New Zealand Journal of Agricultural Research, 1998, Vol. 41: 545–553
0028–8233/98/4104–0545 $7.00/0

A body condition score system and its use for farmed red deer hinds

L. AUDIGÉ*
P. R. WILSON†
R. S. MORRIS
Institute of Animal, Veterinary and Biomedical Sciences
Massey University
Private Bag 11 222
Palmerston North, New Zealand

*Present address: Institute of Virology and Immunoprophylaxis, CH–3147, Mittelhäusern, Switzerland.

Abstract A longitudinal observational study of 15 red deer farms in New Zealand was carried out for a 2-year period. To assess the body condition of deer, a scoring chart was developed with scores ranging from 1 (lean) to 5 (fat) with half-unit increments. Scores were given after palpating the tuber coxae, sacrum, and rump area of the deer standing straight and quiet. Repeatability and reproducibility were evaluated on 39 yearling hinds and 90 adult hinds on four properties which were independently scored twice by two assessors to investigate assessor bias and consistency.

A body condition score (BCS) was assigned to 1400 and 2100 hinds in consecutive years in March before mating, in September before calving, and in March of the next year at weaning. There were wide variations of individual hind body condition and mean hind body condition between farms. Overall, yearling hinds lost body condition during winter and subsequently during lactation up to weaning. Repeatability and reproducibility were above 0.8. There was variability between assessors confirming the need for training when more than one assessor is involved. It is proposed that the condition scoring chart presented here should be adopted industry-wide as a tool for the management of breeding hinds to achieve optimum reproductive performance, since BCS was significantly associated with conception rate, conception date, dystocia, weight of weaned offspring, and ability of the hind to rear a calf to weaning. A management plan for the use of this body condition scoring system is proposed.

Keywords body condition score; red deer hinds; reproduction

INTRODUCTION

It has been recognised that the ability of a yearling red deer hind to conceive is conditional upon the achievement of a weight threshold of 60–65 kg, or 70% of mature bodyweight (Kelly & Moore 1977; Hamilton & Blaxter 1980; Moore et al. 1985; Hamilton 1988). In adult hinds, body weight influences the timing of conception as well as conception *per se* (Guiness et al. 1978). In that age group, bodyweight is related to body condition (Mitchell et al. 1976).

The importance of body condition of deer to reproductive performance has been demonstrated in the wild (Mitchell & Lincoln 1973; Albon et al. 1986). In the deer farming environment, body condition has been suspected to be important (Yerex 1982; Heydon et al. 1992) but no studies have confirmed its significance. This may be because of the lack of objective methods to date to assess the body condition of live deer. Condition of wild deer has been commonly assessed post mortem by the amount of fat enveloping kidneys (Wegge 1975; Finger et al. 1981; Albon et al. 1986; Audigé 1992). The body condition of live deer has also been assessed visually in the wild (Riney 1955; Watson 1971), but it required close proximity to the deer and only large variation in body condition could be assessed.

It is therefore likely that body condition is an important factor along with bodyweight,

†Author for correspondence
A97081
Received 24 November 1997; accepted 12 May 1998

92

A.

Ideally, deer should be standing straight and quiet. The three landmarks used for body condition scoring are wings of pelvis, estimation of the depth of tissue over tuber coxae; sacrum: appraisal of the sharpness of spinous process; rump areas: appraisal of muscle mass and fat cover beside the sacrum. If deer bend their back legs under the palpation pressure, the assessment of the wings of pelvis should be ignored.. Scores range from 1 to 5 as described below with half unit increments.

Score 1: Very poor condition (Cachexia)

B.

Wings of pelvis are extremely prominent and sharp. Sacral spinous processas are very sharp. There is little muscle in the rump and no fat cover, the rump areas are very concave at palpation.

Score 2: Poor condition (Leanness)

C.

Wings of pelvis are prominent, but rounded and can be easily felt by palpation with slight finger pressure. Sacral spinous processes are slightly enveloped and not prominent. The rump areas are flat.

Score 3: Moderate condition

D.

Wings of pelvis are prominent, but rounded and can be easily felt by palpation with slight finger pressure. Sacral spinous processes are slightly enveloped and not prominent. The rump areas are flat.

Score 4: Good condition

E.

Wings of pelvis are rounded and can be felt by palpation under a thin layer of fat. Sacral spinous processes are enveloped and are felt by palpation only with firm finger pressure. The rump areas are slightly convex.

Score 5: Very good condition (fat)

F.

Wings of pelvis are concealed under a thick layer of fat and cannot be felt by palpation with firm finger pressure. Sacral spinous processes are well enveloped and not felt at palpation. The rump areas are convex.

Fig. 1 Body condition score chart for use in red deer.

influencing reproductive success of farmed deer. Indeed, above the threshold bodyweight for an individual, deer body condition may be a more important determinant of reproductive success than bodyweight *per se*. There have been no studies of the relationships between bodyweight, body condition, and reproductive success measured by pregnancy rate and date, calving rate, and weaning rate in farmed red deer. There has been no standard body condition scoring system developed for farmed deer in New Zealand. These factors prompted the need to investigate the relative importance of bodyweight and body condition in yearling and adult hinds, and define the optimal values for achievement of reproductive success.

This paper describes a body condition scoring technique, its validation, and application to red deer farming in New Zealand. Its potential use as a management support tool in commercial farms and for deer research is outlined.

MATERIALS AND METHODS

Data and deer used for this study were derived from 15 red deer farms in the lower North Island of New Zealand.

Scoring system

A body condition score (BCS) chart has been developed based on the system described by Russel et al. (1969) for sheep. Scores range from 1 (very poor condition) to 5 (very good condition) with half-unit increments, as described in Fig. 1.

This body condition scoring system was designed to fulfil several requirements: application for animals which may have a thick coat, in particular in winter; the parts of the body which are scored should be safely and quickly accessible by the assessor; the scoring system should detect minor change in body condition while remaining simple, and be usable on farms which may have limited handling facilities and poor lighting.

Condition scoring is ideally done with deer standing upright and relaxed in normal posture, in small numbers in small pens. To score, the assessor must palpate the tuber coxae, then move the hand over the sacral vertebrae to feel the spinous processes. The gluteal muscle (rump) area is assessed as to its concavity or convexity. If the rump region from the tuber coxae to the sacral spinous processes is flat, a score of 2.5 is ascribed. Scores are described in Fig. 1.

Repeatability and reproducibility

Thirty-nine yearling hinds and 90 adult hinds from four herds were independently scored twice on the same day by two assessors to investigate assessor bias and consistency (Evans 1978; Nicholson & Sayers 1987). One assessor, the senior author, was experienced, whereas the other assessor was trained on one farm prior to this investigation.

Repeatability, the proportion of the score variance attributable to scoring variation by the same assessor, and reproducibility, the score variance attributable to hind difference only, were calculated using the method described by Jansen et al. (1985). Analyses were carried out separately for yearling and adult hinds. The variability attributable to assessor, score, and hind was investigated by a three-way ANOVA using SAS Version 6.04 (SAS Institute Inc., Cary, NC, USA). Preliminary analyses were carried out to determine whether interaction terms were significant, and only statistically significant terms were included in the final model for calculation of repeatability and reproducibility. The final model and formulations are presented in Table 1.

On-farm variability

A body condition score was assigned by one assessor to 1400 and 2100 breeding hinds in 14 herds in Years 1 and 2 of the study, respectively, in March (autumn) before mating, in September (spring) before calving, and in March of the next

Table 1 Model components and calculation formula for the repeatability and reproducibility of hind body condition scoring.

Model $y_{ijk} = \mu + h_i + a_j + s_k + (ha)_{ij} + e_{ijk}$

Where :

y_{ijk} = body condition score on the i^{th} hind by the j^{th} assessor for the k^{th} score

μ = overall mean body condition score

h_i = effect of the i^{th} hind ($i = 1...n$)

all yearling hinds: $n = 39$

all adult hinds: $n = 90$

a_j = effect of the j^{th} assessor ($j = 1,m$ with $m = 2$)

s_k = effect of the k^{th} score ($k = 1,p$ with $p = 2$)

$(ha)_{ij}$ = interaction of the i^{th} hind with the j^{th} assessor

e_{ijk} = error term

Repeatability $r_1 = (v_{Total} - v_s - v_e) / v_{Total}$

Reproducibility $r_2 = v_h / v_{Total}$

where :

v_h, v_a, v_s, v_{ha}, and v_e are the variance components of h_i, a_j, s_k, $(ha)_{ij}$, and e_{ijk}, respectively.

and the total variance $v_{Total} = v_h + v_a + v_s + v_{ha} + v_e$

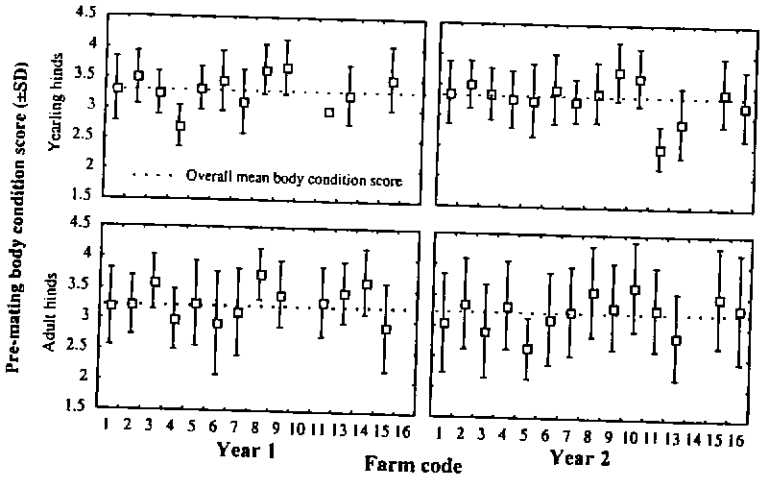

Fig. 2 Farm mean (±SD) yearling and adult hind pre-mating body condition score in Year 1 and Year 2 on 15 farms. Line is overall mean body condition score.

year at weaning. Descriptive data were calculated for each farm in each year, and overall seasonal patterns were computed.

The variability of hind body condition scores attributable to year, farm, deer age (yearling or adult), and seasonal differences (pre-mating, post-winter, and weaning), was investigated by a multiple-way ANOVA using the computer package SAS, Version 6.04. Second order interaction terms were included in the model.

RESULTS

Validation of the technique

Calculated variance components repeatability and reproducibility are presented in Table 2. There were highly significant effects of hind and assessor on BCS estimates of both adult and yearling hinds. A significant effect of scores was observed only with adult hinds. There was a significant interaction between hind and assessor, indicating that assessor differences varied according to the level of hind BCS, with greatest variation at high and low condition scores.

Body condition score distribution

Mean (±SD) pre-mating body condition scores of yearling and adult hinds on each farm in Years 1 and 2 are presented in Fig. 2. A summary of analysis of variance is presented in Table 3. There was significant variation of hind BCS to farm, age, and season ($P < 0.001$). There was no

Table 2 Analyses of variance, estimates of variance components, repeatability (r_1), and reproducibility (r_2) of body condition scoring in yearling and adult hinds. d.f. = degrees of freedom; *, $P < 0.05$; **, $P < 0.01$; NS = not significant.

Effects	d.f.	Mean type III squares	Estimates of variance components	r_1	r_2
Yearling hinds					
Hinds	38	2.3505 **	0.5598	0.91	0.81
Assessors	1	3.3910 **	0.0420		
Scores	1	0.1603 NS	0.0012		
Hinds × Assessors	38	0.1114 *	0.0243		
Error	77	0.0629	0.0629		
Adult hinds					
Hinds	89	2.8923 **	0.6612	0.89	0.79
Assessors	1	1.4694 **	0.0068		
Scores	1	0.3361 *	0.0014		
Hinds × Assessors	89	0.2475 **	0.0793		
Error	179	0.0889	0.0889		

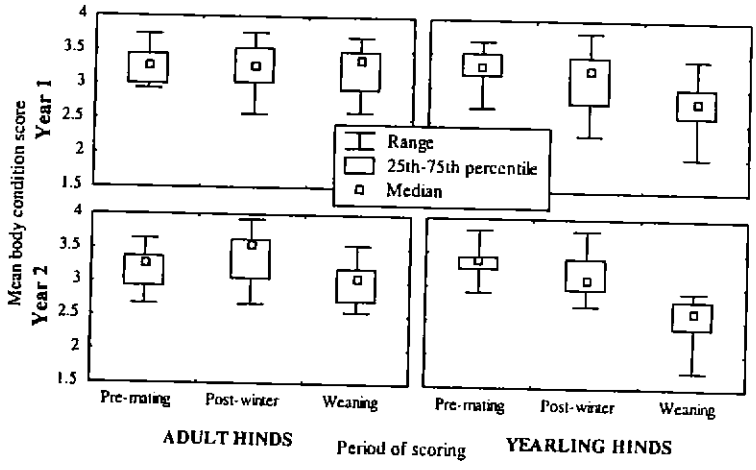

Fig. 3 Range and quartiles of farm mean yearling and adult hind body condition score recorded pre-mating, post-winter, and at weaning in Year 1 and Year 2.

significant variation between years overall, although the interaction terms "Year × Farm" ($P < 0.05$) and "Year × Season" ($P < 0.01$) were significant. Thus, the difference between years varied between farms and season. The interaction term "Age × Season" was significant ($P < 0.001$), as the variation of body condition score differed between yearling and adult hinds. Consequently,

Table 3 Analysis of variance data for variability of body condition scores of hinds attributable to age, year, farm, and visit. d.f. = degrees of freedom; Type III SS = Type III sum of squares.

Effects	d.f.	Type III SS	Mean square	*F* value	*P* value
All hinds					
Year	1	0.277	0.277	3.21	0.0766
Farm	14	3.963	0.283	3.29	0.0003
Age	1	1.306	1.306	15.16	0.0002
Season	2	4.276	2.138	24.81	0.0001
Year × Season	2	1.101	0.55	6.39	0.0026
Year × Farm	13	2.103	0.162	1.88	0.0439
Year × Age	1	0.027	0.027	0.31	0.5788
Farm × Season	27	3.459	0.128	1.49	0.0864
Farm × Age	13	1.226	0.094	1.09	0.3745
Age × Season	2	1.751	0.875	10.16	0.0001
Error	87	7.497	0.086		
Yearling hinds					
Year	1	0.480	0.480	5.44	0.0293
Farm	13	2.300	0.177	2.00	0.0728
Season	2	4.630	2.315	26.22	0.0001
Year × Season	2	0.500	0.250	2.83	0.0804
Year × Farm	13	2.060	0.158	1.79	0.1096
Farm × Visit	26	3.991	0.153	1.74	0.0957
Error	22	1.942	0.088		
Adult hinds					
Year	1	0.062	0.062	0.84	0.3688
Farm	14	2.462	0.176	2.38	0.0297
Season	2	0.411	0.206	2.79	0.0816
Year × Season	2	0.779	0.389	5.28	0.0126
Year × Farm	13	1.370	0.105	1.43	0.2173
Farm × Season	27	2.274	0.084	1.14	0.3739
Error	24	1.771	0.074		

data from both years and ages were kept separate for presentation (Fig. 2).

The ranges and quartiles of farm mean yearling and adult hind body condition scores recorded by season (pre-mating, post-winter, and at weaning) are presented in Fig. 3. Three-way ANOVA with Year, Farm, and Season main effects carried out within each age class showed a significant seasonal effect only in yearling hinds ($P < 0.01$). There was no significant main Year effect. The mean BCS of yearling hinds decreased from mating to weaning ($P < 0.01$). The "Year × Season" interaction term was significant ($P < 0.01$) in the analysis of adult hind mean score, as BCS was different between Year 1 and in Year 2 (Fig. 3).

DISCUSSION

To our knowledge, neither visual nor palpation assessment of body condition has been previously studied in or applied to farmed deer. The body condition scoring system presented in this study has been adapted from that described by Russel et al. (1969) for sheep. Body condition scoring systems have also been defined for cattle (Lowman et al. 1976; Edmonson et al. 1989) and horses (Henneke 1985). There is variability in scoring scales between authors, although most identify 8 to 10 increments. Edmonson et al. (1989) described a 17-point scale for scoring dairy cows.

In production animal systems, the principal advantage of a BCS is to enable farmers to objectively assess the body condition of their animals. Some scoring systems employ palpation, while others require only visual assessment. The latter are thought to be quicker because the animals do not need to be handled and palpated. This is an advantage when the animals are difficult to handle or when the handling facilities are poor. A visual assessment of BCS was devised earlier for deer to overcome handling difficulties (Riney 1955; Watson 1971). Visual scoring, however, is not likely to detect minor change in BCS of deer. In paddocks, deer may have a long flight distance which would make scoring difficult. Furthermore, the thick winter coat of deer is likely to conceal leanness. Scoring by palpation overcomes these problems. The system proposed for deer in the present study was a 5-point scale with 0.5 score increments employing simple anatomical landmarks and tissue conformation, which is easily applied in a variety of handling systems.

We believe that the most practical body site for condition scoring of deer is the sacral area. Attempts were initially made to score body condition by the palpation of the ribs and loin region, but these areas were difficult to approach on every hind for quick palpation and scoring. In cattle, other areas have been used for scoring such as the lower rib cage or at the "second thigh" from the hock to the pin bones (Lowman et al. 1976), but this is impractical and potentially dangerous to implement with deer. The body condition score defined in this study is easy to learn, very practical, and safe to implement on commercial farms.

It is also essential to consider coat character, which tends to be thicker in deer with a high BCS, and thinner in low BCS hinds which may show signs of victimisation (Moore et al. 1985). Thus, there may be a tendency to over- and underestimate scores at the extremes. Validation data in this study highlighted variation of judgement between assessors at low and high scores (Table 2).

It is essential that a BCS system is validated statistically. In this study, there was no significant interaction between hind and score, so the corresponding interaction term was removed for final calculations. This was expected since hind body condition could not have changed between the two assessments that were done on the same day no more than 2 hours apart (Evans 1978). The repeatability and reproducibility of BCS in both yearling and adult hinds were >0.78, and were higher than those recorded for cows and ewes (Evans 1978). The significant term "hind × assessor" suggests that the scoring chart should be carefully described. Training of assessors may improve consistency of scoring and close interpretation of condition status if comparisons are to be made between studies (Jansen et al. 1985), or between farms where data are collected from different operators.

Body condition scores have been studied in relation to health and production performance in cattle (Treacher et al. 1986; Edmonson et al. 1989; Garnsworthy & Haresign 1989; Gearhart et al. 1990; Rasby et al. 1990; Markusfeld et al. 1997) and sheep (Cumming et al. 1975; Pollott & Kilkenny 1976; Thomas 1990). Many associations have been observed between BCS and

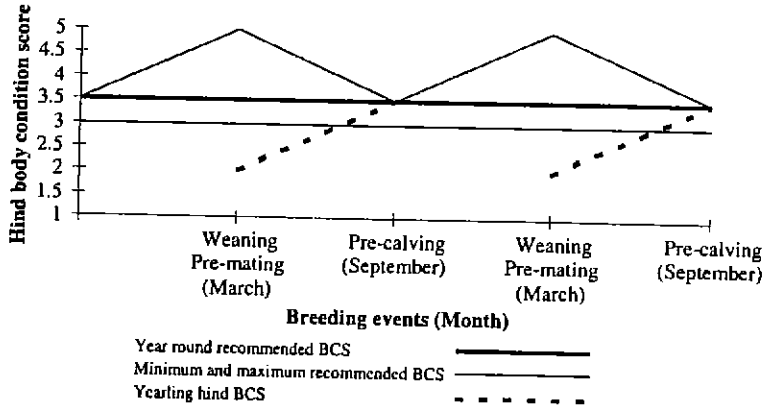

Fig. 4 Proposed year-round body condition scores (BCS) of yearling and adult hinds to optimise reproductive performance.

productivity and health, such as cows with a high BCS at drying off being more likely to develop cystic ovarian disease and reproductive problems (Gearhart et al. 1990), and less likely to retain placental tissue at parturition (Markusfeld et al. 1997). Body condition may be associated with other production outcomes for deer including carcass quality and velvet antler characteristics.

There was a range of condition scores throughout the study within and between farms which allowed investigation of associations with farm management practices and reproductive performance (Audigé 1995). There was a clear drop in BCS of yearling hinds from mating to weaning. This may reflect the nutritional stress imposed during their first reproductive and lactational season. Adult hind BCS did not change as much, although some seasonal variation did occur. In Year 2, the mean BCS of adult hinds dropped during lactation (Fig. 3), possibly because of dry environmental conditions which resulted in poorer nutrition.

This study of body condition scoring of farmed red hinds is unique. Risk factor analyses using the methods of data analysis described by Audigé (1995), showed that hind BCS or its change over time were associated with key reproduction outcomes:

- adult hinds in moderate to good body condition, with a BCS over the threshold 2.5, were more likely to conceive or to conceive early ($P < 0.05$);
- yearling hinds in very good condition, i.e., with a BCS over the threshold 3.5, were less likely to conceive early ($P < 0.05$);
- yearling and adult hinds gaining body condition during pregnancy, and thus more likely to be in good post-winter body condition, were less likely to lose their progeny up to weaning ($P < 0.05$);
- hinds with post-winter BCS over 3.5 were 2.9 times more prone to dystocia than those with a BCS lower than 3.5 or less ($P < 0.01$). This relationship was stronger if hinds in very good condition were kept on flat paddocks prior to calving;
- adult hinds losing body condition during the last third of pregnancy and lactation produced lower weight calves on 1 April ($P < 0.01$).

Although these associations do not prove causal relationships, they allow the design of a putative year-round management plan likely to achieve optimum reproductive performance on commercial farms as defined elsewhere (Audigé 1995). The consequences of exceeding the BCS limits proposed in Fig. 4 are contained in that reference.

Management

A proposed optimum BCS pattern based on risk factor analyses above, is presented in Fig. 4. Yearling hinds (15 months of age) should have a pre-mating BCS of 2–3.5 and gain body condition by September (post-winter). Adult hinds should have a pre-mating BCS >2.5. Yearling and adult hind BCS should be 3.5 in September. If their BCS is more than 3.5, they should be restricted in feed or they should be grazed on steep paddocks before calving to reduce the risk of dystocia. Hinds should not lose body condition during lactation. It is critical that hind BCS be >2.5 at weaning in order to ensure that optimum lactation has occurred and to optimise the probability of conceiving or of conceiving early.

Hinds losing condition during lactation should be separated from their calves early and preferentially fed after weaning so that they can recover their body condition for mating and the following calving season. Since loss of body condition in hinds during early pregnancy and late pregnancy/lactation is associated with progeny loss and reduced weaner weight on 1 April, respectively, hinds should ideally maintain a BCS of 3.5 all year round.

The body condition chart presented in this study (Fig. 1) could also provide a tool to assess the carcass fat content of deer before slaughter. Currently at deer slaughter premises, the fatness of deer carcasses is assessed through the tissue measurement over the 11th rib (GR measurement). Overfatness is penalised through lower financial return to the farmer. Body condition score is a good indicator of the level of fatness in cattle (Wright 1985). In sheep, the BCS is correlated with a direct measurement of backfat depth or the proportion of fat in the animal body, providing a better estimate than body weight alone (Russel et al. 1969). The relationship between BCS and GR measurement in deer should be investigated as a potential management tool for the farmer in selecting prime animals for slaughter and minimising the risk of financial penalty because of overfatness.

CONCLUSION

This study has defined a practical body condition scoring system for use in red deer hinds which should be adopted industry-wide in New Zealand for farm management. Deer farmers should use condition scores to routinely assess the nutritional status of breeding hinds. It appears to be the most useful determinant of several reproductive and productive outcomes on commercial deer farms. Body condition scoring is also a valuable tool for investigation of the adequacy of farm management practices. It is a simple, repeatable, and reproducible system.

ACKNOWLEDGMENTS

We wish to thank participating farmers for their active co-operation during the project. We thank the staff and personnel of the Veterinary Faculty at Massey University for help and assistance. Financial assistance was provided by the New Zealand Game Industry Board, the French Government (for stipend), CIRAD-EMVT, Deer Branch of the NZVA, Massey University, Pitman Moore (now Schering Plough, New Zealand), Rhône Mérieux, Cyanamid, Ag-Research, Allflex New Zealand Ltd, and Te Pari Products.

REFERENCES

Albon, S. D.; Mitchell, B.; Huby, B. J.; Brown D. 1986: Fertility in female red deer (*Cervus elaphus*): the effects of body composition, age and reproductive status. *Journal of zoology 209*: 447–460.

Audigé, L. 1992: Haematological values of rusa deer (*Cervus timorensis russa*) in New Caledonia. *Australian veterinary journal 69*: 265–268.

Audigé, L. 1995: Deer herd health and production profiling. Unpublished PhD thesis, Massey University, Palmerston North, New Zealand. 550 p.

Cumming, I. A.; Blickey, M. A. D. B.; Winfield, C. G.; Parr, R. A., Williams, A. H. 1975: A study of relationships of breed, time of mating, level of nutrition, live weight, body condition, and face cover to embryo survival in ewes. *Journal of agricultural science 84*: 559–565.

Edmonson, A. J.; Lean, I. J.; Weaver, L. D.; Farver, T.; Webster, G. 1989: A body condition scoring chart for holstein dairy cows. *Journal of dairy science 72*: 68–78.

Evans, D. G. 1978: The interpretation and analysis of subjective body condition scores. *Animal production 26*: 119–125.

Finger, S. E.; Brisbin, I. L.; Smith, M. H. 1981: Kidney fat as a predictor of body condition in white-tailed deer. *Journal of wildlife management 45*: 964–968.

Garnsworthy, P. C.; Haresign, W. 1989: Fertility and nutrition. *In*: Chamberlain, A. T. *ed.* Dairy cow nutrition; the veterinary angles. Sutton Bonnington, University of Nottingham School of Agriculture. Pp. 23–34.

Gearhart, M. A.; Curtis, C. R.; Erb, H. N.; Smith, R. D.; Sniffen, C. J.; Chase, L. E.; Cooper, M. D. 1990: Relationship of changes in condition score to cow health in Holsteins. *Journal of dairy science 73*: 3132–3140.

Guiness, F. E.; Alban, S. D.; Clutton-Brock, T. H. 1978: Factors affecting reproduction in red deer (*Cervus elaphus*) hinds on the Isle of Rhum. *Journal of reproduction and fertility 54*: 325–334.

Hamilton, W. J. 1988: Early nutrition, growth and reproductive performance in young Scottish red deer (*Cervus elaphus*) hinds, and their economic signficance in commercial herds. *In*: The management and health of farmed deer. Dordrecht, Netherlands, Martinus Nijhoff Publishers. Pp. 191–198.

Hamilton, W. J.; Blaxter, K. L. 1980: Reproduction in farmed red deer. I. Hind and stag fertility. *Journal of agriculture science 95*: 261–273.

Henneke, D. R. 1985: A condition score system for horses. *Equine practice 7*: 13–15.

Heydon, M. J.; Loudon, A. S. I.; Milne, J. A.; Brinklow, K. R. 1992: Influence of plane of nutrition on seasonal changes in food intake and reproduction in grazing red deer. *In*: Brown, R. D. *ed.* The biology of deer. New York, Springer-Verlag. Pp. 279–284.

Jansen, J.; Bech Andersen, B.; Busk, H.; Lagerweij, G. W.; Oldenbroek, J. K. 1985: *In vivo* estimation of the body composition in young bulls for slaughter. I. The repeatability and reproductibility of a scoring system, an ultrasonic scanning technique and body measurements. *Livestock production science 12*: 221–230.

Kelly, R. W.; Moore, G. H. 1977: Reproductive performance in farmed red deer. *New Zealand agricultural science 11*: 179–181.

Lowman, B. G.; Scott, N. A.; Somerville, S. H. 1976: Condition scoring of cattle. *East of Scotland College of Agriculture revue bulletin 6.*

Markusfeld, O.; Galon, N.; Ezra, E. 1997: Body condition score, health, yield and fertility in dairy cows. *Veterinary record 141*: 67–72.

Mitchell, B.; Lincoln, G. A. 1973: Conception dates in relation to age and condition in two populations of red deer in Scotland. *Journal of zoology 171*: 141–152.

Mitchell, B.; McCowan, D.; Nicholson, I. A. 1976: Annual cycles of body weight and condition in Scottish red deer (*Cervus elaphus*). *Journal of zoology 180*: 107–127.

Moore, G. H.; Cowie, G. M.; Bray, A. R. 1985: Herd management of farmed red deer. *In*: Fennessy, P. F.; Drew, K. R. *ed.* Biology of deer production. *The Royal Society of New Zealand bulletin 22*: 343–355.

Nicholson, M. J.; Sayers, A. R. 1987: Repeatability, reproducibility and sequential use of condition scoring of *Bos indicus* cattle. *Tropical animal health and production 19*: 127–135.

Pollott, G. E.; Kilkenny, J. B. 1976: A note on the use of condition scoring in commercial sheep flocks. *Animal production 23*: 261–264.

Rasby, R. J.; Wettemann, R. P.; Geisert, R. D.; Rice, L. E.; Wallace, C. R. 1990: Nutrition, body condition and reproduction in beef cows: fetal and placental development, and estrogens and progesterone in plasma. *Journal of animal science 68*: 4267–4276.

Riney, T. 1955: Evaluating condition of free-ranging red deer (*Cervus elaphus*), with special reference to New Zealand. *New Zealand journal of science and technology*: 429–463.

Russel, A. J. F.; Doney, J. M.; Gunn, R. G. 1969: Subjective assessment of body fat in live sheep. *Journal of agriculturalx science 72*: 451–454.

Thomas, J. O. 1990: Survey of the causes of dystocia in sheep. *Veterinary record 127*: 574–575.

Treacher, R. J.; Reid, I. M.; Roberts, C. J. 1986: Effect of body condition at calving on the health and performance of dairy cows. *Animal production 43*: 1–6.

Watson, A. 1971: Climate and the antler-shedding and performance of red deer in north-east Scotland. *Journal of applied ecology 8*: 53–67.

Wegge, P. 1975: Reproduction and early calf mortality in Norwegian red deer. *Journal of wildlife management 39*: 92–100.

Wright, I. A. 1985: The relationships between body condition, nutrition, and performance of beef cows. *In*: Baker, F. H.; Miller, M. E. *ed.* Emerging technology and management of ruminants. Boulder, Colorado, Westview Press. Pp. 110–118.

Yerex, D. E. 1982: The farming of deer. *In*: Yerex, D. *ed.* World trends and modern techniques. Wellington, New Zealand, Agricultural Promotion Associates Ltd.