increase the dressing-%.

*By-products*

In connection with slaughter the head, tongue, lungs, liver, heart, diaphragm, bowel and kidney fats, kidneys, spleen, skin and thyroid gland were weighed in most experiments. In calculations, however, only the head, liver, heart and kidney fats were included. In experiments I—IV, IX and X also bowel fats were weighed. The percentage of by-products was calculated from carcass weight.

*Dissection of flanks*

The flanks were dissected from the carcasses of the ½-year olds and partitioned into meat and fat — flanks comprise no bones. The flanks were dissected according to the scheme in Figure 1.

*Means of dressing-%, by-products and cutting results of flanks by experiment*

Table 19 presents the means and standard deviations of dressing-%, by-products and cutting results of flanks.

*Stepwise regression analysis, results and discussion*

Estimation of carcass composition with live weight, dressing-%, by-products and cutting rcsults of flanks.

The $R^2$ for m e a t - k g increased only by 0.4 %-units in both age groups from the value obtained with mere carcass weight (Tables 20 and 21).

The $R^2$ for f a t - k g for 1-year olds (n = 142) was 62 % (Table 20) and for $^1/_2$-year olds 48 % (Table 21), when the traits in a) acted as estimators. When in the estimation of fat-kg the traits mentioned in b) were estimators an $R^2$ of 60 % was obtained for the 1-year olds (Table 20). The standardized regression coefficient for kidney fat (kg) was when calculated in both ways about twice as high as that of the other estimators.

When fat-kg was estimated for the $^1/_2$-year olds with carcass weight, kidney and bowel fats plus cutting results of flanks, an $R^2$ of 70 % was obtained (Table 21, b). With mere fat-kg in flanks a 10 % higher value for $R^2$ was obtained than the one obtained with all the traits in a). Bowel fats would have been the fourth step in the stepwise regression analysis but the value of the regression coefficient was nonsignificant. The correlation of bowel fat (kg) on carcass fat-kg was 0.630 for the 1-year olds and only 0.181 for the $^1/_2$-year olds.

Inclusion of bowel fats increases the $R^2$ of fat-kg for 1-year olds approximately by 3 %-units and, as the regression coefficient for the $^1/_2$-year olds was nonsignificant, it seems useless to weigh carcass bowel fats for this purpose. Removal and weighing of bowel fats requires quite much extra work as the intestines are removed immediately after slaughter and taken to another room to be cleaned and washed.

Instead, the $R^2$ for fat-kg obtained with flank fats is considerably higher than those obtained with any other trait, and removal of one flank and partition-

Table 19. Means and standard deviations of dressing-%, percentages of carcass by-products and cutting results of flanks by experiment.

| Exp. No. | Mean | SD | Statistical significance | | | Mean | SD | Statistical significance | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Breed | Feed. | Age | | | Breed | Feed. | Age |
| | 1-year olds, n = 205 | | | | | | | | | |
| | Dressing-% | | | | | Head, % | | | | |
| I | 51.0 | 2.2 | * | | — | 6.0 | 0.3 | ** | | — |
| II | 47.0 | 1.2 | — | — | — | 6.6 | 0.5 | — | — | — |
| III | 46.8 | 1.6 | — | — | — | 6.3 | 0.5 | * | — | — |
| IV | 45.4 | 1.3 | | *** | — | 6.2 | 0.5 | | *** | — |
| V | 46.2 | 1.7 | — | ** | — | 7.3 | 0.6 | — | — | — |
| VI | 44.9 | 1.5 | | — | — | 7.0 | 0.3 | | — | — |
| | Liver, % | | | | | Heart, % | | | | |
| I | 2.5 | 0.2 | — | | — | 0.8 | 0.1 | — | | — |
| II | 3.3 | 0.2 | ** | — | — | 1.1 | 0.2 | — | — | — |
| III | 3.1 | 0.3 | * | *** | — | 1.0 | 0.1 | * | — | — |
| IV | 2.9 | 0.2 | | ** | — | 0.9 | 0.1 | | — | — |
| V | 3.1 | 0.2 | — | ** | — | 0.8 | 0.1 | — | — | — |
| VI | 3.1 | 0.2 | | — | — | 0.8 | 0.1 | | — | — |
| | Kidney fat, % | | | | | Bowel fat, % (n = 142) | | | | |
| I | 2.4 | 0.8 | — | | — | 2.2 | 0.6 | — | | — |
| II | 2.2 | 0.8 | — | — | — | 1.9 | 0.6 | — | — | — |
| III | 2.1 | 0.7 | — | — | — | 2.2 | 0.6 | — | — | — |
| IV | 2.3 | 0.6 | | *** | — | 3.4 | 0.9 | | *** | — |
| V | 1.8 | 0.3 | * | * | — | | | | | |
| VI | 0.3 | 0.1 | | — | — | | | | | |
| | 1/2-year olds, n = 94 | | | | | | | | | |
| | Dressing-% | | | | | Head, % | | | | |
| IX | 49.6 | 1.4 | * | | — | 6.9 | 0.5 | — | | — |
| X | 50.2 | 1.7 | *** | — | — | 6.6 | 0.5 | *** | * | — |
| | Liver, % | | | | | Heart, % | | | | |
| IX | 3.5 | 0.4 | ** | | — | 0.9 | 0.1 | * | | — |
| X | 3.4 | 0.3 | *** | — | — | 0.9 | 0.2 | — | — | — |
| | Kidney fat, % | | | | | Bowel fat, % | | | | |
| IX | 2.0 | 0.4 | *** | | — | 2.0 | 0.4 | *** | | — |
| X | 2.4 | 0.5 | *** | — | — | 2.4 | 0.7 | * | — | — |
| | Flanks, kg | | | | | Flanks, % | | | | |
| IX | 4.9 | 0.8 | * | | — | 5.2 | 0.5 | ** | | — |
| X | 6.4 | 0.7 | *** | *** | — | 5.7 | 0.5 | * | — | — |
| | Meat-% in flanks | | | | | Fat-% in flanks | | | | |
| IX | 82.2 | 2.3 | — | | — | 18.1 | 2.2 | — | | — |
| X | 84.2 | 4.1 | — | — | — | 15.6 | 4.2 | — | — | — |

Table 20. Result of stepwise regression analysis.

1-year olds

a) Live and carcass weight, dressing-% and carcass by-products — carcass composition.

b) Carcass weight, bowel and kidney fat — carcass fat-kg and -%.

| Step | x | r | R | $R^2$ | b | $\beta$ |
|---|---|---|---|---|---|---|
| | $y$ = Meat-kg, $\bar{y}$ = 109 kg | | | | | |
| a) 1. | Carcass weight | .980 | .980 | 96.0 | 0.762*** | 0.963 |
| 2. | Kidney fat, % | −.084 | .981 | 96.2 | −0.569* | −0.031 |
| 3. | Dressing-% | .476 | .982 | 96.4 | 0.247** | 0.034 |
| | $y$ = Fat-kg, $\bar{y}$ = 6.6 kg | | | | | |
| a) 1. | Kidney fat, kg | .700 | .700 | 49.0 | 2.152*** | 1.171 |
| 2. | Kidney fat, % | .535 | .752 | 56.6 | −1.724*** | −0.556 |
| 3. | Liver, % | −.327 | .763 | 58.2 | −1.631** | −0.185 |
| 4. | Heart, % | −.102 | .777 | 60.4 | 5.970* | 0.363 |
| 5. | Head, % | −.430 | .786 | 61.8 | −0.808* | −0.172 |
| b) 1. | Kidney fat, kg | .700 | .700 | 49.0 | 1.931*** | 1.051 |
| 2. | Kidney fat, % | .535 | .752 | 56.6 | −1.661*** | −0.536 |
| 3. | Bowel fat, kg | .630 | .772 | 59.6 | 0.373** | 0.232 |
| | $y$ = Bone-kg, $\bar{y}$ = 30.9 kg | | | | | |
| a) 1. | Carcass weight | .731 | .731 | 53.4 | 0.097*** | 0.485 |
| 2. | Kidney fat, kg | .011 | .759 | 57.6 | −0.655*** | −0.234 |
| 3. | Live weight | .713 | .767 | 58.8 | 0.035* | 0.332 |
| | $y$ = Meat-%, $\bar{y}$ = 72.9 % | | | | | |
| a) 1. | Carcass weight | .367 | .367 | 13.5 | 0.078*** | 0.852 |
| 2. | Kidney fat, % | −.248 | .434 | 18.8 | −0.463*** | −0.217 |
| 3. | Live weight | .279 | .463 | 21.4 | −0.022* | −0.459 |
| 4. | Heart, kg | .047 | .482 | 23.2 | −1.034* | −0.147 |
| | $y$ = Fat-%, $\bar{y}$ = 4.0 % | | | | | |
| a) 1. | Kidney fat, kg | .645 | .645 | 41.6 | 0.610*** | 0.648 |
| 2. | Liver, kg | −.114 | .670 | 44.9 | −0.688*** | −0.277 |
| 3. | Heart, % | .009 | .688 | 47.3 | 1.652** | 0.209 |
| 4. | Head, % | −.253 | .710 | 50.4 | −0.503** | −0.209 |
| b) 1. | Kidney fat, kg | .645 | .645 | 41.6 | 0.468*** | 0.497 |
| 2. | Bowel fat, % | .543 | .689 | 47.5 | 0.421*** | 0.283 |
| | $y$ = Bone-%, $\bar{y}$ = 20.7 % | | | | | |
| a) 1. | Carcass weight | −.446 | .446 | 19.9 | −0.077*** | −0.865 |
| 2. | Kidney fat, % | −.279 | .539 | 29.1 | −0.648*** | −0.313 |
| 3. | Live weight | −.393 | .555 | 30.8 | 0.017* | 0.369 |
| 4. | Heart, kg | −.055 | .567 | 32.1 | 0.885* | 0.129 |

In estimation of meat-kg and -%, and bone-kg and -% the no. of animals is 205, and in that of fat-kg and -% 142.

Table 21. Result of stepwise regression analysis.
$^1/_2$-year olds a) Live and carcass weight, dressing-% and carcass by-products — carcass composition.
n = 94
b) Carcass weight, bowel and kidney fat, and cutting results of flanks — carcass fat-kg and -%.

| Step | x | r | R | $R^2$ | b | β |
|---|---|---|---|---|---|---|
| | y = Meat-kg, $\bar{y}$ = 76.6 kg | | | | | |
| a) 1. | Carcass weight | .982 | .982 | 96.4 | 0.928*** | 1.146 |
| 2. | Live weight | .882 | .984 | 96.8 | −0.079*** | −0.176 |
| | y = Fat-kg, $\bar{y}$ = 3.4 kg | | | | | |
| a) 1. | Live weight | .553 | .553 | 30.6 | 0.143* | 0.241 |
| 2. | Kidney fat, kg | .548 | .654 | 42.8 | 0.709*** | 0.375 |
| 3. | Liver, kg | .508 | .691 | 47.7 | 0.609** | 0.271 |
| b) 1. | Fat-kg in flanks | .759 | .759 | 57.6 | 3.605*** | 1.056 |
| 2. | Kidney fat, kg | .548 | .808 | 65.3 | 0.488*** | 0.258 |
| 3. | Fat-% in flanks | .529 | .838 | 70.2 | −0.120*** | −0.455 |
| | y = Bone-kg, $\bar{y}$ = 21.2 kg | | | | | |
| a) 1. | Live weight | .796 | .796 | 63.4 | 0.069*** | 0.658 |
| 2. | Head, kg | .620 | .819 | 67.1 | 0.753** | 0.237 |
| | y = Meat-%, $\bar{y}$ = 73.9 % | | | | | |
| a) 1. | Dressing-% | .421 | .421 | 17.7 | 0.242** | 0.306 |
| 2. | Head, % | −.359 | .482 | 23.2 | −0.725** | −0.276 |
| 3. | Kidney fat, % | −.210 | .519 | 26.9 | −.0.551* | −0.195 |
| | y = Fat-%, $\bar{y}$ = 3.3 % | | | | | |
| a) 1. | Kidney fat, kg | .518 | .518 | 26.8 | 0.783*** | 0.520 |
| 2. | Liver, % | .282 | .592 | 35.0 | 0.613*** | 0.286 |
| b) 1. | Fat-kg in flanks | .689 | .689 | 47.5 | 1.431*** | 0.526 |
| 2. | Kidney fat, % | .452 | .748 | 56.0 | 0.465*** | 0.283 |
| 3. | Flanks, % | .508 | .765 | 58.5 | 0.297** | 0.187 |
| | y = Bone-%, $\bar{y}$ = 20.6 % | | | | | |
| a) 1. | Carcass weight | −.435 | .435 | 18.9 | −0.154*** | −1.187 |
| 2. | Live weight | −.298 | .514 | 26.4 | 0.046** | 0.650 |
| 3. | Head, kg | −.067 | .553 | 30.6 | 0.552* | 0.255 |

ing it into meat and fat is a simple and fast procedure. If only one flank is removed per carcass this should not decrease its commercial value too much.

With 1-year olds the $R^2$ for fat-% obtained with traits in a) was 50 % (Table 20) and with traits in b) 47.5 % (Table 20), the best estimating trait in both a) and b) being kidney fat-kg. Correspondingly with $^1/_2$-year olds the $R^2$ obtained with traits in a) on fat-% was 35 % and with those in b) 58.5 % (Table 21).

The $R^2$-values obtained, 50 % and 58.5 %, can be considered quite satisfactory as estimation of the percentages has been fairly unreliable in general.

Estimation of bone-kg was less certain with the 1-year olds than with the $^1/_2$-year olds, $R^2$-values were 59 % and 67 % (Tables 20 and 21). The correlation of head (kg) on bone-kg was 0.553 for 1-year olds and 0.630 for $^1/_2$-year olds.

Estimation of meat and bone percentages was unreliable in both age groups. Carcass weight and live weight were the best estimators of bone-%, their correlations on bone-% were negative (Tables 20 and 21).

In quite a few studies carcass characteristics have been estimated with the same traits as here. In several studies, however, in the estimation of a trait thickness of fat cover, the area of the MLD and other carcass measurements have been used in addittition (EPLEY et al. 1970, HENDERSON et al. 1966 a, b, LEVY et al. 1968, du BOSE et al. 1967, DUMONT et al. 1961, ÇUNDIFF et al. 1967 and BRÄNNÄNG and NILSSON 1969).

Through combination of several traits high multiple correlations and $R^2$-values have been obtained for percentages, too. Especially estimation of fat has been more reliable in several other studies than in the present one, although the $R^2$-values for fat-kg and fat-% in the present study can be regarded fairly satisfactory.

Table 22 presents the interrelations literature provides between live weight, carcass weight, dressing-%, and by-products on carcass traits. Also some correlations obtained in the present study are included.

In several respects the results differ largely from each other. For example the correlations between carcass weight and carcass fat obtained by ALLEN et al. (1968), FIELD et al. (1966) and BUTTERFIELD (1965) were much higher than the ones obtained in the present study.

## Vth estimator: *cutting results of shanks*

### *Dissection of shanks*

Dissection of the shanks, like that of the flanks described in Chapter IV, require a partial destruction of a carcass. Removal of the shanks from the carcass and cutting them into selections is quite a simple and fast procedure. It is, however, difficult to estimate how much the removal of the shanks reduces the commercial value of a carcass.

Only the fore shanks were removed from the carcasses in experiments IX and X. They were cut into meat, bone and tendon selections, no fat was found. From the other carcasses of the 1-year olds, except in experiment I, the fore and hind shank on the right hand side of the carcasses were removed and dissected boneless, tendons were not removed from the muscular tissue.

In experiments V and VI there were differencies in dissection and cutting techniques of the shanks if compared to those in II, III and IV. In all of them, however, tibia fibula has been separated in one piece. In experiments V and VI part of the meat in the fore shank remained with the

Table 22. Correlations between carcass composition and live weight, carcass weight, dressing-% and by-products found in the literature.

| | | Meat kg | Fat kg | Bone kg | Meat % | Fat % | Bone % |
|---|---|---|---|---|---|---|---|
| Live weight | | | | | | | |
| du Bose et al. 1967 | | .85[1] | — | — | .02[2] | — | — |
| Brackelsberg & Willham 1968 | | — | — | — | –.28 | .18 | –.33 |
| Schmitten 1968 | | — | — | — | .27 | — | — |
| Varo 1969 | | .90 | .36 | — | — | — | — |
| Present study | 1-yr. | .911 | .496 | .713 | .279 | .120 | –.393 |
| | 1/2-yr. | .882 | .553 | .796 | .186 | .305 | –.298 |
| Carcass weight | | | | | | | |
| Allen et al. 1968 | | .86 | .80 | .77 | –.03 | .04 | .0 |
| du Bose et al. 1967 | | .94[1] | — | — | –.03[2] | — | — |
| Brackelsberg et al. 1968 | | .41 | .08 | — | .10 | –.12 | — |
| Brackelsberg & Willham 1968 | | — | — | — | –.30 | .35 | –.40 |
| Butterfield 1965 | | .97 | .84 | .80 | — | — | — |
| Dinkel et al. 1965 | | — | — | — | –.49 | — | — |
| Field et al. 1966 | $R^2$ = | 97 % | 82 % | 92 % | 31 % | 48 % | 54 % |
| Present study | 1-yr. | .980 | .484 | .731 | .367 | .088 | –.446 |
| | 1/2-yr. | .982 | .504 | .773 | .324 | .264 | –.435 |
| Dressing-% | | | | | | | |
| Nielsen 1962 | | — | — | — | .25 | –.07 | –.26 |
| Wismer-Pedersen 1969 | bulls | — | — | — | .32 | –.06– –.17 | — |
| | calves | — | — | — | .42– .39 | –.09– –.15 | — |
| Present study | 1-yr. | .476 | .103 | .289 | .340 | –.073 | –.254 |
| | 1/2-yr. | .491 | .101 | .167 | .421 | –.043 | –.431 |
| Kidney and bowel fat, kg | | | | | | | |
| Butterfield 1965 | | — | .91 | — | — | — | — |
| Varo 1969 | | — | .46 | — | — | — | — |
| Kidney fat kg | | | | | | | |
| du Bose et al. 1967 | | .30[1] | — | — | –.53[2] | — | — |
| Hinks & Bech Andersen 1968 | | — | — | — | –.40 | — | — |
| Present study | 1-yr. | — | .700 | — | — | .645 | — |
| | 1/2-yr. | — | .548 | — | — | .518 | — |

[1]) Boneless roast and steak, kg.
[2]) » » » » %

shoulders, and part of the hind shanks with the rounds. In comparison of the mean results (Table 23) the difference in dissection can be observed.

*Means of cutting results of shanks by experiment*

Table 23 presents the means and standard deviations of the cutting results of shanks by experiment.

Differencies in dissection techniques are most apparent in bone-% and meat-% where differencies between experiments II, III and IV on one hand and V and VI on the other hand are distinct (Table 23).

Table 23. Means and standard deviations of cutting results of fore and hind shanks by experiment.

| Exp. No. | Mean | SD | Statistical significance | | | Mean | SD | Statistical significance | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Breed | Feed. | Age | | | Breed | Feed. | Age |
| | 1-year olds, n = 181 | | | | | | | | | |
| | Hind shank, kg | | | | | Hind shank, % | | | | |
| II | 3.8 | 0.3 | *** | – | – | 2.6 | 0.2 | – | – | – |
| III | 4.4 | 0.5 | ** | * | * | 2.7 | 0.3 | – | – | – |
| IV | 4.0 | 0.3 sires | *** | ** | – | 2.5 | 0.2 | | *** | – |
| V | 3.5 | 0.4 | * | – | – | 2.6 | 0.2 | – | – | – |
| VI | 3.6 | 0.3 | | – | – | 2.9 | 0.2 | | – | – |
| | Meat-% in hind shank | | | | | Bone-% in hind shank | | | | |
| II | 55.2 | 1.8 | – | – | – | 44.8 | 1.8 | – | – | – |
| III | 59.1 | 2.4 | – | – | – | 40.9 | 2.3 | – | – | – |
| IV | 57.9 | 2.8 | | ** | – | 42.4 | 2.8 | | ** | – |
| V | 51.6 | 1.7 | – | – | * | 48.4 | 1.7 | – | – | * |
| VI | 53.5 | 1.9 | | * | – | 46.7 | 1.9 | | * | – |
| | Fore shank, kg | | | | | Fore shank % | | | | |
| II | 3.2 | 0.5 | ** | – | ** | 2.3 | 0.3 | – | – | ** |
| II | 3.9 | 0.4 | ** | * | ** | 2.4 | 0.1 | – | – | – |
| IV | 3.7 | 0.4 sires | * | ** | – | 2.6 | 0.2 | | ** | – |
| V | 2.5 | 0.2 | ** | – | ** | 1.9 | 0.1 | – | – | – |
| VI | 2.3 | 0.2 | | – | – | 1.9 | 0.1 sires | ** | – | – |
| | Meat-% in fore shank | | | | | Bone-% in fore shank | | | | |
| II | 56.4 | 2.7 | – | – | – | 43.6 | 2.7 | – | – | – |
| III | 55.3 | 2.1 | – | – | – | 44.8 | 2.0 | – | – | – |
| IV | 57.4 | 2.6 | | ** | – | 43.0 | 2.3 | | ** | – |
| V | 52.0 | 1.1 | – | *** | – | 48.0 | 1.1 | – | *** | – |
| VI | 52.1 | 2.5 | | – | – | 47.7 | 2.2 | | – | – |
| | 1/2-year olds, n = 94 | | | | | | | | | |
| | Fore shanks, kg | | | | | Fore shanks, % | | | | |
| IX | 4.9 | 0.9 | ** | | – | 5.1 | 0.2 | ** | | ** |
| X | 5.4 | 0.4 | *** | *** | – | 4.9 | 0.3 | * | – | – |
| | Meat-% in fore shanks | | | | | Bone-% in fore shanks | | | | |
| IX | 47.2 | 2.8 | – | | – | 45.8 | 1.9 | * | | – |
| X | 51.9 | 3.6 | – | – | – | 44.4 | 2.6 | ** | – | – |

With ½-year olds bone-% and meat-% did not total 100 % because tendons are dissected into another selection. The share of tendons is 4–6 %, which is not, however, included in the calculations.

*Stepwise regression analysis, results and discussion*

Estimation of carcass composition with cutting results of shanks.

In addition to the cutting results of the shanks, carcass weight has acted as one estimator (Tables 24 and 25). Where carcass weight has produced no additional information the results have been omitted from the tables.

Table 24. Result of stepwise regression analysis.

1-year olds, n = 181

a) Cutting results of fore and hind shank — carcass meat-kg, bone-kg and bone-%.
b) Carcass weight and cutting results of fore and hind shank — carcass meat-kg, bone-kg and bone-%.
c) Carcass weight and cutting results of fore shank — carcass bone-kg and bone-%.
d) Carcass weight and cutting results of hind shank — carcass bone-kg and bone-%.

| Step | x | r | R | $R^2$ | b | $\beta$ |
|---|---|---|---|---|---|---|
| | $y =$ Meat-kg, $\bar{y} = 106$ kg | | | | | |
| a) 1. | Fore shank, kg | .690 | .690 | 47.6 | 7.657*** | 0.257 |
| 2. | Fore shank, % | −.224 | .916 | 83.9 | −11.582*** | −0.202 |
| 3. | Hind shank, % | −.422 | .929 | 86.3 | −34.950*** | −0.623 |
| 4. | Hind shank, kg | .642 | .975 | 95.1 | 21.312*** | 0.724 |
| b) 1. | Carcass weight | .984 | .984 | 96.8 | 0.827*** | 1.052 |
| 2. | Hind shank, kg | .642 | .985 | 97.0 | −2.956*** | −0.100 |
| 3. | Bone-% in hind shank | −.040 | .986 | 97.2 | −0.139* | −0.029 |
| | $y =$ Bone-kg, $\bar{y} = 30.9$ kg | | | | | |
| a) 1. | Bone-kg in hind shank | .768 | .768 | 59.0 | 7.461*** | 0.420 |
| 2. | Fore shank, kg | .664 | .798 | 63.7 | 6.547*** | 0.853 |
| 3. | Fore shank, % | .008 | .818 | 66.9 | −3.760*** | −0.255 |
| 4. | Meat-kg in fore shank | .562 | .825 | 68.1 | −4.508* | −0.368 |
| c) 1. | Carcass weight | .716 | .716 | 51.3 | 0.071*** | 0.352 |
| 2. | Bone-kg in fore shank | .685 | .780 | 60.8 | 9.071*** | 0.538 |
| 3. | Fore shank, % | .008 | .787 | 61.9 | −2.298* | −0.156 |
| d) 1. | Bone-kg in hind shank | .768 | .768 | 59.0 | 9.275*** | 0.523 |
| 2. | Carcass weight | .716 | .810 | 65.6 | 0.072*** | 0.355 |
| | $y =$ Bone-%, $\bar{y} = 21.0$ % | | | | | |
| a) 1. | Hind shank, % | .564 | .564 | 31.8 | 5.454*** | 0.828 |
| 2. | Bone-% in hind shank | .166 | .687 | 47.2 | 0.298*** | 0.534 |
| 3. | Bone-kg in hind shank | .051 | .715 | 51.1 | −3.520*** | −0.435 |
| 4. | Bone-kg in fore shank | .061 | .743 | 55.2 | 2.245*** | 0.292 |
| c) 1. | Carcass weight | −.464 | .464 | 21.5 | −0.066*** | −0.723 |
| 2. | Bone-kg in fore shank | .061 | .641 | 41.1 | 3.578*** | 0.465 |
| 3. | Bone-% in fore shank | .412 | .654 | 42.8 | 0.092*** | 0.153 |
| d) 1. | Hind shank, % | .564 | .564 | 31.8 | 4.058*** | 0.616 |
| 2. | Bone-% in hind shank | .166 | .687 | 47.2 | 0.210*** | 0.376 |
| 3. | Carcass weight | −.464 | .716 | 51.3 | −0.020*** | −0.218 |

With mere weight and percentage of the shanks the meat-kg could be estimated with $R^2$ of 95 % to 96 %. When carcass weight was included as one estimator of meat-kg this alone gave a higher $R^2$-value than the cutting results of the shanks. The shanks increased the $R^2$ with 0.4—1.8 %-units (Tables 24 and 25).

Table 25. Result of stepwise regression analysis.
$^{1}/_{2}$-year olds a) Cutting results of fore shanks — carcass composition.
n = 94 b) Carcass weight and cutting results of fore shanks — carcass composition.

| Step | x | r | R | $R^2$ | b | $\beta$ |
|---|---|---|---|---|---|---|
| | $y$ = Meat-kg, $\bar{y}$ = 76.6 kg | | | | | |
| a) 1. | Meat-kg in fore shanks ............ | .656 | .656 | 43.0 | 30.182*** | 1.242 |
| 2. | Fore shanks, % ...................... | −.340 | .867 | 75.2 | −17.459*** | −0.692 |
| 3. | Meat-% in fore shanks ............ | .154 | .979 | 95.8 | −1.259*** | −0.598 |
| b) 1. | Carcass weight ...................... | .982 | .982 | 96.4 | 0.772*** | 0.953 |
| 2. | Meat-% in fore shanks ............ | .154 | .987 | 97.4 | 0.146*** | 0.069 |
| 3. | Fore shanks, % ...................... | −.340 | .990 | 98.0 | −2.075*** | −0.082 |
| 4. | Bone-% in fore shanks ............ | −.158 | .991 | 98.2 | −0.142* | −0.048 |
| | $y$ = Fat-kg, $\bar{y}$ = 3.4 kg | | | | | |
| b) 1. | Carcass weight ...................... | .544 | .544 | 29.6 | 0.058*** | 0.544 |
| | $y$ = Bone-kg, $y$ = 21.2 kg | | | | | |
| a) 1. | Bone-kg in fore shanks ............ | .742 | .742 | 55.1 | 20.945*** | 3.511 |
| 2. | Fore shanks, kg ...................... | .544 | .780 | 60.8 | −6.257*** | −2.538 |
| 3. | Bone-% in fore shanks ............ | .337 | .864 | 74.6 | −0.794*** | −1.136 |
| 4. | Fore shanks, % ...................... | .062 | .907 | 82.1 | −1.783*** | −0.299 |
| | $y$ = Meat-%, $\bar{y}$ = 73.9 % | | | | | |
| a) 1. | Meat-% in fore shanks ............ | .543 | .543 | 29.5 | 0.099* | 0.227 |
| 2. | Fore shanks, % ...................... | −.437 | .713 | 50.8 | −2.372*** | −0.518 |
| 3. | Meat-kg in fore shanks ............ | .339 | .735 | 53.7 | 1.003* | 0.227 |
| 4. | Bone-% in fore shanks ............ | −.518 | .749 | 56.1 | −0.121* | −0.225 |
| | $y$ = Fat-%, $\bar{y}$ = 3.3 % | | | | | |
| b) 1. | Carcass weight ...................... | .264 | .264 | 7.0 | 0.022* | 0.264 |
| | $y$ = Bone-%, $\bar{y}$ = 20.6 % | | | | | |
| a) 1. | Bone-% in fore shanks ............ | .603 | .603 | 36.4 | 0.213*** | 0.449 |
| 2. | Fore shanks, % ...................... | .507 | .788 | 62.1 | 2.468*** | 0.608 |
| 3. | Meat-kg in fore shanks ............ | −.357 | .836 | 69.9 | −1.298*** | −0.332 |

In the estimation of fat-kg and fat-% the results obtained with shank cutting results were unreliable in both age groups.

For the 1-year olds an $R^2$ of 68 % was obtained for bone-kg with the cutting results of shanks (Table 24, a), carcass weight gave no additional information to this value. The value of $R^2$ did not increase in the experiments (II—IV) where the shanks had been dissected uniformly.

When the estimation was performed separately with the fore shanks and again with the hind shanks and carcass weight, the result remained less reliable than the one obtained with mere cutting results of the fore and hind shanks (Table 24, c, d).

With cutting results of the fore shanks an $R^2$ of 82 % was obtained with the ½-year olds (Table 25, a). With carcass weight and cutting results of fore shanks the $R^2$ was 83 %.

Estimation of meat-% was rather unreliable with the 1-year olds, but for the ½-year olds an $R^2$ of 56 % was obtained with the mere cutting of the fore shanks (Table 25, a).

The $R^2$ for bone % was 55 % for the 1-year olds (Table 24, a). In the experiments where the shanks were dissected in the same way (experiments II—IV), the $R^2$ obtained was about 10 %-units higher than the one for the whole material. For the ½-year olds the $R^2$ for bone-% was 70 % (Table 25, a).

According to personal impression it seems probable that with the cutting results of mere fore or hind shank the same degree of reliability can be achieved as with dissection of both the fore and the hind shanks. In earlier studies at the S.W. Finland Experiment Station in experiments on Charolais cross-breds similar values for $R^2$ for bone-kg and bone-% were obtained with cutting results of the fore shanks as in the present study with the ½-year olds. In all the experiments the fore shanks were removed and cut into selections in the same manner as in the present study in the experiments for the ½-year olds.

In several studies attention has been paid to the information of carcass composition obtained with dissection and cutting of the shanks. This is quite natural considering that removal of the shanks requires no high expenses and no entire destruction of the carcass.

In the study by Callow (1962) the following correlations were obtained with shank cutting results:

| | | | | | | |
|---|---|---|---|---|---|---|
| Fore | shank | meat-kg | — | carcass | meat-kg | r = 0.96 |
| Hind | » | » | — | » | » | r = 0.62 |
| Fore | » | fat-kg | — | » | fat-kg | r = 0.53 |
| Hind | » | » | — | » | » | r = 0.58 |
| Fore | » | bone-kg | — | » | bone-kg | r = 0.98 |
| (radius + ulna) | | | | | | |
| Hind | » | » | — | » | » | r = 0.97 |
| (tibia fibula) | | | | | | |

In a study by Butterfield (1965) one half of 29 carcasses were dissected into muscles and bones and these were compared to the meat and bone quantities in the other half. Between separate bones and the bone quantity correlations of 0.92—0.99 were obtained. Radius and ulna gave the highest estimations. The correlations between separate muscles and meat quantity varied between 0.87 and 0.99. The correlation between fore shank meat and the total meat quantity was 0.95. Correlations for the percentages were low.

The material in a study by Orme et al. (1959 b) comprised 8 A. Angus and 23 Hereford steers, of which the left half was dissected. The results follow:

| | | | | | | |
|---|---|---|---|---|---|---|
| Fore | shank | bone-kg | — | carcass | meat-kg | r = 0.66 |
| » | » | » % | — | » | meat-% | r = 0 |
| Hind | » | bone-kg | — | » | meat-% | r = 0.69 |
| » | » | » % | — | » | meat-% | r = −0.01 |

In a study by Brackelsberg et al. (1968) the correlation obtained between fore shank meat-% and carcass meat-% was 0.61, the correlation between the corresponding bone-% was 0.43, and between fat-% 0.23.

Cole et al. (1960) obtained a correlation of 0.81 between fore shank meat-kg and carcass meat-kg and through addition of carcass weight the R-value rose up to 0.89.

Materials in these studies have been quite different from the one in the present study, therefore there remains only little ground for comparison. In estimation of fat the present results with shank dissection provided virtually no information. Instead in some foreign studies relatively high correlations have been obtained even in estimation of fat, which evidently is due to the abundancy of fat even in the shanks of the breeds studied. In the present study no fat is cut off the shanks as it is very scarce in young animals of our breeds.

In several studies the cutting results of the shanks have been estimators of other carcass traits in addition to other estimating characteristics. But because the thickness of fat cover and the area of the MLD have often been included, there is no reason to do any comparisons here. (Some results are presented in Chapter IV).

## VIth estimator: *cutting results of the fore and hind quarters*

As the fore quarters of a carcass, excluding the shoulders, are regarded as the cheaper part, and the shoulders with the hind quarters — the rounds and the back — as the more valuable parts of a carcass, a principle was established that if the carcass traits can not be properly estimated with any other method, the cheaper part i.e. the fore quarters could be dissected.

In all experiments the rounds were dissected of the hind quarters behind the last lumbar vertebra. The bones were removed of the steaks in the rounds, different muscles were not, however, separated but the flesh was weighed in one piece. The MLD was removed of the back. The other muscles of the back were not weighed separately. The dissection of the inner fillets differed between experiments, therefore they are excluded from the calculations.

In all the carcasses the fore and hind quarters were separately partitioned into meat, fat, bone and tendons.

*Means of cutting results of the fore and hind quarters by experiment*

Tables 26 and 27 present the means and standard deviations of the cutting results of the fore and hind quarters by experiment.

The proportions of the fore and hind quarters to the total carcass weight remained rather constant from one experiment to another. The differencies in percentages between breeds were, however, statistically significant in all experiments. Differencies in percentages of meat, fat and bone were only in a few cases statistically significant for the 1-year olds. For the ½-year olds the differencies of most traits were statistically significant between breeds.

Table 26. Means and standard deviations of cutting results of the fore quarters by experiment.

| Exp. No. | Mean | SD | Statistical significance | | | Mean | SD | Statistical significance | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Breed | Feed. | Age | | | Breed | Feed. | Age |
| | 1-year olds, n = 205 | | | | | | | | | |
| | Fore quarters, kg | | | | | Fore quarters, % | | | | |
| I | 73.0 | 5.8 | * | | – | 43.0 | 0.9 | *** | | – |
| II | 60.9 | 4.3 | *** | – | – | 43.0 | 1.0 | *** | – | *** |
| III | 68.4 | 5.3 | * | *** | ** | 42.7 | 0.7 | *** | * | – |
| IV | 68.2 | 8.2 | | *** | – | 42.6 | 0.8 | | – | – |
| V | 58.7 | 6.4 | – | – | ** | 43.6 | 1.0 | ** | – | – |
| VI | 55.2 | 4.2 | | – | – | 44.7 | 1.4 | | – | – |
| | Meat-kg | | | | | Meat-% | | | | |
| I | 54.3 | 4.5 | * | | – | 74.4 | 1.3 | – | | – |
| II | 43.4 | 3.4 | ** | – | – | 71.3 | 1.5 | – | – | – |
| III | 48.7 | 4.2 | * | *** | ** | 71.2 | 1.7 | – | – | – |
| IV | 47.2 | 6.3 | | *** | – | 69.1 | 1.9 | | * | – |
| V | 38.5 | 4.6 | – | – | * | 65.4 | 1.3 | – | – | – |
| VI | 40.2 | 3.4 | | – | – | 72.7 | 1.3 | | – | – |
| | Fat-% | | | | | Bone-% | | | | |
| I | 3.3 | 0.8 | – | | – | 20.1 | 0.8 | * | | – |
| II | 3.0 | 0.9 | – | – | – | 23.4 | 1.0 | – | – | – |
| III | 3.4 | 1.3 | – | – | – | 22.9 | 1.4 | – | * | – |
| IV | 5.3 | 1.1 | | *** | – | 22.7 | 1.8 | | *** | – |
| V | 10.0 | 1.2 | * | – | – | 22.7 | 1.2 | – | * | – |
| VI | 0.4 | 0.2 | | – | * | 25.3 | 0.4 | | – | – |
| | 1/2-year olds, n = 94 | | | | | | | | | |
| | Fore quarters, kg | | | | | Fore quarters, % | | | | |
| IX | 39.1 | 3.9 | – | | * | 41.5 | 0.8 | ** | | – |
| X | 45.5 | 3.2 | *** | *** | ** | 41.3 | 0.6 | *** | – | – |
| | Meat-kg | | | | | Meat-% | | | | |
| IX | 27.3 | 3.0 | – | | * | 69.9 | 1.4 | * | | – |
| X | 33.1 | 2.6 | *** | *** | ** | 72.5 | 1.9 | ** | – | – |
| | Fat-% | | | | | Bone-% | | | | |
| IX | 3.1 | 0.6 | ** | | – | 23.7 | 1.3 | *** | | – |
| X | 2.5 | 1.0 | – | – | – | 22.8 | 1.6 | *** | – | – |

*Stepwise regression analysis, results and discussion*

Estimation of carcass composition with carcass weight and cutting results of the fore and hind quarters.

Carcass weight estimated the meat-kg with an $R^2$ of 96 % as already mentioned. With the addition of the cutting results of the fore and hind

Table 27. Means and standard deviations of cutting results of hind quarters by experiment

| Exp. No. | Mean | SD | Statistical significance | | | Mean | SD | Statistical significance | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Breed | Feed. | Age | | | Breed | Feed. | Age |
| | 1-year olds, n = 205 | | | | | | | | | |
| | Hind quarters, kg | | | | | Hind quarters, % | | | | |
| I | 97.0 | 7.3 | *** | | — | 57.0 | 0.9 | *** | | — |
| II | 81.1 | 6.6 | *** | — | — | 57.0 | 1.0 | *** | — | *** |
| III | 92.3 | 7.2 | ** | *** | ** | 57.3 | 0.7 | *** | * | — |
| IV | 91.6 | 10.5 | | *** | — | 57.4 | 0.8 | | — | — |
| V | 76.2 | 8.2 | * | — | * | 56.4 | 1.0 | ** | — | — |
| VI | 68.4 | 4.8 | | — | — | 55.3 | 1.4 | | — | — |
| | Meat-kg | | | | | Meat-% | | | | |
| I | 75.4 | 5.9 | *** | | — | 77.7 | 1.2 | — | | — |
| II | 61.4 | 5.4 | *** | — | — | 75.5 | 1.0 | — | — | — |
| III | 69.5 | 6.1 | ** | *** | ** | 75.5 | 1.6 | — | — | — |
| IV | 67.0 | 8.1 | | *** | — | 73.2 | 1.3 | | *** | — |
| V | 53.3 | 6.0 | ** | — | * | 69.9 | 1.1 | ** | * | — |
| VI | 53.1 | 4.0 | | — | — | 77.6 | 1.0 | | — | — |
| | Fat-% | | | | | Bone-% | | | | |
| I | 3.9 | 0.9 | — | | — | 16.9 | 0.5 | *** | | — |
| II | 2.3 | 0.7 | — | — | — | 19.5 | 0.8 | — | — | — |
| III | 3.3 | 1.3 | — | — | — | 18.4 | 1.5 | — | — | — |
| IV | 6.0 | 1.4 | | *** | — | 18.6 | 1.5 | | *** | — |
| V | 10.1 | 1.5 | * | ** | — | 19.2 | 0.8 | — | ** | — |
| VI | 0.4 | 0.2 | | — | * | 21.6 | 1.1 | | — | — |
| | ½-year olds, n = 94 | | | | | | | | | |
| | Hind quarters, kg | | | | | Hind quarters, % | | | | |
| IX | 55.2 | 5.9 | * | | * | 58.7 | 0.8 | ** | | — |
| X | 64.8 | 4.9 | *** | *** | * | 58.7 | 0.6 | *** | — | — |
| | Meat-kg | | | | | Meat-% | | | | |
| IX | 41.3 | 4.7 | ** | | * | 74.7 | 1.4 | ** | | — |
| X | 49.5 | 3.9 | *** | *** | * | 76.4 | 1.1 | *** | ** | — |
| | Fat-% | | | | | Bone-% | | | | |
| IX | 4.0 | 0.7 | * | | — | 19.6 | 1.2 | ** | | — |
| X | 3.5 | 0.9 | — | — | — | 18.3 | 1.0 | *** | — | * |

quarters the coefficient increased by 2—3 %-units in both age groups (Tables 28 and 30). It is, however, questionable whether for such a modest, less than 3 %-units, increase in the coefficient it is reasonable to perform a costly dissection.

In the estimation of f a t - k g considerably higher values of $R^2$, 86 %-87 %, were obtained with cutting results of the fore and hind quarters with the 1-year olds than with any earlier estimator (Table 28, a, b).

Table 28. Result of stepwise regression analysis.

1-year olds a) Carcass weight and cutting results of fore quarters — quantities of carcass meat, fat and bone.

n = 205 b) Carcass weight and cutting results of hind quarters — quantities of carcass meat, fat and bone.

| Step | x | r | R | $R^2$ | b | $\beta$ |
|---|---|---|---|---|---|---|
| | y = Meat-kg, $\bar{y}$ = 109 kg | | | | | |
| a) 1. | Carcass weight ........................ | .980 | .980 | 96.0 | 0.793*** | 1.002 |
| 2. | Meat-% in fore quarters ......... | .433 | .989 | 97.8 | 0.939*** | 0.138 |
| 3. | Fat-kg » » » .......... | .397 | .990 | 98.0 | −2.084*** | −0.158 |
| 4. | Fat-% » » » ........... | .009 | .991 | 98.2 | 1.239*** | 0.119 |
| b) 1. | Carcass weight ........................ | .980 | .980 | 96.0 | 0.737*** | 0.932 |
| 2. | Meat-% in hind quarters ........ | .440 | .992 | 98.4 | 1.227*** | 0.147 |
| 3. | Boneless steaks of round, % .... | .246 | .992 | 98.4 | 0.120* | 0.021 |
| | y = Fat-kg, $\bar{y}$ = 6.7 kg | | | | | |
| a) 1. | Fat-kg in fore quarters ............ | .918 | .918 | 84.3 | 2.088*** | 0.871 |
| 2. | Bone-% » » » ............ | −.474 | .922 | 85.1 | −0.150*** | −0.108 |
| 3. | Fore quarters, % ................... | −.044 | .925 | 85.6 | −0.135* | −0.060 |
| b) 1. | Fat-% in hind quarters .......... | .830 | .830 | 68.9 | 1.197*** | 0.714 |
| 2. | Carcass weight ........................ | .484 | .928 | 86.1 | 0.048* | 0.336 |
| 3. | Fat-kg in hind quarters............ | .579 | .930 | 86.5 | 0.059* | 0.062 |
| 4. | Meat-kg » » » ............ | .396 | .931 | 86.7 | −0.142** | −0.459 |
| 5. | Hind quarters, kg .................. | .496 | .933 | 87.0 | 0.128** | 0.525 |
| | y = Bone-kg, $\bar{y}$ = 30.9 kg | | | | | |
| a) 1. | Bone-kg in fore quarters .......... | .902 | .902 | 81.4 | 1.983*** | 0.924 |
| 2. | Fore quarters, % ................... | .039 | .910 | 82.8 | −0.341*** | −0.122 |
| b) 1. | Bone-kg in hind quarters ......... | .904 | .904 | 81.7 | 1.473*** | 0.765 |
| 2. | Hind quarters, % ................... | −.030 | .913 | 83.4 | −0.360*** | −0.128 |
| 3. | Rounds with hind shanks, kg ... | .761 | .919 | 84.5 | 0.106*** | 0.188 |
| 4. | Boneless steaks of round, % .... | −.131 | .920 | 84.6 | −0.089* | −0.062 |

With the ½-year olds the $R^2$ was 73 % with the cutting results of the fore quarters and 86 % with those of the hind quarters. (Table 30, a, b). With kidney fats and cutting results of the flanks the $R^2$ obtained was 70%(Chapter IV). For this reason the purpose of cutting the fore quarters becomes questionable considering cutting of large materials.

Almost uniform $R^2$-values were obtained for bone-kg with cutting results of both the fore and hind quarters, $R^2$-values were from 83 % to 85 % and 95 % (Tables 28 and 30).

The $R^2$ for meat-% was 76 % with cutting results of fore quarters and 82 % with cutting results of hind quarters for both age groups. (Tables 29 and 30).

The $R^2$ obtained for fat-% was 12—14 %-units higher with the cutting results of hind quarters than with those of the fore quarters (Tables 29 and 30).

In estimation of b o n e - % a higher result was obtained here than with any other earlier presented estimator: the $R^2$ for the 1-year olds was 88 % (Table 29, a, b) with cutting results of both the fore and hind quarters and for the ½-year olds 81 % and 91 % respectively (Table 30, a, b).

In the literature no studies were found in which the carcass traits were estimated with the cutting results of the fore or hind quarters alone. However, results obtained in other countries are seldom comparable to the ones presented here because even the dissection of a carcass into fore and hind quarters may be done between the 6th and the 7th rib till the 13th rib and the 1st lumbar vertebra. The weight of the fore and hind quarters separately and their proportion of carcass weight thus varies according to the separation of the quarters.

Table 29. Result of stepwise regression analysis.
1-year olds, n = 205
a) Carcass weight and cutting results of fore quarters — percentages of carcass meat, fat and bone.
b) Carcass weight and cutting results of hind quarters — percentages of carcass meat, fat and bone.

| Step | x | r | R | $R^2$ | b | β |
|---|---|---|---|---|---|---|
| | $y$ = Meat-%, $\bar{y}$ = 72.9 % | | | | | |
| a) 1. | Meat-% in fore quarters | .840 | .840 | 70.6 | 0.440*** | 0.558 |
| 2. | Carcass weight | .367 | .847 | 71.7 | 0.057*** | 0.625 |
| 3. | Fat-kg in fore quarters | −.183 | .855 | 73.3 | −0.461*** | −0.300 |
| 4. | Bone-kg » » » | −.011 | .871 | 75.9 | −0.371*** | −0.377 |
| b) 1. | Meat-% in hind quarters | .892 | .892 | 79.6 | 0.791*** | 0.812 |
| 2. | Hind quarters, % | −.115 | .899 | 80.8 | −0.160*** | −0.124 |
| 3. | Bone-% in hind quarters | −.516 | .905 | 81.9 | −0.094* | −0.090 |
| 4. | Boneless steaks, kg | .461 | .908 | 82.4 | 0.035* | 0.084 |
| | $y$ = Fat-%, $\bar{y}$ = 4.4 % | | | | | |
| a) 1. | Fat-% in fore quarters | .870 | .870 | 75.7 | 0.840*** | 0.838 |
| 2. | Bone-% » » » | −.349 | .876 | 76.7 | −0.082** | −0.112 |
| b) 1. | Fat-% in hind quarters | .944 | .944 | 89.1 | 0.838*** | 0.944 |
| | $y$ = Bone-%, $\bar{y}$ = 20.7 % | | | | | |
| a) 1. | Bone-% in fore quarters | .918 | .918 | 84.3 | 0.757*** | 0.879 |
| 2. | Fore quarters, % | −.017 | .931 | 86.7 | 0.194*** | 0.156 |
| 3. | Fat-% in fore quarters | −.355 | .934 | 87.2 | −0.110*** | −0.093 |
| 4. | Meat-kg » » » | −.512 | .936 | 87.6 | −0.001* | −0.076 |
| b) 1. | Bone-% in hind quarters | .913 | .913 | 83.4 | 0.513*** | 0.506 |
| 2. | Boneless steaks of round, % | −.494 | .921 | 84.8 | −0.070*** | −0.110 |
| 3. | Rounds with hind shanks, % | .352 | .926 | 85.7 | 0.093* | 0.070 |
| 4. | Carcass weight | −.446 | .930 | 86.5 | −0.036*** | −0.401 |
| 5. | Bone-kg in hind quarters | .202 | .935 | 87.4 | 0.267*** | 0.311 |
| 6. | Fat-% » » » | −.388 | .937 | 87.8 | −0.149* | −0.143 |
| 7. | Meat-% » » » | −.463 | .938 | 88.0 | −0.088* | −0.093 |

Table 30. Result of stepwise regression analysis.

$^1/_2$-year olds a) Carcass weight and cutting results of fore quarters — carcass composition.

n = 94 b) Carcass weight and cutting results of hind quarters — carcass composition.

| Step | x | r | R | $R^2$ | b | $\beta$ |
|---|---|---|---|---|---|---|
| | y = Meat-kg, $\bar{y}$ = 76.6 kg | | | | | |
| a) 1. | Carcass weight ........................ | .982 | .982 | 96.4 | 0.813*** | 1.004 |
| 2. | Meat-% in fore quarters ......... | .468 | .994 | 98.8 | 0.488*** | 0.117 |
| 3. | Bone-kg » » » ......... | .617 | .994 | 98.8 | −0.722*** | −0.084 |
| b) 1. | Meat-kg in hind quarters ......... | .987 | .987 | 97.4 | 1.155*** | 0.708 |
| 2. | Hind quarters, % .................. | .159 | .995 | 99.0 | −0.786*** | −0.081 |
| 3. | Carcass weight ....................... | .982 | .996 | 99.2 | 0.231*** | 0.285 |
| 4. | Bone-% in hind quarters ......... | −.543 | .996 | 99.2 | −0.312*** | −0.047 |
| | y = Fat-kg, $\bar{y}$ = 3.4 kg | | | | | |
| a) 1. | Fat-kg in fore quarters ............ | .823 | .823 | 67.7 | 1.490*** | 0.721 |
| 2. | Carcass weight ....................... | .544 | .852 | 72.6 | 0.026*** | 0.243 |
| b) 1. | Fat-kg in hind quarters .......... | .925 | .925 | 85.6 | 1.426*** | 0.925 |
| | y = Bone-kg, $\bar{y}$ = 21.2 kg | | | | | |
| a) 1. | Bone-kg in fore quarters .......... | .965 | .965 | 93.1 | 1.872*** | 0.921 |
| 2. | Fore quarters, % .................. | −.024 | .974 | 94.9 | −0.297*** | −0.131 |
| 3. | Meat-kg in fore quarters ......... | .653 | .977 | 95.5 | 0.056** | 0.096 |
| b) 1. | Bone-kg in hind quarters ......... | .970 | .970 | 94.1 | 1.825*** | 0.988 |
| 2. | Hind quarters, % .................. | .024 | .977 | 95.5 | −0.275*** | −0.121 |
| | y = Meat-%, $\bar{y}$ = 73.9 % | | | | | |
| a) 1. | Meat-% in fore quarters ......... | .865 | .865 | 74.8 | 0.693*** | 0.920 |
| 2. | Fat-% » » » ......... | −.247 | .973 | 76.2 | 0.194* | 0.134 |
| b) 1. | Meat-% in hind quarters ........ | .883 | .883 | 78.0 | 0.706*** | 0.709 |
| 2. | Bone-% » » » ........ | −.718 | .904 | 81.7 | −0.242** | −0.201 |
| 3. | Boneless steaks, kg ................ | .513 | .908 | 82.4 | 0.060(*) | 0.105 |
| | y = Fat-%, $\bar{y}$ = 3.3 % | | | | | |
| a) 1. | Fat-% in fore quarters ............ | .809 | .809 | 65.4 | 0.422** | 0.499 |
| 2. | Fat-kg » » » ............ | .795 | .821 | 67.4 | 0.558* | 0.339 |
| b) 1. | Fat-% in hind quarters .......... | .902 | .902 | 81.4 | 0.821*** | 0.902 |
| | y = Bone-%, $\bar{y}$ = 20.6 % | | | | | |
| a) 1. | Bone-% in fore quarters ......... | .856 | .856 | 73.3 | 0.365*** | 0.487 |
| 2. | Meat-% » » » ......... | −.699 | .874 | 76.4 | −0.335*** | −0.502 |
| 3. | Fat-% » » » ......... | −.151 | .902 | 81.4 | −0.383*** | −0.298 |
| b) 1. | Bone-% in hind quarters ......... | .956 | .956 | 91.4 | 1.020*** | 0.956 |

## VIIth estimator: *detailed cutting results of the carcasses*

In all experiments the outer fillets and rounds including and excluding bones were weighed separately. The detailed cutting method applied to the carcasses in experiments IX and X is presented on page 395. The cutting results of flanks and shank have already been explained in Chapters IV and V. The correlations between other carcass parts and carcass composition will be discussed below.

*Results and discussion*

Estimation of carcass composition with detailed cutting results.

With the ½-year olds the $R^2$ obtained for meat-kg with the weights of the hind quarter cuts and carcass weight was 97 %. In addition to the carcass weight the only statistically significant factor was the weight of the back. With carcass weight the cuts of the fore quarters were nonsignificant. The carcass weight was the first estimator for bone-kg, 60 %. Of the other cuts the weight of the back increased the value by 3 %-units. For fat-kg the $R^2$ obtained with mere weight of flanks was 45 %. The results of the estimation of meat-%, fat % and bone-% remained low.

Only in few studies the quantities of meat, fat and bone in some cuts of a carcass are compared to the respective traits in the whole carcass. Instead, in most of the studies the percentages of meat, fat and bone in different cuts of a carcass are compared to the respective percentages in the carcass.

However, in a study by Cole et al. (1960) the correlations of the meat-kg in the rounds, shoulders and back on the meat-kg of the whole carcass have been calculated. The following correlations were obtained: 0.95, 0.93 and 0.80 respectively. In the present study the corresponding correlations were 0.969, 0.881 and 0.894 which are very close to those obtained by Cole et al. In the same study the following values for R were obtained with the stepwise regression analysis on the meat-kg in the cuts:

| | | | |
|---|---|---|---|
| Carcass weight + round | meat, kg — | carcass meat-kg | R = 0.97 |
| » » + shoulder | » » — | » » | R = 0.94 |
| » » + back | » » — | » » | R = 0.90—0.85 |

Below are presented the correlations by Thorton and Hiner (1965) and the correlations obtained in the present study between the weight of rounds and the weights of carcass meat, fat and bone. In the study in question the material comprised 43 A. Angus and 80 Hereford calves, age 6 months, thus the results obtained are well comparable to the ones obtained in this study for the $^1/_2$-year olds.

| | Meat kg | | Fat-kg | | Bone-kg | |
|---|---|---|---|---|---|---|
| Thorton & Hiner: | AA | H | AA | H | AA | H |
| weight of the rounds | 0.93 | 0.96 | 0.24 | 0.84 | 0.80 | 0.95 |
| Present study $^1/_2$-yr. | 0.963 | | 0.476 | | 0.786 | |
| 1-yr. | 0.943 | | 0.394 | | 0.761 | |

In the study by Varo (1969) the weight of the rounds was the first estimator of carcass meat-kg, fat-kg and bone -kg in the younger part of the material.

When the rounds were omitted, the R-value obtained with the ratio of carcass weight and size for the meat-kg was 0.949, the percentage of the rounds increased the R-value till 0.962. In the estimation of bone-kg the first estimator was the weight of head, the R-value obtained was 0.691, and the second one the percentage of the rounds, R-value obtained was 0.779. The highest estimate for the percentage of meat and bone was also obtained with the rounds.

It can be observed that the correlations obtained for the meat-kg and bone-kg in the present study are uniform with those obtained in the other studies.

Table 31 presents correlations found in the literature of the percentages of meat, fat and bone of some cuts of a carcass on the respective percentages in the whole carcass. Beside them the corresponding correlations found in the present study are presented.

The correlations for the meat-% and fat-% found in the other studies (Table 31) are in several of them higher than the ones obtained here. The correlation of the bone-% in the rounds on the carcass bone-% was considerably lower in the other studies than in the present study.

Table 31. Correlations between percentages of meat, fat and bone in carcass cuts and respective percentages of the whole carcass found in the literature.

| | | Round | Back | Flanks | Short plate | Brisket | Fore back | Shoulder | Neck |
|---|---|---|---|---|---|---|---|---|---|
| Meat-% | | | | | | | | | |
| BRACKELSBERG et al. 1968 | | .81–.89 | .89 | .87 | .90 | .91 | .96 | .97[1] | – |
| HERTKAMPF ref. WENIGER 1965 | | .813 | – | .710 | .712 | .753 | .741 | .872 | .649 |
| HINKS & BECH ANDERSEN 1968 | | – | – | – | – | .28 | – | – | .52 |
| Present study | 1/2-yr. | .738 | .668 | .186 | .454 | – | – | .539 | .617 |
| Fat-% | | | | | | | | | |
| BRACKELSBERG et al. 1968 | | .82–.87 | .92 | .89 | .92 | .88 | .96 | .96[1] | – |
| BUSS 1968 | | – | .751–.852 | – | – | – | – | – | – |
| HERKAMPF ref. WENIGER 1965 | | .923 | – | .717 | .771 | .764 | .780 | .832 | .604 |
| Present study | 1/2-yr. | .761 | – | .566 | – | – | – | – | – |
| Bone-% | | | | | | | | | |
| BRACKELSBERG et al. 1968 | | .28–.61 | .64 | .38[2] | .66 | .58 | .60 | .70[1] | – |
| HERTKAMPF ref. WENIGER 1965 | | .696 | – | – | .445 | .554 | .587 | .629 | .428 |
| Present study | 1/2-yr. | .908 | .785 | – | – | – | – | – | – |

[1]) shoulder + neck, [2]) flanks comprise ends of ribs.

The carcass meat quantity has been estimated by some separate muscles. In the study by LILJEDAHL (1965) the weights of *Musculus pectoralis profundus* and *M.p. superficialis* were compared to the meat quantity in the carcass. The correlations obtained varied between 0.73—0.98. In the present study the correlations obtained in the experiments III and V (material in all 78 1-year olds) between the muscles in question and the carcass meat-kg was 0.774.

In the study by JENSEN (1967) the relations between separate muscles and the meat quantities of a carcass of three different weight categories were compared. The highest correlation, r = 0.94, was obtained with the two muscles of the rounds. Of the 20 muscles studied the muscles in the rounds and the shanks were the best estimators of meat-kg.

ORME et al. (1959 a) obtained correlations of 0.795 to 0.957 with separate muscles and the meat quantity with a material comprising 43 animals of $9^1/_2$—11 years of age. The correlation between the weight of the MLD and the meat quantity was 0.843. In the present study the corresponding correlations were 0.817 for the 1-year olds and 0.835 for the $^1/_2$-year olds.

There are several studies on the relation between the weight and area of the MLD and the different traits of a carcass. In earlier experiments the interrelations between area of the MLD on the other traits in a carcass have been studied (RUOHOMÄKI and VARO 1967) but, like in the present one, the correlations obtained have been low.

As in several studies the correlations between the different carcass components — meat, fat and bone — are calculated. Table 32 presents the correlations found in the literature with the corresponding correlations obtained in the present study.

In several studies it has been observed that no adequately reliable and accurate information of a carcass for scientific purpose can be obtained with dissection of only some parts or with mere partial dissection of a carcass. For example ALLEN et al. (1969) dissected only one half of the carcasses into salable boneless retail cuts but the $R^2$ obtained corresponded only 71 % of the result obtained by the complete cutting of the other half.

Estimation of all the traits in Chapters VI and VII requires destruction of the whole carcass. With the bigger parts, like hind quarters, the fore quarters or the rounds, higher $R^2$ values are obtained than with the small parts. Large parts represent quite a large portion of the quantities of meat, fat and bone which makes it self-evident that these parts are more accurate estimators of the named traits than the smaller parts. According to a personal opinion there is no great difference whether a larger or a smaller part of a carcass is separated for research if the effect of both of them is destructive for the carcass. However, if the quantities and percentages of the whole carcass could be estimated with cutting only a small part of the carcass it would save labour. When separation of even a small part, for instance separate muscles or bones, requires dissection of the carcass into two parts and destruction of one of them, this also reduces the value of the carcass.

The same applies to the partition and study of the three rib joint, which is quite abudantly used in foreign studies. Dissection of one part and destruction

Table 32. Correlations between quantities and percentages of carcass meat, fat and bone found in the literature.

| | | Fat-kg | Bone-kg | Meat-% | Fat-% | Bone-% |
|---|---|---|---|---|---|---|
| Meat-kg | | | | | | |
| ALLEN et al. 1968 | | .40 | .90 | — | — | — |
| THORTON & HINER 1965 | | −.06− −.20 | .45− .63 | — | — | — |
| COLE et al. 1960 | | — | .75 | — | — | — |
| Present study | 1-yr. | .399 | .666 | .513 | .006 | .502 |
| | 1/2-yr. | .478 | .676 | .480 | .195 | −.548 |
| Fat-kg | | | | | | |
| ALLEN et al. 1968 | | — | — | — | — | .28 |
| THORTON & HINER 1965 | | — | .10− −.31 | — | — | — |
| Present study | 1-yr. | — | .166 | −.197 | .867 | −.515 |
| | 1/2-yr. | — | .345 | −.169 | .942 | −.324 |
| Bone-kg | | | | | | |
| Present study | 1-yr. | — | — | −.018 | −.154 | .186 |
| | 1/2-yr. | — | — | −.166 | .130 | .219 |
| Meat-% | | | | | | |
| ALLEN et al. 1968 | | — | — | — | −.98 | .74 |
| GOTTSCH et al. 1961 | | — | — | — | −.91 | — |
| HENDERSON et al. 1966 b. | | — | — | — | −.95 | −.77 |
| HINKS & BECH ANDERSEN 1968 | | — | — | — | −.72 | −.64 |
| SCHÖN 1969 | | — | — | — | −.936 | −.445 |
| WISMER-PEDERSEN 1969 | | — | — | — | −.84− −.92 | −.72− −.83 |
| Present study | 1-yr. | — | — | — | −.406 | −.583 |
| | 1/2-yr. | — | — | — | −.303 | −.762 |
| Fat-% | | | | | | |
| ALLEN et al. 1968 | | — | — | — | — | −.84 |
| SCHÖN 1969 | | — | — | — | — | −.686 |
| Present study | 1-yr. | — | — | — | — | −.400 |
| | 1/2-yr. | — | — | — | — | −.206 |

of the most expensive area of the carcass reduces its value when it is sold again. If it is in any case dissected into parts for retail or processing pourpses even a larger part could be studied.

Considering material comprising large numbers of animals it seems unlikely that this could be performed in Finland under the present circumstances.

Table 33. Coefficients of determination obtained with live measurements on live and carcass weight and with live weight and live measurements on carcass weight and with initial weight and daily gain on live and carcass weight.

| | Live weight | | Carcass weight | |
|---|---|---|---|---|
| | 1-yr. | 1/2-yr. | 1-yr. | 1/2-yr. |
| I a. Live measurements | 87 | 82 | 84 | 80 |
| I b. and live weight | | | 90 | 87 |
| II. Initial weight and daily gain | 96 | 93 | 86 | 77 |

Table 34. Coefficients of determination obtained with different trait groups on carcass composition.

| | | 1-year olds | | | | | | ½-year olds | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Meat | | Fat | | Bone | | Meat | | Fat | | Bone | |
| | | kg | % | kg | % | kg | % | kg | % | kg | % | kg | % |
| I a. | Live measurements | 78 | 26 | 37 | 16 | 64 | 45 | 78 | 20 | 37 | 9 | 78 | 45 |
| I b. | and live weight | 85 | 26 | 39 | 16 | 65 | 45 | 84 | 20 | 36 | 9 | 81 | 48 |
| II. | Initial weight and daily gain | 79 | — | 24 | — | 52 | — | 71 | — | 29 | — | 56 | — |
| III a. | Carcass quality scores | 47 | 29 | 17 | 11 | 19 | 41 | 59 | 34 | 24 | 12 | 11 | 54 |
| III b. | and carcass weight | 97 | 29 | 34 | 15 | 63 | 44 | 97 | 34 | 24 | 12 | 74 | 54 |
| IV a. | Live and carcass weight, dressing-% and by-products | 96 | 23 | 62 | 50 | 59 | 32 | 97 | 27 | 48 | 35 | 67 | 31 |
| IV b. | Carcass weight, bowel and kidney fats and cutting results of flanks[1]) | — | — | 60 | 47 | — | — | — | — | 70 | 59 | — | — |
| V a. | Cutting results of fore and hind shanks | 95 | 22 | 29 | 15 | 68 | 55 | — | — | — | — | — | — |
| V b. | and carcass weight | 97 | 24 | 35 | 15 | 68 | 56<br>65[2]) | — | — | — | — | — | — |
| V a. | Cutting results of fore shanks | — | — | — | — | — | — | 96 | 56 | 30 | 7 | 82 | 70 |
| V c. | and carcass weight | 97 | 21 | 35 | — | 62 | 43 | 98 | 56 | 30 | 7 | 83 | 70 |
| V d. | Cutting results of hind shanks and carcass weight | 97 | 24 | 41 | — | 65 | 51 | — | — | — | — | — | — |
| VI. | Carcass weight and cutting results of fore quarters | 98 | 76 | 86 | 77 | 83 | 88 | 99 | 76 | 73 | 67 | 95 | 81 |
| VI. | Carcass weight and cutting results of hind quarters | 98 | 82 | 87 | 89 | 85 | 88 | 99 | 82 | 86 | 81 | 95 | 91 |

[1]) cutting results of flanks only for 1/2-year olds.

[2]) $R^2$-value for the experiments where the shanks were dissected in a similar manner.


## Summary

Tables 33 and 34 present the coefficients of determination for live weight, carcass weight and carcass composition obtained with different trait groups.

Procedure with which the estimates mentioned in the Tables 33 and 34 can be obtained (excluding those obtained with cutting results of fore and hind quarters):

1. Determination of live weight with weighing.
2. Measuring of heart girth, width of chest, height at withers natural length and width of hind cannon on a live animal to estimate live and carcass weight.
3. Determination of carcass weight with weighing.
4. Giving carcass quality scores paying special attention to fleshiness.
5. Weighing the head, heart, liver and kidney fats and eventual bowel fats to estimate the quantity and percentage of carcass fat.
6. Dissection of one flank into meat anf fat selection to estimate the quantity and percentage of carcass fat.
7. Dissection of one fore or hind shank into meat and bone selection to estimate the quantity and percentage of bone and percentage of meat.

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SELOSTUS

# Nuoren lihanaudan teurasominaisuuksien arvioimisesta

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Tutkimuksen tarkoituksena oli selvittää, voidaanko elävän eläimen mitoilla arvioida riittävällä luotettavuudella elopainoa, teuraspainoa ja ruohon koostumusta — lihan, rasvan ja luiden kilo- ja prosenttimääriä — ja voidaanko ruhon koostumusta arvioida riittävällä luotettavuudella muilla keinoin kuin paloittelemalla koko ruho. Aineiston muodosti yht. 205 n. vuoden vanhaksi kasvatettua härkää ja sonnia sekä 174 n. $^1/_2$-vuotiaaksi kasvatettua sonnivasikkaa. Pienimmän neliösumman menetelmällä lasketuilla korjaustermeillä korjattiin kukin ominaisuus yksilöittäin kokeiden sisällä iän, ruokinnan ja rodun suhteen. Korjatuista arvoista laskettiin askeltavalla regressioanalyysilla ne ominaisuudet tai ominaisuusyhdistelmät, jotka parhaiten selittivät edellä mainittuja arvioitavia ominaisuuksia.

Elopainoille saatiin elävän eläimen mitoilla 1-vuotiailla 87 %:n ja $^1/_2$-vuotiailla 82 %:n sekä teuraspainoille vastaavasti 84 %:n ja 80 %:n selitysasteet. Parhaat elävän eläimen mitat näiden ominaisuuksien sekä lihan kilomäärän arvioimisessa olivat rinnan ympärys, rinnan leveys ja pituus. Lihan kilomäärää arvioi parhaiten teuraspaino, selitysaste molemmissa ikäryhmissä 96 %. Muut ominaisuudet lisäsivät teuraspainolla saatua selitysastetta 1—2 %-yksikköä. Lihan prosenttimäärän selitysaste jäi pieneksi 1-vuotiailla, mutta $^1/_2$-vuotiailla saatiin etupotkien paloittelutuloksilla 56 %:n selitysaste. Rasvan kilo- ja prosenttimäärää arvioivat 1-vuotiailla parhaiten teuraspaino ja elimet, selitysasteet 62 % ja 50 %, kun taas $^1/_2$-vuotiailla vastaavat selitysasteet olivat 70 % ja 59 %, jotka saatiin munuaisrasvoilla ja kupeiden paloittelutuloksilla. Luiden kilo- ja prosenttimäärälle saatiin 1-vuotiailla potkien paloittelutuloksilla 68 %:n ja 55 %:n selitysasteet sekä $^1/_2$-vuotiailla etupotkien paloittelutuloksilla vastaavasti 82 %:n ja 70 %:n selitysasteet. Etu- ja takapään paloittelutuloksilla saadut selitysasteet olivat suurempia kuin muilla ominaisuusryhmillä saadut. Teurasarvostelupisteillä saadut selitysasteet jäivät edellä selostettuja pienemmiksi.

Taulukoissa 33 ja 34 esitettyjen eri ominaisuusryhmillä saatujen selitysasteiden — lukuunottamatta etu- ja takapään paloittelulla saatuja selitysasteita — saavuttaminen edellyttää seuraavia toimenpiteitä:

1. Elopainon toteaminen punnitsemalla.
2. Elävän eläimen rinnan ympäryksen, rinnan leveyden, pituuden, säkäkorkeuden ja takasäären leveyden mittaaminen elopainon ja teuraspainon arvioimiseksi.
3. Teuraspainon toteaminen punnitsemalla.
4. Teurasarvostelussa lihakkuuden arvioiminen.
5. Pään, sydämen, maksan ja munuaisrasvojen punnitseminen rasvan kilo- ja prosenttimäärän arvioimiseksi.
6. Toisen kuvekappaleen leikkaaminen liha- ja rasvalajitelmiin rasvan kilo -ja prosenttimäärän arvioimiseksi.
7. Toisen etu- tai takapotkan leikkaaminen liha- ja luulajitelmiin lihan prosenttimäärän sekä luiden kilo- ja prosenttimäärän arvioimiseksi.