THE PRODUCTION OF VENISON AND BY-PRODUCTS FROM HILL COUNTRY

K.R. Drew
Invermay Agricultural Research Centre
Ministry of Agriculture and Fisheries
Private Bag, Mosgiel, New Zealand

SUMMARY

Hill country development in New Zealand is being accomplished by encouraging the development of an improved ryegrass/white clover pasture through the application of phosphate fertilizer, farm subdivision and controlled stock grazing. Stock management principles which have been developed for sheep and cattle can be applied to red deer in the production of meat, velvet antler and by-products. The efficiency of converting feed to animal growth favors the young deer mainly because of low carcass fat and high carcass protein when compared with sheep and cattle. Mature stags, however, can reach 21 to 24 percent carcass fat at the end of the summer and this reduces to 12 to 14 percent by the end of the breeding season. Calculations are made which show that carcass lean (protein + water) production with deer is 630 kg/ha compared with 330 from cattle and that fat gain/ha is 50 and 93 kg respectively.

INTRODUCTION

It is widely recognized that ruminant animals are relatively inefficient at converting the products of arable farm land into animals products when compared with species such as pigs and chickens (Cook, 1977). In the U.S.A., 27.1 million tons of cereal, legume and vegetable protein are produced each year 90 percent of which is fed to domestic livestock. However, world wide the situation is very different in that 25 percent of the world's protein requirements are met by domestic animals and yet these animals consume only 17 percent of the world's total vegetable protein (Krummel and Dritochillo, 1977). Eventually, arable areas must be used increasingly for the direct production of human food and not to feed ruminants. Productivity from non-arable hill land, however, is dependent on the ruminant animal with its ability to harvest its own feed over wide areas of difficult topography and on its unique ability to digest plant cell wall. In New Zealand, as in many countries, the potential for increasing production from hill lands is very high and particularly attractive because development requires more management skill than capital expense. Hill lands vary enormously in topography, climate, species of vegetation and seasonal plant production. Extremes in hill land productivity probably range from temperate and tropical land with adequate rainfall to areas in the Arctic and Siberia where plant growth is limited to a short summer. This paper will consider only the use of developed hill land and how deer can be farmed to advantage when compared with sheep and cattle. Much of the information will be drawn from New Zealand but many of the principles will apply to a range of environments.

PRINCIPLES OF HILL COUNTRY DEVELOPMENT IN NEW ZEALAND

- Minimize capital cost.
- Encourage the development of an improved ryegrass/legume pasture by the application of phosphate fertilizer and oversowing with inoculated seed and some grass seed.
- Promote farm subdivision, often with electric fencing in order to allow controlled grazing.

Fitzharris and Write (1981) carried out a survey on 80 hill country properties in the North East of New Zealand to investigate some factors of importance in productivity and profit. They found that farms with 20 or more paddocks had significantly higher production and profitability than those with less than 20 paddocks. They concluded "a minimum number of paddocks (about 25), with fencing into sunny and shady faces, allows maximum flexibility in the management of different age groups of sheep and cattle." Adequate subdivision is vital to achieve controlled defoliation of the sward and to utilize the majority of extra feed grown through improved farm management procedures. A true rotational grazing system with large groups of animals on hill country where the pasture is grazed for a short time and spelled for a long time, will increase plant production and forage utilization (Smith and Dawson, 1976).

PRINCIPLES OF HILL FARMING WITH DEER

The possibility of deer farming in New Zealand arose in the early 1970's partly because world prices for agricultural commodities such as beef had fallen to low levels and partly because of the booming industry in game meat from feral deer shot in the mountains and exported in the carcass form. There was opportunity to capture feral deer from helicopters and transport them to a farm rather than shoot them. Professor Coop at Lincoln College, New Zealand, held a group of deer on the research farm for three years and concluded that "the high stocking rates achieved, good reproductive performance and growth rates, and low mortality show that deer should produce just as much meat per hectare as sheep or cattle." There were considerable reservations, however, about the practicality of deer management because of the flighty nature of the animal and the difficulty of any yearling operation (Coop and Lamming, 1976).

New Zealand farmers found that most of the management techniques which had been developed in the pastoral farming of sheep and cattle could be applied successfully to deer. Many of the early farms were on rough hill country similar to the habitat of the feral deer.

Questions developed about whether the predominant red deer was a browser or grazer and how it would perform on high producing grassland. There are now approximately 200,000 farmed deer in New Zealand and they are seen in every kind of farming environment from high mountain range to first class dairy pastures.

EFFICIENCY OF MEAT PRODUCTION

The efficiency of conversion of feed to meat is usually defined as the units of feed required to produce an increment of 1 kg in body or carcass weight and is a function of two main factors as follows:

1. The energy cost of synthesizing body protein and body fat. Calculations have been made which put the net energetic efficiency of protein synthesis at about 85 percent and that for fat synthesis at around 70 percent. Recent studies, however, show that the

energetic efficiency of protein deposition in a growing animal is lower than the energetic efficiency of fat deposition, even though the efficiency of synthesis of protein is higher than that of fat (Webster, 1974).

2. The fat to protein ratio in the growing animal. Since the energy content of 1 kg of fat is about eight times that for a kg of fat-free lean tissue, there are significant efficiency advantages in minimizing fat deposition in meat animals. This frequently has been shown by comparing the production efficiency in bulls with that of steers. At equal weight, steers are always fatter than bulls and require more feed per kg carcass gain (Turton, 1969). In red deer, castrates have been shown to grow 17 to 20 percent more slowly and have 10 percent more fat at the same carcass weight than entire males (Dres et al., 1978).

Thus, meat animal production systems which maximize the production of lean tissue per kg of feed and per hectare of land will be the most efficient.

GAME ANIMALS FOR MEAT PRODUCTION

Meat production from game animals has been practiced in various forms by man for centuries, but out of 4,500 species of mammals, man has domesticated only 16 in an effort to meet his basic needs (Spillett et al., 1975). Martin (1969) reported "for all practical purposes, experiments with the domestication of large wild herbivores ended in the Neolithic period."

The ranching of game animals on rangelands is now receiving serious study in many countries (Ledger et al., 1967; Dasmann, 1964; Spillett et al., 1975; Drew, 1976). Reported advantages of game animals include increased disease resistance and heat tolerance in tropical countries and increased cold tolerance in high latitude areas as well as improved profitability in many environments. Common to most game operations, however, is the belief that more animal produce per hectare can be achieved with mixed species than with domestic livestock alone. In southern and midwest U.S.A., mixed animal species harvest the varied plant material more effectively than a single animal species as long as diet overlap is not extensive (Teer, 1975).

An important distinction should be made between ranching and farming. Most of the activities previously referred to are ranching operations where the animal harvest must be done with a rifle because it is not practical to yard and handle the game animals. Animal farming should be defined as a system of production where the animals are handled and managed "in the nature of farm livestock". The situation in New Zealand with deer has now reached the stage of a true farming operation where the animals are shifted at will by men on foot, horseback or motorcycle and with or without dogs, yarded for inspection, drenched with anthelmintics, ear tagged, vaccinated, weighed and transported on trucks to other farms or central slaughter plants.

Red deer have been found to be tractable, efficient converters of grassland to animal produce and interesting to work with.

OPERATION OF A NEW ZEALAND HILL DEER FARM

The operating principles are discussed for a farm located on steep to rolling hill country with only a small area of arable land. The farm has been a mixed sheep and cattle property in which some or all of the land area has been fenced to hold deer. The grassland productivity is maintained by aerial oversowing with phosphate fertilizer and sometimes with legume seed. The basic ryegrass/white clover sward is encouraged by controlled management where large numbers of animals are held on relatively small areas for a short time.

Farm Facilities

The perimeter wire mesh fence must be two m high and supported on 12 cm diameter wooden poles spaced about five m apart. The fence costs about 5 to 6 dollars per m. A set of deer yards is built in a strategic location so that a central raceway system can feed the animals from the large holding areas through smaller paddocks and eventually into the yards. Inexpensive subdivision fences using electrified wire can be used, but 2 m high divisions are required to separate mating groups in the fall. Temporary electric fences (60-70 cm) are used for break feeding deer on pasture. The animal handling yards are vitally important on all farms and the following are the essential features (Kelly et al., 1982):

- indirect approach of the yarding race,
- yard walls close boarded or solid,
- 2.25 m high walls,
- no sharp corners or projections, and
- darkened pen for handling.

Recently, mechanical crushes have been developed to assist in the restraint of deer particularly for disease testing and antler removal. Crushes are very useful when handling big animals such as Wapiti.

The Stock and Their Management

Most of the nucleus stock for deer farms came from feral red deer captured in the hills by helicopter. There were many difficulties in establishing these animals. Most animals are now born on farms, however, and are relatively manageable when handled frequently and quietly as calves. On a hill property, sheep and cattle can readily be herded from one large area to another. With deer, it is not simple and such techniques such as erecting a wing fence out into a paddock from a gateway are necessary to allow successful small-mustering. The concept of shifting deer from large areas to progressively smaller paddocks before entering a laneway to the yards is a good one. Fresh feed can be used as a lure to get deer through a gateway.

Seasonal Feed Management

Fennessy et al., (1981) reported that on an annual basis red deer are each equivalent to about two stock units (S.U., 1 S.U. = 55 kg ewe rearing 1.1 lambs to weaning), There are, however, large seasonal differences. In the winter, stags have very high feed requirements. They have mobilized most of their body fat during the autumn rut and have poor coat insulation and high metabolic heat production. Supplements of hay, grain, silage or feed pellets are necessary in winter. Because hinds calve in early summer, their high lactational feed requirements often come at a time when feed quality is low. Good pasture management using electric fences to keep the sward short during the spring is necessary to provide high quality vegetative pasture in summer. The calves can be weaned just before the breeding season and be given preferential feeding, drenching for internal parasite control, and frequent handling to facilitate tameness.

The techniques of farming deer on the hill country of New Zealand can best be summarized as adaptations of the basic skills required to farm sheep and cattle adapted to meet the seasonal feed requirements of deer.

MEAT PRODUCTION FROM DEER

To determine the optimal age for slaughter, the seasonal pattern of weight change must be known. Figure 1 demonstrates the seasonal weight pattern of red deer.

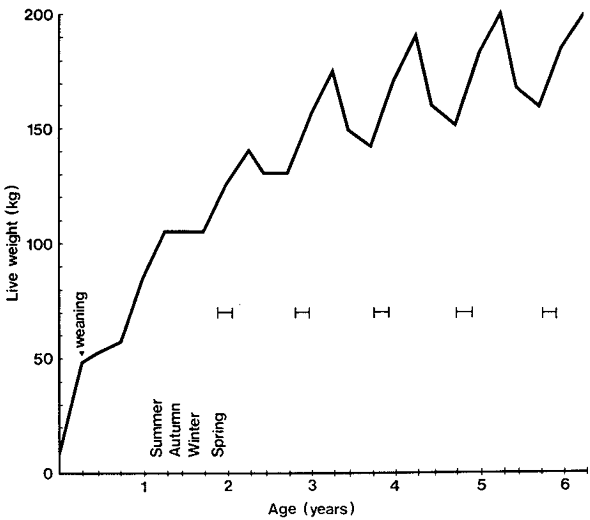

Figure 1. Live weight pattern of red stag deer as affected by season and age.

Stags reach about 70 percent of their ultimate body size by two years of age. This is probably the most economic slaughter point, although factors such as growth rate, costs of supplementary winter feed and the price for antlers from two year old stags all must be considered. The extreme seasonality of live weight change in old stags is clearly shown. Although seasonal fluctuations in available pasture may exaggerate seasonal weight changes, pen feeding studies with deer fed a pelleted feed the entire year have demonstrated a massive drop in dry matter intake from 3.5 kg per day to 50 g per day over a two to three week period in early fall (Fennessy, 1982). During this period of very low feed intake over the rut, there is a very substantial loss in body weight. Subsequently, winter fed intake rises to about 2 kg of dry matter which is sufficient to maintain the reduced body weight.

Muscle Distribution in Deer

Berg and Butterfield (1976) established that the proportional distribution of muscles in the "high priced" parts of the carcass (leg and loin) in cattle of widely differing body types and size remained remarkably constant. Analysis of the white tail deer, however, showed that there was 8 to 23 percent more of the side carcass muscle in the leg and loin than in cattle and much less of the side muscle in the shoulder and rib cage. The advantage of this for meat production from deer is obvious.

Red deer carcasses from New Zealand when cut, according to European requirements, give about 54 percent as loin and hind leg, 20 percent as shoulder and 20 percent as boneless venison from the neck and ribs.

Body and Carcass Composition

Carcass weight as a proportion of liveweight is an important meat production statistic. The value for red deer at 15 to 28 months is about 58 to 60 percent. This is 5 to 15 percentage units higher than that for male sheep or cattle grazing pastures at Invermay (Drew and Fennessy, unpublished data).

The chemical fat content of the deer carcass ranges from 6 to 12 percent for animals not more than two years of age and this is 1/3 to

1/2 of that in commercial lambs and cattle. Conversely, deer carcass protein content is very high (Table 1).

Table 1. Deer carcass composition compared with sheep, cattle and goats.

Species	Age	Carcass Wt.	Carcass Fat	Carcass Protein
	months	kg	---------- %	----------
Cattle*	18	225	25.2	14.4
Lambs¶	2	8.3	17.3	18.8
	4	14.6	28.0	16.0
	7	16.9	29.9	15.3
Goats§	ND	10.0	6.0	18.5
Deer	12	40.8	5.7	21.8
	27	75.7	11.9	20.7

* Maiga, 1974

¶ Everitt and Jury, 1966

§ Kirton, 1970

Experiments have been conducted to compare fatness in feral deer carcasses with those which have been grazed on farmland. Feral deer were leaner than similar farmed deer, but only because they were lighter at a given age. Regression analysis of carcass fat against carcass weight revealed that feral, farmed and feedlot deer all could be described by the same equation:

$$Y = 0.203\ X\ (\pm .01) - 3.34\ (\pm .74) \qquad (r = 0.92)$$

Where Y = percent chemical carcass fat and X = carcass weight (kg).

Stags which are older than two years deposit large quantities of fat in late summer and if slaughtered at this time can be grossly overfat. During the rut almost all the fat is lost (Table 2).

Table 2. Carcass fat in old stags before and after the rut.

Aged Stags	Chemical fat	Separable fat
	------- % carcass weight -------	
Pre-rut	24.0	20.7
Post-rut	4.2	1.3

In yearling stags, during the six months of spring and summer, a carcass gain of 26 kg was recorded of which 86 percent was lean tissue. The comparable figures for aged stags over the same period were 34 kg carcass gain and 37 percent lean tissue (Dres and Suttle, 1982).

Carcass Gain per Hectare of Land

Experiments at Invermay with young male deer grazed at 30 per hectare during the spring and summer showed that over 700 kg of carcass weight per hectare could be produced. The mean of measurements made over four years with cattle on nearby land was 443 kg per ha where weaner cattle were stocked at 5.4 to 6.2 per ha. Growth rates in the young stags ranged from 226 to 244 g per day (Kelly et al., 1982). The cattle and deer were comparable in terms of proportion of mature body weight. Further calculations from one year's data to compute the lean tissue, fat and ash gain per hectare from deer are compared with cattle in Table 3.

The cattle which were Friesian cross animals were estimated to have 21 percent of their carcass gain as fat in comparison with a 7 percent figure in deer. The deer gained almost twice the lean tissue per ha as cattle with half the fat. The carcass composition data in Table 3 is on a chemical basis and although some of the protein and water comes from bone, species differences remain.

Table 3. Increments of carcass protein, water, fat and ash from deer and cattle.

	Cattle*		Deer¶	
	kg/ha	% of carcass§	kg/ha	% of carcass
Period of assessment	270 - 330 days		170 days	
Slaughter weight (kg)	450		85	
Percent mature liveweight	56		47	
Carcass gain	443	100	720	100
Gain in protein + water	328	74	634	88
Gain in fat	93	21	50	7
Gain in ash	22	5	36	5

* Mean of 4 years (Monteath, unpublished)

¶ Data from Kelly et al., 1982 (Table 1)

§ Figures derived from Maiga, 1974

A consequence of the low carcass fat content in the deer is the lower energy content of venison as a table meat. The energy values of rump steak, leg of lamb and leg of venison are estimated to be 1460, 1130, and 630 joules per 100 g respectively. Game meat from deer has obvious health advantages for persons wishing to restrict energy intake.

SALEABLE NON CARCASS PRODUCTS FROM DEER

The partly grown antlers (velvet antler) from Wapiti, red deer, and some other species are valuable commercial items. After 60 to 70 days of growth the antlers can be removed from the deer, frozen, dried and later sold, mainly in the Orient, as a human tonic medicine.

Historically, the velvet antler trade has been an important influence on the development of the deer farming industry. Velvet antler is still an important product, especially for farmers who have built up large herds of stags selected on the basis of their velvet antler production. Currently, the New Zealand velvet antler is graded subjectively, but research in progress may enable a more objective grading system, based on the pharmacological activity of the antler products.

The size of antlers, and hence the yield of velvet antler, are positively correlated with body weight within deer species. In addition, larger species such as the Wapiti produce larger antlers than smaller red deer. Velvet antler yield also increases with age. The production of a stag as a two year old generally is less than half the yield as a mature six year old.

In addition to antlers, by-products such as hide, tail, ligaments, pizzle, and eye teeth are all commercially valuable.

CONCLUSIONS

Deer farming in New Zealand is advancing as fast as animal reproductive rate will allow. With approximately 200,000 deer presently being farmed, the population will rise to 750,000 by the end of the decade. In the mid 1970's, high prices for velvet antler stimulated efforts to capture feral deer and substantial investment from commercial sources was attracted into deer farming, thereby inflating prices paid for farmed deer. The industry has now settled down to a steady rate of development based on venison, velvet antler, and by-products. Profitability on today's prices places deer farming ahead of sheep and cattle by a factor of about three in terms of total gross margins.

In the U.S.A., the mixed vegetation rangelands certainly can be more effectively utilized by several animal species than by any one species. As efforts are made to improve plant production on the hill lands, game animals can be expected to improve the efficiency of converting the increment in plant biomass to animal protein.

LITERATURE CITED

Berg, R.T. and R.M. Butterfield. 1976. New concepts in cattle growth. Halstead Press, New York.

Cook, C.W. 1977. Use of rangelands for future meat production. J. Anim. Sci. 45:1476-1482.

Coop, I.E., and R. Lamming. 1976. Observations from the Lincoln College deer farm. Deer Farming in New Zealand: Progress and Prospects. N. Z. Soc. Anim. Prod. Pub. No. 5.

Dasmann, R.F. 1964. African Game Ranching, Permagon Press, Oxford. 75 pp.

Drew, K.E. 1976. The farming of deer in New Zealand. World Rev. Anim. Prod. XXII:49-60.

Drew, K.R. and J.M. Suttie. 1982. Quality meat from farmed deer. Proc. N. Z. Deer Farmers Assoc. Conf. Napier, New Zealand.

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. 38:142-150.

Everitt, G.C. and K.E. Jury, 1966. 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. J. Agric. Sci. (Camb.). 66:15-27.

Fennessy, P.F. 1082. Growth and nutrition. In: David Xerex (Ed.) The farming of deer. Agri. Promotion Assoc. Ltd, P.O. Box 10-128, Wellington, 1, New Zealand.

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.

Fitzharris, M.J. and D.F. Wright. 1981. Major farm management factors on Gisbourne hill country farms. Proc. N. Z. Grassl. Assoc. 42:213-216.

Kelly, R.W., P.F. Fennessy, G.H. Moore, K.R. Drew, and A.R. Bray. 1982. Management, nutrition and reproductive performance of farmed deer in New Zealand. Biology and management of the cervidae. Nat. Zool. Park, Smithsonian Inst., Wash. D.C.

Kirton, A.H. 1970. Body and carcass composition and meat quality of the New Zealand feral goat. N. Z. J. Agric. Res. 13:167-181.

Krummel, J. and W. Dritschilo. 1977. Resource costs of animal production. World Anim. Rev. No. 21:6-10.

Ledger, J.P., R. Sachs, and N.S. Smith. 1967. Wildlife and food production. World Rev. Ani. Prod. III:11-13.

Maiga, A.M. 1974. Physical and chemical composition of the carcass of the domestic bovine and influenced by breed, sex, level of feed intake and stage of growth. Ph.D. Thesis. Cornell Univ., Ithica, N.Y.

Martin, P.S. 1969. Wanted: a suitable herbivore to convert 600 million acres of western shrubland to protein. Nat. Hist. 70:34-39.

Smith, M.E. and A.D. Dawson. 1976. Hill country grazing management. Proc. N. Z. Grassl. Assoc. 38:47-55.

Spillett, J.J., D.B. Bunch, and W.C. Foote. 1975. The use of wild and domestic animals and the development of new genotypes. J. Anim. Sci. 40:1009-1015.

Teer, J.G. 1975. Commercial uses of game animals on rangelands of Texas. J. Anim. Sci. 40:1000-1008.

Turton, J.D. 1969. The effect of castration on meat production from cattle, sheep and pigs. In: D.N. Rhodes (Ed.). Meat production from entire male animals. J. & A. Churchill Ltd, London.

Webster, A.J.F. 1974. Efficiencies of energy utilization during growth. In: Lister, Rhodes, Fowler and Fuller (Eds.). Meat Animals: Growth and productivity. Plenum Press, New York.