RECENT TRENDS IN CARCASE EVALUATION

(Invited Paper)

G. C. EVERITT*

Summary

The current change of emphasis from purely subjective commercial grading of meat carcases to more objective systems of appraisal is discussed. Modern methods of meat processing and marketing, together with rejection of animal shape as a factor of great productive importance, are considered dominating features of this change. The yield of boneless, fat-trimmed meat is rapidly becoming the criterion of commercial merit. Adoption of this criterion at carcase shows, in place of score cards based on linear measurements and visual appraisals, is urged. A need for standardisation of procedures is recognised.

Universal acceptance of either a fat-free or "fat-corrected" carcase is advocated in research work, with greater attention being paid to fundamental aspects of growth and the design of experiments.

I. INTRODUCTION

Meat is the end point of an intensely complex industry. It is also the commencement of another industry, equally intricate, involving processing, handling, storing, transporting and marketing the final product (Cockrill 1963). Lawrie (1962) emphasises the paradox that our direct enjoyment of the commodity lasts for only a few minutes although it may have taken years to produce.

Unlike milk which is consumed in the natural state and which is a well-defined easily homogenised product, meat is distressingly heterogeneous in composition (Dumont 1965; Pomeroy 1965*a*) and in other "quality" attributes. The evaluation of these organoleptic qualities of meat, which are affected by regional, national, and even local culinary habits, frequently defies biological interpretation (Doty 1960). These factors of *meat* quality have been reviewed recently (Renou 1962; Scheper 1962; Dumont and Renou 1965).

This present contribution attempts to place in perspective the importance of *carcase* evaluation to the producer, the processor and the consumer. It deals, in particular, with commercial carcase grades; their use and the reasons for change; and how these changes, in turn, relate to standards set in research investigations.

II. CARCASE EVALUATION AND THE CONSUMER

Recognition of differences in meat cuts and fatness extends back in antiquity-the loin, for example, being prized by heirarchical members of the Court—but the real emphasis on improvement is a comparatively recent development.

The quest for improvement is encouraged by the demand for meat which is influenced in large part by the accumulation of wealth. In the United States of America (U.S.A.), for example, beef imports largely from Australia and New

*Ruakura Agricultural Research Centre, Private Bag, Hamilton, New Zealand.

Zealand (N.Z.) have increased by 100% in the last decade, accounting for about 10% of domestic consumption in 1964 (C.E.C. 1965). This dynamic demand for beef reflects a growing population and affluence that has increased consumption from 50-90 lb/head/year in 15 years.

Selectivity of the consumer increases, however, as the demand and price rises and today there is a general appreciation of the close interrelations between efficiency of animal production on the one hand, and processing, marketing and consumption on the other. Rapid expansion of world transport and trade, coupled with demands for animal protein, has substantially increased the movement of meat and meat products at all levels of trade organisation. This trend will undoubtedly continue and the resulting diversity of consumer demand supports Friedlander's (1964) view that, "The first important factor (in meat production and research) is the necessity of breaking down the barriers previously existing between primary production, processing and marketing so that one can have a direct line of communication. . . . " Study of isolated components of this integrated system is probably one further reason for our lack of progress for, "Accuracy of appraisal decreases at each processing point along the chain from dinner plate to the live animal " (Butler 1960).

The spasmodic progress in meat production efficiency during the two centuries since Robert Bakewell (1725-1795) is also due to a lack of rational objectives, especially at the consumer level (Pomeroy 1965*b*). Dumont (1961) and Donald (1963) emphasise the difficult task facing the meat production geneticist. Numerous complex characteristics must be considered to cater for immediate needs. The technical and economic definition of the chosen characters poses serious problems. A forecast of the requirements 20-30 years hence must be made; and the great diversity of production methods and different environments should also be included in the appraisal.

III. COMMERCIAL CARCASE EVALUATION

Wardrop (1964) defines grading as, " . . . a process which attempts to divide a heterogeneous group of material into sub-groups, within each of which the material has similar characteristics." A recent report on meat grading in New Zealand comments, "Efficient grading results in the producer being rewarded for the production of the grade of meat in greatest demand at particular times and in particular markets, and allows of the product being bought on its grade mark without inspection " (M.E.G.I.C. 1965).

Many of the basic principles of beef grading (Kiehl and Rhodes 1960; Pierce 1960) are equally applicable to the grading of sheep and pig carcases. Conformation or shape, "finish" or fatness, and "quality" are three major factors determining grade in all species. Each of these visually appraised factors is now under close scrutiny.

(a) Visual Appraisal

When reviewing carcase appraisal and meat grading, Hammond (1963) approved of subjectively applied grades although he recognised that, "In all systems of grading, the details require to be aimed at a special market . . . and need to be revised from time to time to meet changes in public demand." Australia

and New Zealand both export meat to many countries (Aust. Meat Bd. 1965; N.Z. Meat Prod. Bd. 1965). As each importing country has specific demands, graders are faced with a host of diverse requirements. Dumont (1965) notes that "nationalism" is one of the limiting factors to advancement of knowledge in meat production and grading, for it leads to partial solutions which are not translatable to other countries.

Bray (1963) suggests that although visual grade is one of the simplest and perhaps most used research tools, it is one of the most meaningless. Grading authorities in the U.S.A. (Fed. Reg. 1965) state that, "The inability under the present Federal (visual) beef grade system to more precisely identify the yield of meat has forced many retailers to develop individual purchase specifications. Since each specification is slightly different the full force of competition cannot be directed against the total beef supply."

Visual appraisal of quality characters in pig carcases (Harrington 1958; Harrington and Pomeroy 1961; Gatherum, Harrington and Pomeroy 1958, 1961; Pomeroy 19658) although receiving some support (Bostock 1964) is rejected by others (Downey 1961; Fagan 1965). Buck (1963), for example, states, "Visual scores . . . made on the shoulder, ham and streak and on the carcase conformation, bear no relationship to the proportionate weights or to the leanness of the respective parts of the carcase. They reflect only the requirements of the trade which are based on shape and are not substantiated by dissection." Tayler and Rudman (1963) reached a similar conclusion for beef carcase grading in the United Kingdom (U.K.) where, according to Vial and Kelly (1963), there is a tendency to give a premium to fatter carcases which are associated with reduced lean portions and heavier bone. The last authors conclude, "There is little sense in a grading system which penalises the farmer producing lean carcases, and at the same time forces butchers to charge higher prices than are necessary to allow for trimming of superfluous fat." More recently, in the U.K., results on some 5,000 graded beef carcases have been examined (Anon. 1965); the weights of wholesale joints and the actual prices realised were related and it was found that, " . . . the current grading system did not reflect the relative value and profitability to the producer or wholesaler." This statement tallies with the fact that one wholesale organisation in the U.S.A. opposed the introduction of new grade standards on the basis that the high yielding, high quality beef carcases they were buying would cost them 5 U.S. dollars more if they were identified and sold on the basis of their value (Fed. Reg. 1965).

Edwards (1965), reviewing dairy beef production, states, "Grading standards of the past have become outmoded and where they remain in spite of change of taste they are increasingly ignored and by-passed by meat buyers." The reasons are clear. In the U.S.A., beef carcases of the same weight and visual quality grade showed differences of up to 179% in yields of trimmed, boneless retail cuts, with a correspondingly wide difference in value. Differences in the Choice grade, for example, of more than 15 U.S. dollars existed (Fed. Reg. 1965). Pierce (1960) quotes examples of differences in value between individual beef carcases of over 10 U.S. dollars per 100 lb carcase weight or over 60 U.S. dollars per carcase. In N.Z., Barton (1965*a*) has found variation of comparable magnitude in Aber-

deen Angus steers of the same age and carcase grade with price differences amounting to nearly 25 N.Z. shillings per 100 lb carcase weight.

Lamb carcase visual grading is likewise inefficient (Barton 1965a; Timon 1965), although the process has received less attention and criticism than beef. This may be partly because the magnitude of any financial discrepancy will be so much less for an individual lamb than beef carcase; and partly because lamb is most commonly retailed bone-in. The variation within visual grades of lambs may, in fact, be greater than for beef, for the grader has a far greater number of carcases to appraise within a given time. Seebeck (1965) concluded that there was a definite bias in the grading of Australian lambs within sex, breed of sire and age at slaughter discriminating against lighter leaner lambs. Other Australian (Robinson, Binet and Doig 1965) and N.Z. (Kirton 1964a; Ann. Rep. 1964-1965) work with sheep supports this contention. Timon (1965) comments, "Usefulness of subjective grading (of *lamb carcases*) is questioned as all of the carcase scores were biased towards, and almost completely determined by, level of fatness in the carcase."

Breeders of pedigree stock still valiantly defend the value of shape in their animals (Jones 1964), but there is a mass of scientific evidence refuting conformation as a factor of productive importance. The distribution of muscular tissue is very similar in animals of widely different conformation (Butterfield 1964). Shape appears closely related to the amount and distribution of fatty tissue in beef cattle (reviewed Everitt 1964; Riggs 1963; Butterfield 1965a; Dumont, Guelte and Arnoux 1961; Guelte, Dumont and Arnoux 1964), sheep (Boccard *et al.* 1961; Timon 1965) and pigs (reviewed Harrington 1958). Kirton (1964*a*), at Ruakura, paired 28 lamb carcases on the basis of conformation and carcase weight. Each pair contained one carcase of "very poor" and one carcase of "very good" conformation. He found that, " . . . these figures do not support the commonly held belief that carcases of better conformation contain more muscular tissue. In fact the results suggest that the carcases classified as having good conformation contained more fat."

In view of this wealth of evidence, it is surprising to find recently a report (Arbuckle and Alexander 1965) advocating a points system for judging live cattle at Australian shows. The authors state, "Since judging is usually done largely on the basis of trade suitability, (shows) serve as a means of telling the producer what type of carcase is currently required by meat processors." Butler (1960), in contrast, believes, "Fat slaughter cattle that look very similar alive are likely to show marked variation in carcase muscling. This is of major concern to the beef industry." Judging meat animals on their ultimate yield of edible meat (Everitt 1961; Barton 1965*a*) would appear a more progressive procedure.

Work with the pig carcase is not at variance with this general theme (Carroll 1964). Fredeen, Bowman and Stothart (1955) concluded, " . . . relationships obtained in this study strongly suggest that the tapered ham is leaner, a more desirable type, and that the present ideal of a plump ham, well-filled in the upper portion, actually favours the fatter ham." This latter suggestion is surely of substantial importance to the Australian and N.Z. lamb industries. The shape of the hind leg constitutes one of the principal criteria for subjective carcase evaluation;

it is believed that, at the same carcase weight, short legs have a more developed musculature than long legs. Scientific evidence now refutes this view (Boccard *et al.* 1961; Kirton 1964a). It is interesting to note, too, that the shape of the hind limb and, in consequence, that of the carcase, the two being closely linked, has no influence on the principal organoleptic characteristics (Boccard and Radomska 1963).

The question can therefore be raised, "Is the plump hind leg so avidly sought by the N.Z. producer of cross bred lambs more, or less, acceptable today than the tapered leg seen to advantage in the Merino-type lambs of Australia?"

The answer may lie in the method of presentation to the consumer. Where the commodity is marketed bone-in, a shapely leg is of some interest, as those who have experienced carving joints will know. But, on a boneless fat-trimmed basis, interest in shape rapidly fades. Here it must be recognised that there is a growing trade in boneless lamb cuts (N.Z. Meat Prod. Bd. 1965) resembling the early stages in development of marketing boneless fat-trimmed beef (Everitt 1961). It is noteworthy that about 90% of Australian mutton exports in 1962-63 were in boneless form (McKay 1964), while Colebrook (1965) predicts a great increase in the consumption of manufacturing meats in the U.K., resembling the trend in the U.S.A.

Grade standards, then, have not developed in response to expressed consumer interests but have been largely supported by meat producers and processors. Producers expected to benefit by using grades to tap a larger share of the consumer budget. It has rarely been questioned whether the grading standards taken from wholesale market practices have provided guides for maximising either efficiency of production or consumer expenditure and satisfaction. In the post-war struggle for markets between meat production areas, and between animal species, basic principles of the grading procedures have been challenged. Large scale studies have been undertaken. An illustration is the development (Ramsey, Cole and Hobbs 1962) of Yield Grading now operating for beef in the U.S.A. (Fed. Reg. 1965), with variants of the scheme under active consideration in the U.K. (H.M.S.O. 1964) and N.Z. (M.E.G.I.C. 1965). This attempt at uniformity of grading standards, with the virtual exclusion of visual appraisals, and the general recognition of a basic code of requirements will do much to foster international trade and render its expansion. Application of economic incentives for producers would hasten the process of acceptance. As the recent report on grading in N.Z. (M.E.G.I.C. 1965) states, "Emphasis on cutability as the main criterion in beef grading should secure the most rapid improvement in the quality of beef. It will bring home to farmers and drafters the need to avoid excessive finish thus eliminating costly trimming and therefore producing cattle most likely to show a greater return." It is, however, difficult to reconcile this tacit acceptance of yield grading in beef with continued support for visual grading of lamb (M.E.G.I.C. 1965).

(b) Objective Appraisal

Assessment of the yield of boneless, fat-trimmed cuts in beef-or "cutability" - is estimated in the U.S.A. by consideration of four characteristics: (i) amount of external subcutaneous fat; (ii) amount of kidney, pelvic and heart fat; (iii) area of the ***longissimus dorsi*** muscle cross-section; and (iv) carcase weight.

The cutability group, or yield grade, of carcases, quarters or cuts is determined from appropriate regression equations (Fed. Reg. 1965).

Butterfield (196%) has developed and used (Clark et *al.* 1964) regression equations for estimating carcase composition based on carcase weight, fat thickness over the ***Longissimus*** *dorsi* muscle and the weight of the dissected radius/ulna bone and associated muscles. Callow (1962) also found that foreshin dissection allowed estimation of carcase composition. Subcutaneous fat measurements were associated with two to three times as much variation in retail yield as were measurements of the ***longissimus*** *dorsi* muscle cross-section in the recent study of Hedrick et *al.* (1965).

The combination of yield grading with classification by specifications (Charles 1964; Charles, Butterfield and Francis 1965) has much to commend it. A system of classifying and marketing beef by specification of sex, age, weight and approximate carcase composition, as indicated by fat cover, is proposed. As Charles (1964) comments, "... this system would encourage the production of better quality beef no matter what the definition of quality in a particular trade. Demand for certain specifications must eventually result in higher prices being paid for the most suitable meat for current markets." Application of specification buying to lamb warrants attention.

IV. CARCASE EVALUATION IN RESEARCH

The objectives of many meat production investigations are similar to those of commercial grading; namely, the identification of animals producing edible meat most efficiently. Many of the principles underlying current revision of grading schemes originate from research programmes as, for example, in yield grading of beef. Confusion, however, has resulted from not knowing precisely what is required and this has, in turn, affected considerations of productive efficiency.

The objectives of carcase evaluation in research are defined by Pomeroy (1965a) as the measurement of the amount and distribution of various tissues (bone, muscle and fat) in the carcase. Dumont (1961) emphasises that optimum meat production in a technical sense is an inadequate definition and an economic component is also needed. He proposed the following parameter:

$$\frac{Q\ (C\text{-}R)}{T} \quad \ldots (1)$$

where,

Q = weight of carcase in kg
C = sale price of carcase in kg
R = cost price of carcase in kg
T = time (years) taken for production

suggesting it was sufficiently schematic for interpreting meat production efficiency. However, as Dumont points out, the expression suffers from parochialism.

This scheme of appraisal can moreover be criticised on the grounds that carcase weight is of variable composition. Such a formula breaks down if a large proportion of the carcase is the most expensive product but of least demand—

fat. Berg and Butterfield (1965) propose that the percentage of fat in the carcase could be used as an index of marketing acceptability; this is an indirect measure of the proportion of muscular tissue in the carcase.

A second parameter, again forwarded by Dumont (1961), is thus superior:

$$\frac{\text{Weight of Muscle}}{\text{Given Age}} \quad \ldots (2)$$

and this can be reasonably extended to include the food intake required for production:

$$\frac{\text{Weight of Muscle}}{\text{Given Age}} \text{ per unit of food intake} \quad \ldots (3)$$

for 1 kg of muscle requires 1000 kcal compared with 8600 kcal for the production of 1 kg of fat (Witt 1961) with no evidence of genetic differences in the productive requirement (Nehring, Schiemann and Hoff man 196 1).

Model (3) satisfies two objectives. It approaches the expressed consumer requirement for lean meat; and it clarifies the objectives of nutritional and genetic experimental work. The last objective is important for the use of live weight or carcase weight as a sole parameter of performance can be misleading (Luitingh 1963).

One disadvantage of using rate of live-weight gain is that it makes no distinction between gain associated with skeletal growth and gain associated with muscular development (Gibson and Watson 1963). Another more serious disadvantage is variable fatness. Hargrove (1963) compared the performance of Brahman, Shorthorn and their first crosses adjusting the carcases to a fat-constant basis of 1297 kcal/lb using the method of Meyer (1960). A striking change in ranking order of the breeds was recorded depending upon the inclusion or exclusion of fat in the comparison. Hargrove comments, "The point is that animals must be produced with the genetic potential of storing the proper amount of fat or economy of production will be lowered." Martin and Torreele (1965) found that the variation within breeds of dual-purpose cattle was greater than between breeds in most of the carcase characters studied. At a given weight or age, animals of larger mature size will gain more rapidly on less feed than animals of smaller mature size, and, further, carcases of the larger animals will contain a higher proportion of bone and muscle and a lower proportion of fat (Kidwell and McCormick 1956; Mason 1963, 1962, 1964; Langlet 1965). These facts underlie the current marked interest in such breeds as the Friesian and Charolais for beef production.

Recent investigations reveal that breeders of British-type breeds of cattle have succeeded in developing animals that will store a large amount of fat at a young age. Bond et *al.* (1965), for 'example, compared several breeds and crosses under different planes of nutrition and reached the startling conclusion that, "The Angus was the most efficient breed in fat production"; a conclusion supported by the studies of Witt (1965). There is little reason to suppose that breeders of British-type meat-producing sheep have performed differently.

Cole et *al.* (1964) examined the effect of type and breed of British, Zebu and dairy cattle on beef production and concluded, "These results depict the role that fat plays in depressing % separable muscle, separable bone and protein and the yield of major untrimmed wholesale joints among breeds", a conclusion in line with other studies (reviewed Everitt 1964; Holme 1963; Guelte, Dumont and Arnoux 1964; Hedrick et ***al.*** 1965). Current research in the U.K. on the use of Charolais sires on dairy cows suggests that, " . . . the apparently much greater efficiency of food conversion of the Charolais crosses from British breeds can be largely though not entirely explained by the difference in the degree of finish of the crosses compared (Boyd, D. A.; personal communication). Luitingh (1963) and Lucas (1964) agree that the whole problem of efficiency of growth and fattening is complicated by lack of knowledge of the nature, and therefore the energy value, of the gains during specific periods. A solution to this problem must be found before any absolute energetic efficiency values can be calculated.

The solution will need to be sought in techniques of assessing body and carcase composition of animals, with special reference to the proportion of fat. It is not intended to deal here with the battery of techniques now in use; these have been reviewed elsewhere (Bray 1963; Hedrick et al. 1963; Morris and Moir 1964; Panaretto 1964; Kirton 1964b; Timon and Bichard 1965; Joblin 1965). The search for correlations will continue.

Greater attention does need to be given to fundamental aspects of growth and development, especially where these can be integrated with practical aspects of carcase evaluation. The studies undertaken by Pomeroy (1965*a*) and others (Butterfield 1965*a*; Butterfield and Berg 1965*b*) are good examples in this connexion. The recent challenge of traditional concepts of growth (Elsley, McDonald and Fowler 1964; Tulloh 1964*a*), with revived interest in allometric principles (Boccard, Dumont and Lefebvre 1962; Tulloh 1964*a,b*; Butterfield and Berg 1965*a,b*; Everitt and Jury 1965), provides a sound basis for a renewed approach. The current belief that excess nutrients at ***any*** stage of growth are converted into fat (reviewed Lucas 1964) and that rapid rates of gain in the early stages of fattening may be detrimental to carcase quality. (Boccard and Duplan 1961; Henrickson, Pope and Hendrickson 1965; Duckworth 1965; Fowler 1965) illustrates the need for further nutritional studies involving carcase evaluation.

Investigations of "abnormal" conditions may indicate profitable methods of improvement in normal meat-producing animals. Muscular hypertrophy (reviewed Lauvergne, Vissac and Perramon (1963), or hyperplasia, as suggested recently (Butterfield 1965*c*), is a good example. Basic features of this condition are a high proportion of tender muscle; a large muscle:bone ratio, with a low proportion of fat—all highly desirable features. The condition shows variable expressivity but it is interesting that it is most clearly recognised in those breeds of cattle at present in great demand for beef production (e.g., Charolais, Limousin). Can the anatomical and physiological components of this condition be recognised in other species and breeds of meat-producing animals and, if so, what is the extent of their heritability?

The design of experiments involving a measure of carcase composition and evaluation also needs reviewing. Several of the classical meat-production experi-

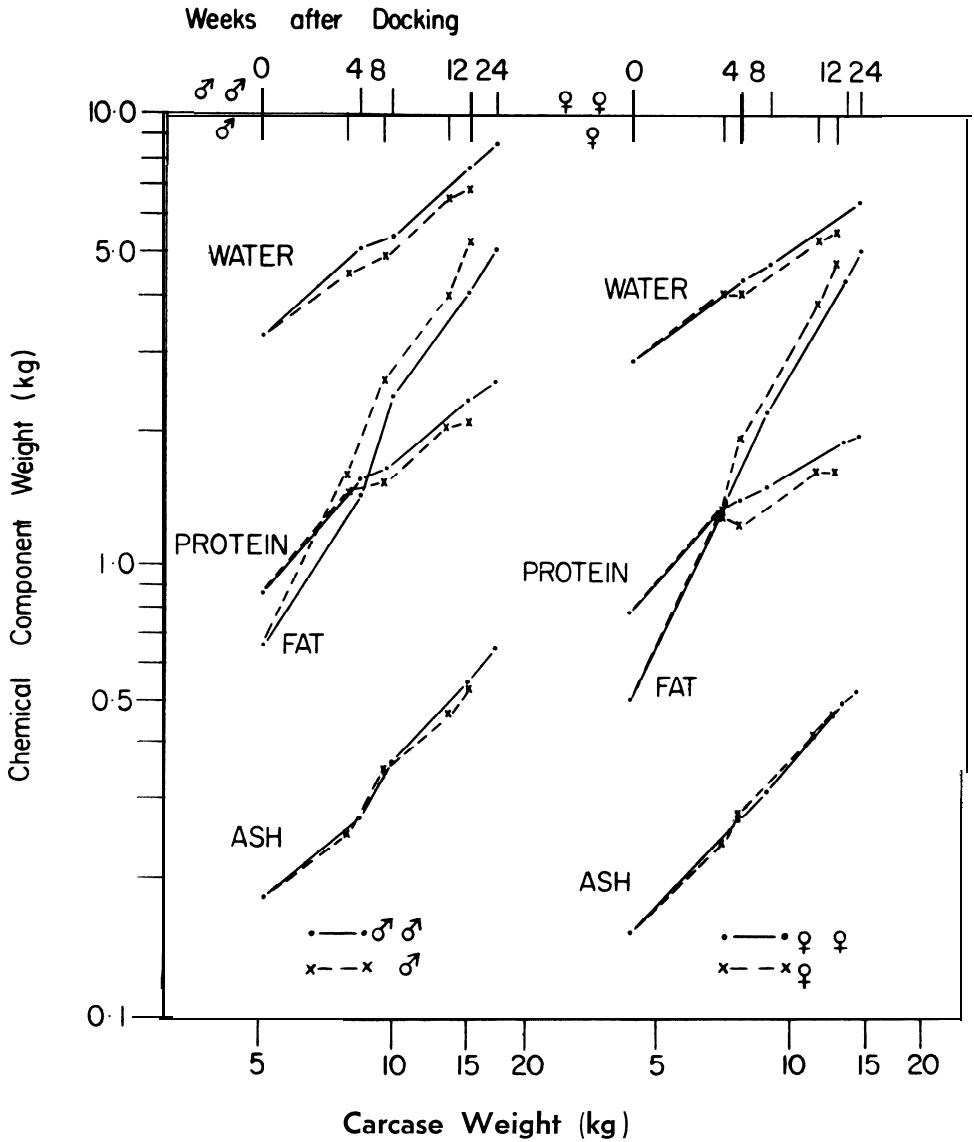

Fig. 1.-Relative growth of chemical components in lamb carcases.
(From Everitt and Jury 1965; reproduced by kind permission of the Editor of the Journal of Agricultural Science.)

♂ ♂ = Entire male.
♂ = Castrated male.
♀♀ = Entire female.
♀ = Spayed female.

ments have recently been criticised on grounds of design and analysis (Buck, Harrington and Johnson 1962; Elsley, McDonald and Fowler 1964; Tulloh 1964*a*). An experiment examining the effects of sex and gonadectomy on the growth and development of lambs (Everitt and Jury 1965) was of comparative slaughter design with sequential sacrifice of small numbers of individuals in

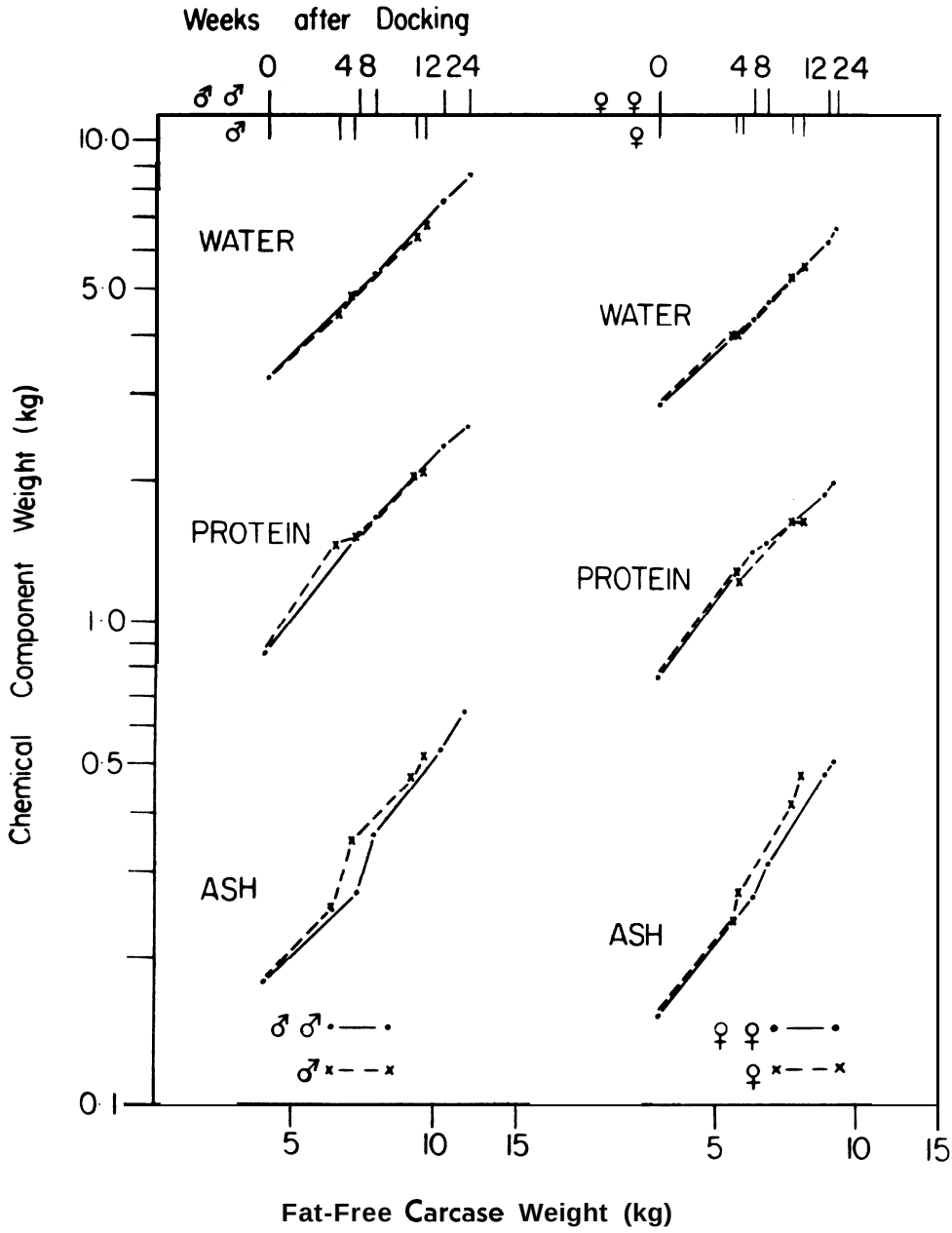

Fig. 2.—Relative growth of chemical components in fat-free lamb carcases.
♂ ♂ = Entire male.
♂ = Castrated male.
♀♀ = Entire female.
♀ = Spayed female.
(From Everitt and Jury 1965: reproduced by kind permission of the Editor of the Journal of Agricultural Science.)

place of the slaughter of a large number at one time or weight. Figure 1 shows that this design yielded useful information on carcase compositional changes, while Figure 2 indicates the small variation in chemical composition of the lamb carcases on a fat-free basis. Moreover, such a design permits evaluation of the time taken to achieve a specified level of carcase fatness.

Pomeroy (1965*a*) proposes such a sequential slaughter pattern so that by statistical methods animal performance may be compared at a constant level of carcase fatness. Since the level of fatness affects considerations of feed conversion efficiency (Meyer 1960; Witt 1961, 1965), carcase composition and conformation (Tayler and Rudman 1963; Tayler 1964; Everitt 1964) and meat quality (Renou 1962), it is vital that this should be standardised in any given experiment. The difficulties of interpreting trials terminated on either weight constant, time constant or equal "finish" bases have been discussed by Pomeroy (1965*a*) and Dinkel et *al.* (1965). The last workers also deprecate the use of ratios and percentages involving weight as a denominator-a conclusion in line with Tulloh's (1964*a,b*) proposals. Use of a "fat-corrected" carcase where weight gains are adjusted (by covariance analysis) to equal energy content (reviewed Meyer 1960) appears desirable. Lofgreen (1965) finds this a superior procedure to using weight gain, or weight gain in association with dressing-out percentage and grade.

The ultimate objective should be to base all comparisons on either a fat-corrected or a fat-free carcase basis. Either procedure approaches the requirements of model (3) proposed earlier.

V. CONCLUSIONS

The fact that shape is quite largely determined by the amount and distribution of fat, leading to the rejection of conformation as a factor of great productive importance by scientists, if not pedigree breeders, represents a notable recent trend in carcase evaluation. Fat is in least demand by consumers; it affects the yield and distribution of lean meat; and at the same time it is energetically most expensive to produce. There seems little point, therefore, in the continuation of traditional breeding policies. Rapid growth rate, coupled with high feed conversion efficiency, leading to maximum muscle production represent parameters of greatest importance.

Meat animals need to be appraised on their yield of muscular tissue, or at least edible meat, and the use of score cards based on linear measurements and visual appraisals seems unprofitable. Standardisation of procedures is urgently needed in commercial and research spheres of evaluation.

Greater attention needs to be paid to the composition of weight change. Acceptance of a fat-corrected or fat-free carcase would lead to considerable progress.

Techniques for evaluation of body and carcase composition continue to warrant the substantial support of research authorities. As Mason (1964) aptly comments, "There are no short cuts to the desired end. . . . "

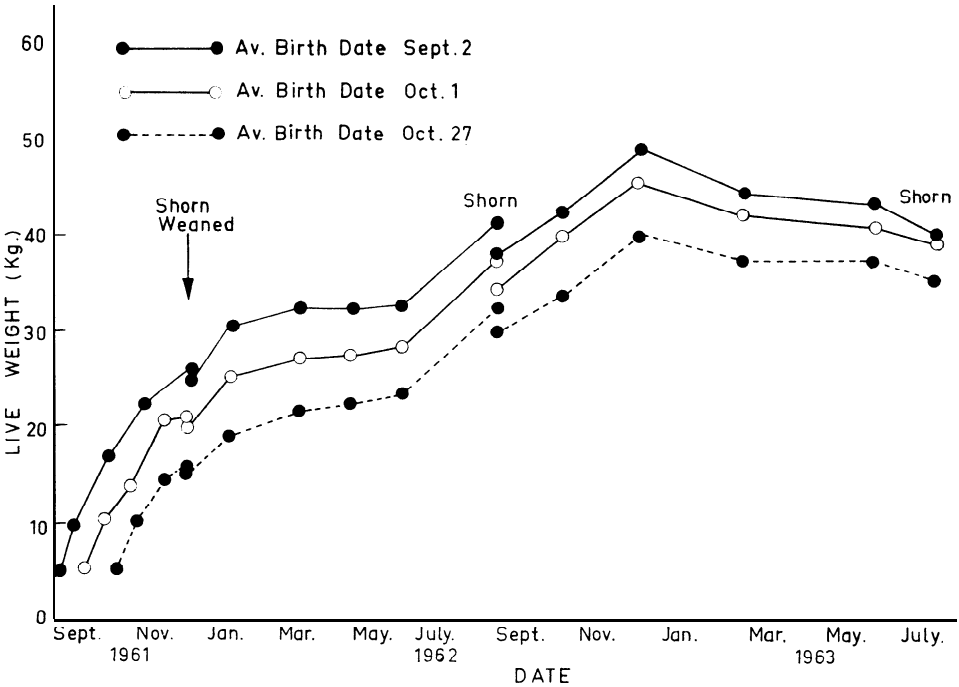

Fig. 2.—Liveweight change 1962-64 of sheep born 14, 11 and 8 weeks before pasture maturity 1962.

IV. DISCUSSION

Variation in the timing of birth in relation to the drying off of pastures and in the age at weaning, has been accompanied by differences in growth and wool production which have persisted for at least two to three years. Furthermore, the different early treatment appears to have resulted in differences in reproductive performance at two years of age. Differences in wool production and liveweight at the first post-weaning shearings were probably associated with differences in age between groups, but at later shearings, age differences were of minor importance. Although the number of ewes per group was small, differences in reproductive performance were likely to occur because of differences in liveweight at mating (Coop 1962).

It is not possible to decide from these observations whether the differences in results were a consequence of the timing of birth in relation to seasonal nutritional stress or of differences in age at weaning, but it seems likely that the former factor was the more important.

Certainly Watson and Elder (1960) and McLaughlin (unpublished data) did not find that early‘ weaning of lambs (at 10-12 weeks of age) on to mature pasture had any adverse effect on growth relative to unweaned lambs. McInnes and Briggs (1964) showed that crossbred lambs weaned at seven weeks of age and fed a high protein diet grew as fast as unweaned lambs offered a similar diet.

BUTTERFIELD, R. M., and BERG, R. T. (19653 Relative growth patterns of corn tnercially important muscle groups of cattle. *Research in Veterinary Science* (in press).

CALLOW, E. H. (1962). The relationship between the weight of a tissue in a single joint and the total weight of the tissue in a side of beef. *Animal Production 4: 37.*

CARROLL, M. A. (1964). Commercial cut-out and carcase composition of pigs killed at 200 lb. and 260 lb. live weight. *Proceedings 10th European Conference on Meat Research, Copenhagen.*

C.E.C. (1965). Meat-a review. Commonwealth Economic Committee, page 1. (London: H.M.S.O.).

CHARLES, D. D. (1964). Classifying trade beef by specifications. *Australian Veterinary Journal* 40: *27.*

CHARLES, D. D., BUTTERFIELD, R. M., and FRANCIS, J. (1965). Marketing beef by specifications. *Agriculture (London) 72: 167.*

CLARK, K. W., DUDZINSKI, M. L., BUTTERFIELD, R. M., and BENNETT, D. (1964). The muscle, fat and bone content of Angus steer carcasses as affected by stocking rates. *Australian Journal of Agricultural Research* 15: 858.

COCKRILL, W. R. (1963). International problems and practices in meat hygiene. *Veterinary Record* 75: *875.*

COLE, J. W., RAMSEY, C. B., HOBBS, C. S., and TEMPLE, R. S. (1964). Effect of type and breed of British, Zebu and dairy cattle on production, palatability and composition. III. Percent wholesale cuts and yield of edible portion as determined by physical and chemical analysis. *Journal of Animal Science 23:* 71.

COLEBROOK, P. M. (1965). The role of the retail meat trader. *Bulletin of the Znstitute of Meat 48: 8.*

DINKEL, C. A., WILSON, L. L., TUMA, H. J., and MINYARD, J. A. (1965). Ratios and percents as measures of carcass traits. *Journal of Animal Science* 24: 425.

DONALD, H. P. (1963). Modern trends in animal health and husbandry: Livestock genetics. *British Veterinary Journal* 119: 12.

DOTY, D. M. (1960). Relationship between beef quality, grades and standards. *in* "Beef For Tomorrow". *National Academy Science—National Research Council Publication* 751: 53.

DOWNEY, L. A. (1964). Pig carcase competitions and some methods of judging. *in* "Carcase Composition and Appraisal of Meat Animals". Section 18: page 1. (Melbourne: C.S.I.R.O.)

DUCKWORTH, J. E. (1965). The influence of pre-weaning nutrition on subsequent growth and development of bacon pigs. *Animal Production 7: 165.*

DUMONT, B. L. (1961). Testing and selection for meat production in cattle. (Translated title.) *in* "Scientific Problems of Recording Systems and Breeding Plans of Domestic Animals", page 325 (Ed. E. Schilling). (Max-Planck Institute: N.A.T.O.)

DUMONT, B. L. (1965). Criteria for evaluation beef characteristics. *World Review of Animal Production* 1: 25.

DUMONT, B. L. GUELTE, P. LE, and ARNOUX, J. (1961) . Biometric study of beef cattle. I. Variability of the anatomic composition of the carcass of Charolais cattle. (Translated title.) *Annals Zootechnie* 10: 149.

DUMONT, B. L., and RENOU, Y. (1965). Particular problems posed by meat. (Translated title.) *Annals de la Nutrition et de l'Alimentation* 19: 289.

EDWARDS, J. (1965). Dairy herds and beef supply. *World Review of Animal Production* 1: 13.

ELSLEY, F. W. H., MCDONALD, I., and FOWLER, V. R. (1964). The effect of plane of nutrition on the carcasses of pigs and lambs when variations in fat content are excluded. *Animal Production 6:* 141.

EVERITT, *G. C.* (1961). A recent development in meat marketing for New Zealand. ***Bulletin of the Institute*** of ***Meat*** **31**: 2; 32: 2; **33**: 3.

EVERITT, *G. C.* (1964). Beef carcase appraisal by jointing. *in* "Carcase Composition and Appraisal of Meat Animals". Section 16, page 1. (Melbourne: C.S.I.R.O.)

EVERITT, G. C., and JURY, K. E. (1965). Effects of sex and gonadectomy on the growth and development of Southdown x Romney cross lambs. II. Effects on carcass grades, measurements and chemical composition. ***Journal*** of ***Agricultural Science*** (in press).

FAGAN, V. J. (1965). Observations on some aspects of the Smithfield system of pig carcass appraisal ***Experimental Agriculture and Animal Husbandry 5: 279.***

FED. REG. (1965). Official standards for grades of carcass beef. Federal Regulations (United States of America), Document 65: 3595 (Washington).

FOWLER, V. R. (1965). The effect of different growth rates to 50 lb. live-weight followed by high or low feeding levels for pigs slaughtered at pork weight. ***Animal Production 7:*** 284 P.

FREDEEN, H. T., BOWMAN, G. H., and STOTHART, J. G. (1955). Relationships between certain measurements of ham and carcass quality. ***Canadian Journal*** of ***Agricultural Science*** 35: 98.

FRIEDLANDER, J. A. P. (1964). Meat research from farm gate to consumer. National Agricultural Advisory Service ***Quarterly Review 66: 66.***

GATHERUM, D. P., HARRINGTON, G., and POMEROY, R. W. (1958). A study of certain subjective assessments important in animal improvement. ***Occupational Psychology 32*** :229.

GATHERUM, D. P., HARRINGTON, *G.*, and POMEROY, R. W. (1961). Visual judgments of quality in meat. ***Journal*** *of* ***Agricultural Science 57:*** 401.

GIBSON, D., and WATSON, J. H. (1963). A comparison of growth rate in twin cattle of eight breeds and crosses. ***Animal Production 5:*** 175.

GUELTE, P. LE, DUMONT, B. L., and ARNOUX, J. (1964). Biometric study of beef cattle. III. Variability in proportion of cuts and characteristics of carcass conformation in Charolais cattle. (Translated title.) ***Annals Zootechnie*** 13: 255.

HAMMOND, J. (1963). Carcase appraisal and meat grading. ***Commonwealth Royal*** *Agricultural Society (Sydney) 34:* page 1.

HARGROVE, D. (1963). Hybrid vigour and feed consumption. *in* "Crossbreeding Beef Cattle". Chapter 9 pp. 73-81. (Ed. Cunha, T. J., Koger, M., and Warnick, A. C.) (Gainesville: University Florida Press.)

HARRINGTON, G. (1958). Pig Carcass Evaluation. ***Commonwealth Bureau Animal Breeding Genetics.*** Technical Communication 12: page 1.

HARRINGTON, *G.*, and POMEROY, R. W. (1961). The yields of cuts from Wiltshire bacon sides in relation to length and other carcass measurements. ***Animal Production*** 3: 163.

HEDRICK, H. B., MEYER, W. E., ALEXANDER, M. A., LASLEY, J. F., COMFORT, J. E., DYER, A. J., and NAUMANN, H. D. (1963). Indices of meatiness in beef. ***Missouri Agricultural Experiment Station*** Research Bulletin 820: page 1.

HEDRICK, H. B., MILLER, J. C., THOMPSON, G. V., and FREITAG, R. R. (1965). Factors affecting longissimus dorsi area and fat thickness of beef and relations between these measurements and retail yield. ***Journal*** *of* ***Animal Science 24: 333.***

HENRICKSON, R. L., POPE, L. S., and HENDRICKSON, R. F. (1965). Effect of rate of gain of fattening beef calves on carcass composition. ***Journal*** *of* ***Animal Science 24:*** 507.

H.M.S.O. (1964). Committee of Inquiry into Fatstock and Carcass Meat Marketing and Distribution. Command 2282. pp. 322. (London: H.M.S.O)

HOLME, D. W. (1963). Effect of rates of gain on carcass quality in the bacon pig. ***Animal Production 5: 220*** P.

JOBLIN, A. D. H. (1965). The estimation of carcass composition of bacon weight pigs. ***Proceedings*** *of* ***the New Zealand Society*** of *Animal* ***Production 25: 26.***

JONES, E. (1964). The value to breeders of showing. *Journal of the Farmers Club,* May, 1964, page 63.

KIDWELL, J. F., and MCCORMICK, J. A. (1956). The influence of size and type on growth and development of cattle. *Journal of Animal Science* **15**: 109.

KIEHL, E. R., and RHODES, J. (1960). Historical development of beef quality and grading standards. *Missouri Agricultural Experiment Station Research Bulletin 728:* page 1.

KIRTON, A. H. (1964a). How important is conformation? *Proceedings of the Ruakura Farmers' Conference* : page 1.

KIRTON, A. H. (1964b). Assessment of body composition in the live animal. *Proceedings of the New Zealand Society of Animal Production 24:* 77.

LANGLET, J. (1965). Review of existing knowledge of genetic relationship of meat and milk production with special emphasis on experimental techniques and design. *World Review of Animal Production* 1: 31.

LAUVERGNE, J. J., VISSAC, B., and PERRAMON, A. (1963). Study of the double muscle character. I. Bibliographical account. *Annals Zootechnie* 12: 133.

LAWRIE, R. A. (1962). Some current aspects of meat research. *Bulletin of the Institute of Meat* **37**: *2.*

LOFGREEN, G. P. (1965). A comparative slaughter technique for determining net energy values with beef cattle. *in* "Energy Metabolism", page 309. (Ed. Blaxter, K. L.) (London: Academic Press.)

LUCAS, I. A. M. (1964). Modern methods of pig nutrition: the impact of recent research. *Veterinary Records 76:* 101.

LUITINGH, H. C. (1963). The efficiency of beef production in terms of carcass weight increase as influenced by the ration concentration and the age of steers. *Journal of Agricultural Science* 61: 127.

MCKAY, D. H. (1964). Meat production and markets. *Proceedings of the Australian Society of Animal Production 5: 226.*

MARTIN, J., and TORREELE, G. (1965). A contribution to the problem of beef production by dual-purpose cattle breeds. *World Review of Animal Production* 1: 79.

MASON, I. L. (1961). How big are our beef breeds? *Agriculture (London) 68: 7* 1.

MASON, I. L. (1962). Beef production in the United Kingdom (with particular reference to breeding). *Zootechnie* 11: 79.

MASON, I. L. (1964). Genetical aspects of breeding cattle for beef. *Veterinary Record 76:* 765.

M.E.G.I.C. (1965). Report to the New Zealand Meat Producers Board: Meat Export Grades Investigation Committee, October: page 1. (Wellington.)

MEYER, J. (1960). Some nutritional factors in beef production. *in* "Beef For Tomorrow". *National Academy Science—National Research Council Publication* 751 page 100.

MORRIS, J. G., and MOIR, K. W. (1964). Methods of determining the chemical composition of dead animals. *in* "Carcase Composition and Appraisal of Meat Animals". Section 2, page 1. (Melbourne: C.S.I.R.O.)

N.Z. MEAT PROD. BD. (1965). Annual Report (43rd). New Zealand Meat Producers Board, page 1. (Wellington.)

NEHRING, K., SCHIEMANN, R., and HOFFMAN, L. (1961). The evaluation of food energy depending on the level of nutrition. 3rd report. Experiments with beef cattle and sheep. (Translated title.) *Archives für Tierernährung* 11: 157.

PANARETTO, B. A. (1964). The estimation of body composition in living animals. *in* "Carcase Composition and Appraisal of Meat Animals". Section 1, page 1. (Melbourne: C.S.I.R.O.)

PIERCE, J. (1960). Beef grades and standards-past and present. *in* "Beef For Tomorrow". *National Academy Science—National Research Council Publication* 751: 48.

POMEROY, R. W. (1965*a*). Carcass evaluation. ***World Review of Animal Production 1: 83.***

POMEROY, R. W. (1965*b*). Carcass value and meat quality. ***Bulletin*** of ***the Institute of Meat*** 50: 5.

RAMSEY, C. E., COLE, J. W., and HOBBS, C. S. (1962). Relation. of beef carcass grades, proposed yield grades and fat thickness to separable lean, fat and bone. ***Journal of Animal Science*** 21: 193.

RENOU, *Y.* (1962). The organoleptic qualities of meat. (Translated title.) ***Annals Nutrition de l'Alimentation*** 16: 1.

RIGGS, J. K. (1963). Effect of crossbreeding on carcass characteristics in Texas. ***in*** "Crossbreeding Beef Cattle". Chapter 28, pp. 196-201. (Ed. Cunha, T. J., Koger, M., and Warnick, A. C.) (Gainesville: University Florida Press.)

ROBINSON, T. J., BINET, F. E., and DOIG, ALISON G. (1956). Fat lamb studies in Victoria. I. An assessment of the relative value of various external measurements for differentiating between various grades of export lamb carcasses. ***Australian Journal*** of ***Agricultural Research 7: 345.***

SCHEPER, J. (1962). On meat quality characters and the possibility of influencing them before slaughter. (Translated ttile). ***Zeitschrift*** *für Tierzüchtung und Zuchtüngsbiologie* ***77:*** 335; 77: 420.

SEEBECK, R. M. (1965). A comparison of the progeny of three breeds of fat lamb sires. ***Journal*** of *Agricultural* ***Science 64:*** 19.

TAYLER, J. C. (1964). The relationship between growth and carcass quality in cattle and sheep. A review. ***Empire Journal*** *of Experimental* ***Agriculture 32:*** 191.

TAYLER, J. C., and RUDMAN, J. E. (1963). The assessment of conformation and fatness in beef carcasses. ***Bulletin*** of ***the Institute*** of ***Meat 40: 2.***

TIMON, V. M. (1965). Interrelationships between carcass composition, carcass conformation and subjective carcass merit in fat lamb carcasses. ***Animal Production 7: 283*** P.

TIMON, V. M. and BICHARD, M. (1965). Quantitative estimates of lamb carcass composition. III. Carcass measurements and a comparison of the predictive efficiency of sample joint composition, carcass specific gravity determinations and carcass measurements. ***Animal Production 7:*** 189.

TULLOH, N. M. (1964a). The carcase compositions of sheep, cattle and pigs as functions of body weight, ***in*** "Carcase Composition and Appraisal of Meat Animals". Section 5, page 1. (Melbourne: C.S.I.R.O.)

TULLOH, N. M. (19643). Comparative breed studies of beef cattle. III. Carcass composition. ***Australian Journal*** *of* ***Agricultural Research*** 15: 333.

VIAL, V. E., and KELLY, W. R. (1963). Beef production: an Irish viewpoint. ***British Veterinary Journal*** 119: 448.

WARDROP, I. D. (1964). Beef grading: production, trade and technical considerations. ***Meat Industry Bulletin*** (July) page 1.

WITT, M. (1961). Economical aspects in breeding for production. *in* "Scientific Problems of Recording Systems and Breeding Plans of Domestic Animals". Page 1. (Ed. Schilling, E.) (Max-Planck Institute: N.A.T.O.)

WITT, M. (1965). Differences in feed conversion and carcass quality between Black Pied Lowland cattle and their F progeny, products of crossing with Aberdeen Angus, Yellow-Hill and Jersey. ***World Review of Animal Production*** 1: 101.