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Meat Production from Farmed Deer

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Abstract

The deer is considered as a meat producing animal and contrasted with domesticated livestock. A high rate of weight gain during spring/summer means that slaughter of young animals for meat production is most economic at about 15 or 27 months of age. Young deer carcasses have 50 – 80% less carcass fat than sheep and cattle. The rate of fat deposition was significantly different between animals up to 27 months of age and those older than 27 months when all stags were slaughtered during the spring/summer growing season, with regression coefficients in relating carcass fat (kg) to carcass weight being 0.23 and 0.34 respectively. Animals slaughtered in winter, ranging in age from 6 months to 8 years and from 21 to 92 kg in carcass weight, had an average carcass fat content of 2.87 kg (s.d. = 1.61 kg). Groups of mature stags were slaughtered at 7 different times of year and the carcass composition measured. These stags had a carcass fat content in late summer of 20 – 25% and virtually all the storage fat was mobilised over the 6-week breeding season. Fat was replenished very rapidly in spring.

Low voltage electrical stimulation of stags immediately after slaughter improved meat tenderness by 20 – 40% compared with non-stimulation, and holding carcasses overnight at 10°C further improved tenderness.

Keywords: Cervus elaphus, *meat, fat, carcass, seasonal changes, growth*

Introduction

For thousands of years man has harvested the deer as a food source whether to eat the meat raw, cooked, or smoked or to dry it for consumption at a later time. In considering meat production from farmed deer it is assumed that man has established managerial control and can organise the animal in the pattern of a traditional domesticated species, involving herding, yarding, weighing, drenching, ear tagging, live transport, and controlled abattoir slaughter. All this is now possible in New Zealand, Australia, China, the U.K. and to a lesser extent in a number of other countries. Because of the great range of temperament in different species of deer only a few seem to be amenable to farm management. The most important deer for farming in New Zealand is *Cervus elaphus* or red deer, and although the information presented in this paper is derived from this species the principles apply to many groups. The male animal will provide most of the deer meat in a newly developing industry for some time and for this reason information has been confined to stags only.

The introduction of deer into New Zealand and the explosive population growth of deer that followed has been documented by Challies (1985). There are now more than 250 000 farmed deer in New Zealand and a significant venison industry is beginning to develop. Most markets in the 1980s are seeking meat products which are high in protein and low in fat and energy. The deer with its low fat content offers an opportunity to improve the nutritional properties of human food as well as to improve the profitability of grassland farming. In this paper, basic data for red deer derived mainly from work at Invermay are presented; comparisons are made with traditional domestic livestock where appropriate.

The Deer as a Meat Producer

Seasonal growth

Irrespective of feed quality and quantity available deer exhibit a strong seasonal pattern of feed intake and liveweight gain. A typical stylised weight graph is shown in Fig. 1 where the information has been derived from stags (Fennessy *et al* 1981). Better weight for age performance is possible with concentrate feeding, but poorer performance occurs with management under difficult conditions such as in the Scottish hill country (Kay and Staines 1981; Blaxter *et al* 1974). However, the pattern of spring/summer growth and a relative lack of growth in autumn/winter is common to all environments. In New Zealand, age at slaughter for most farmed deer is about 15 or 27 months, as increases in weight during subsequent spring/summer periods are likely to be uneconomic in terms of feed costs.

Carcass as a proportion of liveweight

An important variable in assessing the efficiency

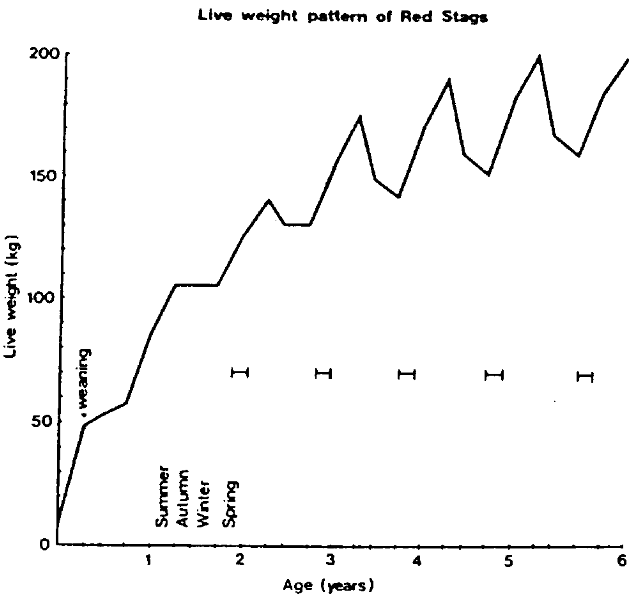


Fig. 1: General pattern of liveweight gain for red deer stags (from Fennessy *et al* 1981).

of meat production from various species is the proportion of liveweight which is clean carcass (dressing %). With increasing age from 6 to 27 months Invermay deer show a progressive increase in dressing % from 54.8 to 56.9% (Table 1). These figures are some 4 or 5 units higher than those published from hill deer in Scotland (Kay and Staines 1981). Mature pasture-fed stags at Invermay dress out at 59% (with little variation between seasons), this being similar to the value for penned deer fed a concentrate diet in Scotland (Blaxter *et al* 1974). Compared with other domestic ruminants, such dressing % values are high (40 – 50% for young sheep and cattle slaughtered at Invermay; Fennessy and Drew unpubl.). Therefore deer clearly exhibit a superior carcass weight to liveweight ratio compared with other species.

Musculature and carcass lean content

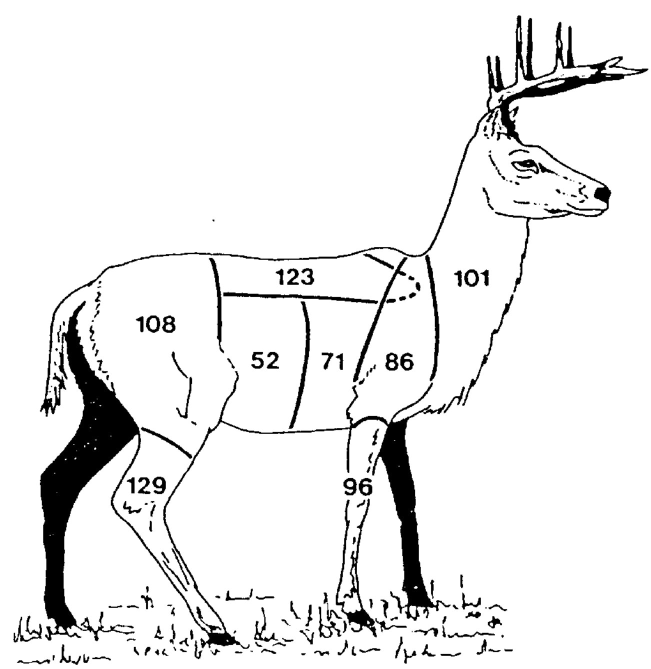
The high-priced cuts from any meat animal come from the hind leg and back. The deer has a different muscle distribution compared with cattle,

Table 1: Carcass as a proportion of liveweight in red stags (not fasted)

Age (months)	Carcass weight (kg)	Carcass weight/ liveweight (%)
6	24.4	54.8
12·	40.8	55.1
18	51.9	55.8
27	75.7	56.9

as shown in Fig. 2 which is derived from white-tailed deer but the principles apply to other species. Muscle groups in the hind leg and saddle areas are proportionately 8 – 23% heavier in deer than the same muscle groups in cattle, while muscles around the rib cage and shoulder are less well developed in the deer (Berg and Butterfield 1976). These developments have probably evolved over a long period in aiding the *fright and flight* reflex so well developed in deer to evade predators.

World feral venison trading has generally been in the 3 primal cuts of leg, saddle or loin, and shoulder as well as boneless meat from the ribs and neck. Table 2 gives the proportions of the carcass of young deer in these categories. The hind legs and saddles comprise high-priced cuts and the rest is of lower value. The carcass comprises 52 – 54% of high-priced cuts, 39 – 42% of second class cuts, and about 6% of discarded bone. A comparison of young deer and young sheep carcasses in terms of boned-out meat from the leg, saddle, and shoulder showed that the deer yielded 40% more first class carcass meat than sheep (Blaxter *et al* 1974). Lean, fat, and bone comparisons with Angus bulls are shown in Table 3. The pre-rut stag



Adapted from Berg & Butterfield, 1976.
Index figures are percentage of total muscle in each group relative to the same group in Cattle - 100.

Fig. 2: Muscle weight distribution of male white-tailed deer relative to bulls.

Table 2: Proportions (%) of salable cuts in red deer carcasses

	Age (months) 12	27
Number	5	5
Carcass weight (kg)	41	76
Component		
Hind legs	40.8	37.6
Saddle	14.7	14.8
Shoulder	18.9	18.1
Ribs and neck[1]	25.6	29.5

[1] Sold as boneless venison ("boneless B") with approx. 80% meat and 20% discarded bone

has proportionately slightly more lean and less bone than bulls and is of similar fatness. The lean/bone ratio clearly favours the deer. Post-rut stags are much higher in carcass lean and much lower in fat than bulls. Holstein (Fresian) bulls have a higher carcass bone content than Angus bulls and a lower lean/bone ratio (Maiga 1974).

Table 3: Dissected components of red deer and Angus bull carcasses (% side weight)

	Mature stags Pre-rut	Post-rut	Bulls[1]
Carcass weight (CW)(kg)	120	87	250
Composition (% CW)			
Fat	20.8	1.3	21.5
Lean	66.0	83.2	62.0
Bone	12.9	15.5	14.0
Lean/bone ratio	5.1	5.3	4.4

[1] Maiga 1974

Carcass fat content

Farmed stags are generally slaughtered at a weight where the fat content is 8 – 12% of the carcass weight. This contrasts sharply with commercial practice in the sheep and cattle industries (Table 4). The commercial deer carcass has less than half the fat of entire male lambs or cattle and about a third of the fat in commercial wether and steer carcasses.

Table 4: Carcass weight (CW) and fatness in lambs, bulls, and stags

	CW range (kg)	Carcass fat (% CW)
Ram lambs	15 – 20	22 – 27
Bulls	200 – 240	18 – 22
Stags	55 – 70	8 – 12

Effects of castration

As in all domesticated animal species the penalty for castration in males is a reduction in growth rate and an increase in fat content on an equal weight basis. Table 5 records some data from deer showing that castration reduced carcass weight at 27 months by 17% and increased carcass fat by 16% relative to entire stags at the same carcass weight (Drew *et al* 1978). The forequarter muscles in the castrate were 7% lighter and carcass water was some 3% less than in entire stags (Tan and Fennessy 1981).

Table 5: The effects of castration in stags

	Entire	Castrate	% Change
Carcass weight at 27 months of age[1] (kg)	67.7	55.8	– 17.4
Carcass fat in 60 kg carcass[1] (kg)	6.4	7.4	+ 15.6
Carcass water in 60 kg carcass[1] (kg)	37.9	36.8	– 2.9
Total dissected fore-quarter muscle[2] (kg)	14.60	13.58	– 7.0
Total dissected hind-quarter muscle[2] (kg)	18.40	19.61	+ 7.0

[1] From Drew *et al* 1978
[2] From Tan and Fennessy 1981

Meat Production from Deer

Carcass weight and composition

The most important variable in a meat-producing animal must be the fat content. In centuries past the high energy content of fat in meat probably had value because of the high expenditure of energy in the life style of the times. Nowadays, at least in western countries, high-energy fat is not nutritionally desirable. Much is yet to be understood about the basic mechanisms of fat deposition in animals and about the environmental and genetic factors important in controlling rate of fat deposition.

Deer appear to differ markedly from traditional domesticated species in that body fat is largely mobilised during the autumn rut and there is little capacity for replenishment during the winter irrespective of level of feeding (Drew and Suttie 1982). During spring and summer, however, fat deposition occurs in a similar way to that in sheep and cattle. Fig. 3 shows the increase in fat with increasing carcass weight. The regression lines are highly significantly different ($P < 0.01$) and show that stags older than 27 months at slaughter during the growing season (spring/summer) deposit fat at a much greater rate than stags under 27 months of age. In the young stags 1 kg of carcass gain comprises 0.23 kg of fat and this compares with 0.41 kg fat/kg gain in ram lambs (Fennessy *et al* 1982).

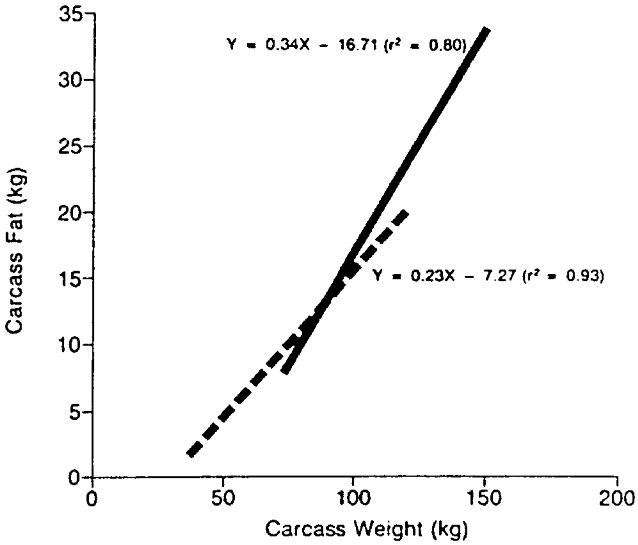


Fig. 3: The relationship of carcass fat (kg) to carcass weight (kg) in red stags.
-------- = stags slaughtered in summer and aged 12 – 27 months.
——— = stags slaughtered in spring/summer and aged more than 27 months.

Autumn and winter slaughter groups of mature stags consistently show carcasses almost devoid of fat. Yearling and 2-year-old stags with carcass weights 55 – 65 kg do not generally show a very pronounced rut and frequently have more fat in winter than old stags. Nevertheless, in winter the carcass fat content is very low irrespective of age: average carcass fat content from 31 stags aged from 6 months to 8 years and ranging in carcass weight from 21 to 92 kg when slaughtered in winter was 2.87 kg (s.d. ± 1.61). For lean meat production stags older than 3 years should be slaughtered in winter.

Seasonal changes in carcass composition

Groups of 4 mature red stags were slaughtered at 7 times of the year. Half carcasses were minced and analysed for water, protein, and fat. Table 6 shows the seasonal variation in liveweight from 203 kg in March (pre-rut) to 134 kg in late winter. Seasonal carcass changes in composition in mature stags are largely independent of feed offered and can be shown in stags fed *ad libitum* on pelleted rations (Blaxter *et al* 1974).

There is a substantial loss in carcass protein during the rut and this is matched by water loss so that carcass water/protein ratio remains about constant at 2.9 (Table 6). During winter when most carcass fat has been catabolised further protein is lost but much less carcass water so that water/protein ratio increases significantly to 3.3. With the onset of rapid spring growth carcass protein synthesis rises dramatically and there is a *lag effect* before water content rises. The carcass water/protein ratio falls to a seasonal low value of 2.64 in late spring. A reduction in carcass protein occurring between December and February appears to be anomalous and without obvious explanation. An increase in liveweight in late summer at a time when feed intake is falling has been observed by P. Fennessy (*pers. comm.*) in pen-fed stags and thought to be due to body water retention possibly associated with a rise in blood testosterone. In the present experiment there was a highly significant increase in carcass water in late summer which was not associated with a concomitant increase in carcass protein.

Carcass fat is mobilised during the rut so that during a period of 2 months 88% of carcass fat is catabolised (Table 6). Little further reduction occurs in carcass fat during winter and increased lipid synthesis is very rapid in spring when fat levels increase by a factor of 7 in 2 months.

Seasonal changes in non-carcass empty body were found to be similar to those in the carcass except that there was little drop in protein after the rut period.

Table 6: Seasonal changes in the composition of mature stags

Season	Liveweight (kg)	Carcass weight (kg)	Component weights(kg) water	protein	fat	Water/protein ratio
March	203	122	67.7	23.3	25.1	2.91
[Autumn rut]						
May	151	87	58.2	20.2	3.1	2.88
July	146	82	55.8	17.1	2.1	3.26
September	134	78	53.8	17.4	2.4	3.09
[Spring]						
November	168	96	53.4	19.3	18.6	2.77
December	181	111	61.6	23.3	19.3	2.64
February	196	112	61.8	21.6	22.8	2.86
March	203	122	67.7	23.3	25.1	2.91

Table 7: Dissected tissues from mature stags

	Pre-rut	Post-rut	Mid winter
Side weight (kg)	59.7	41.6	41.1
Lean (kg)			
Hindquarter and saddle	19.7	17.4	17.5
Forequarter	6.9	5.8	6.4
Neck and ribs	12.8	11.4	8.4
Lean/side weight (%)	66.0	83.2	78.6
Fat (kg)			
Hindquarter and saddle	7.3	0.3	0.03
Forequarter	0.8	0.1	0.01
Neck and ribs	4.3	0.2	nil
Dissected fat/side weight (%)	20.8	1.4	0.1
Chemical fat/side weight (%)	20.6	3.6	ND[1]

[1] Not determined

Assuming that a stag weighing 200 kg in late summer loses 50 kg during the rut it can be estimated that 71% of the whole body energy is lost during the 2 month rut. It is not surprising then that winter feed requirements for stags are high (Fennessy *et al* 1981) and that the animal is precariously balanced between life and death.

Dissected carcass components in mature stags

Separated lean as a proportion of side weight in Invermay experiments increased from 66% pre-rut to 83% after the rut and dropped slightly by mid winter (Table 7). Half of the lean tissue came from the high-priced hindquarter and saddle cuts. Similar Scottish work with 27-month-old stags gave 5% more lean tissue and 5% less fat than the Invermay mature stags slaughtered at the end of summer (Kay 1981). Pre-rut separable fat as a percentage of side weight agreed almost exactly with % chemical carcass fat (20.8% and 20.6% respectively) while the 1.4% post-rut separable fat was understandably a little lower than the 3.6% chemical carcass fat through some fat traces being left in the separable lean components (Table 7). Almost 60% of the dissected fat before the rut came off the hindquarter and saddle cuts. For all practical purposes there was no significant visible fat in the carcass after the rut.

Meat production per hectare of land

Experiments with yearling stags at Invermay have shown that deer can produce more than 700 kg carcass weight/ha in 170 days on first class agricultural land (Kelly *et al in press*). A summary is given in Table 8. The carcass production figures are mainly a consequence of the high rate of lean tissue synthesis and the low rate of fat deposition in the deer. It should be more efficient to convert feed to lean tissue rather than to fat and for this reason deer should be more efficient converters than sheep or cattle. More experiments are needed to investigate the comparative growth and efficiency of deer and domestic animals for meat production.

Table 8: Liveweight gain and carcass meat/ha from young stags — period covers September to February (spring/summer)

Year	Days	Stocking rate (/ha)	Growth rate (g/day)	Liveweight (kg/ha)	Carcass weight (kg/ha)
1	171	31.4	244	1219	731
2	170	30.7	226	1193	716

Venison quality

Pre-slaughter stress in many animals can lead to meat with poor keeping qualities and in this respect MacDougall *et al* (1979) found that the pH of meat from farmed deer 36 hours after slaughter was often higher than that from deer shot in the wild. The differences seemed to be associated with holding the animals in unfamiliar surroundings for some time before slaughter. Little information on this topic is available yet in New Zealand, but it could be important considering the need to truck deer to a slaughter house and hold them in unfamiliar surroundings prior to slaughter.

Another potential problem for a developing farmed venison industry is meat toughness arising from post-mortem carcass treatment. It is well known in the lamb industry that if carcasses are frozen before going through *rigor mortis* the meat after thawing can be very tough. Most deer slaughter premises have a very limited capacity to hold carcasses before freezing and the new technology of electrical stimulation is now being used. The system consists of electrical stimulation of the carcass with low voltage for a short time immediately after death (Chrystall and Devine 1983). This procedure can improve meat tenderness by 20 – 40% (Drew *et al* 1984). Holding non-stimulated carcasses at 10°C overnight improved tenderness by about 30% compared with holding them in a chiller at – 1°C from 2 hours post slaughter. When stimulated carcasses were conditioned at 10°C overnight, improvement in tenderness relative to rapid chilling was 5 – 10%.

Taste-panel testing using deer up to 27 months of age has been done to investigate possible differences between feral, grassfed, and feedlot raised venison. Forss *et al* (1979) have published the most recent findings in this work and concluded that there were no striking differences between the 3 venisons in tenderness, juiciness, flavour, or general acceptability.

The ultimate value of any meat production enterprise is the acceptability of the product on the consumer's plate. Table 9 shows that a 100 g portion of leg of venison has 44% less energy than a similar portion of lamb and 57% less than 100 g of rump steak. Venison can confidently be marketed as a health food for those people who don't like fat, want to limit their energy intake, or want to lower their saturated fatty acid intake while still enjoying a good meal of red meat.

Table 9: Energy value of meats

	Joules/100 g
Leg of lamb	1130
Rump steak	1460
Leg of venison	630

References

Blaxter K L, R N B Kay, G A M Sharman, J M M Cunningham and W J Hamilton 1974 *Farming the Red Deer*. HMSO, Edinburgh.

Berg R T and R M Butterfield 1976 *New Concepts of Cattle Growth*. Halsted Press, John Wiley and Sons, New York.

Challies C N 1985 Establishment, control, and commercial exploitation of wild deer in New Zealand. In: *Biology of Deer Production*. P F Fennessy and K R Drew editors, *Roy. Soc. N.Z. Bull. 22:* 23 – 36.

Chrystall B B and C E Devine 1983 Electrical stimulation of deer carcasses. *N.Z.J. Agric. Res. 26:* 89 – 92.

Drew K R, S F Crosbie and D A Forss 1984 Quality in farmed venison. *The Deer Farmer 22:* 51 – 53.

Drew K R, P F Fennessy and G J Greer 1978 The growth and carcass characteristics of entire and castrate red stags. *Proc. N.Z. Soc. Anim. Prod. 38:* 142 – 144.

Drew K R and J M Suttie 1982 Quality meat from farmed deer. *Proc. N.Z. Deer Farmers Assoc. Ann. Conf. No. 7:* 39 – 47.

Fennessy P F, G J Greer and J J Bass 1982 Progeny test of selected lean and fat rams. *Proc. N.Z. Soc. Anim. Prod. 42:* 137 – 140.

Fennessy P F, G H Moore and I D Corson 1981 Energy requirements of red deer. *Proc. N.Z. Soc. Anim. Prod. 41:* 167 – 173.

Forss D A, T R Manley, M P Platt and V J Moore 1979 Palatability of venison from farmed and feral red deer. *J. Sci. Food and Agric. 30:* 932 – 935.

Kay R N B 1981 The productive potential of domesticated deer. *Annual Report of the Rowett Research Institute 37:* 125 – 134.

Kay R N B and B W Staines 1981 The nutrition of the red deer. *Nutr. Abs. and Reviews 51:* 601 – 622.

Kelly R W, P F Fennessy, G H Moore, K R Drew and A R Bray (in press) Management nutrition and reproductive performance of farmed deer in New Zealand. *In: Biology and Management of the Cervidae.* C. Wemmer editor, Smithsonian Institution, Washington.

MacDougall D B, G B Shaw, G R Nute and D N Rhodes 1979 Effect of pre-slaughter handling on the quality and microbiology of venison from farmed young red deer. *J. Sci. Food and Agric. 30:* 1160 – 1167.

Maiga A M 1974 Physical and chemical composition of the carcass of the domestic bovine as influenced by breed, sex, level of feed intake and stage of growth. *PhD. thesis*, Cornell University, Ithaca, New York.

Tan G Y and P F Fennessy 1981 The effect of castration on some muscles of red deer (*Cervus elaphus* L.). *N.Z.J. Agric. Res. 24:* 1 – 3.