MONITORING ANIMAL PERFORMANCE and PRODUCTION SYMPOSIUM PROCEEDINGS

SOCIETY FOR RANGE MANAGEMENT
40th ANNUAL MEETING

February 12, 1987

Boise, Idaho

Convened by:
Donald A. Jameson
Jerry Holechek

PREFACE

This is the third in a series of symposia which are designed to critically examine the philosophy and methodology currently being used to examine the status and changes in condition of rangelands. Members of the Western Regional Coordinating Committee present the results of their in-depth evaluation of our knowledge, attitudes, and methods for monitoring rangelands as related to cover, soils, and weather data. Financial support has been provided by the respective state agricultural experiment stations.

Jerry Holechek
Donald A. Jameson
Conveners

Sample bibliographic reference:

Currie, P. O. 1987. Herbage yield and cover estimates as guides for predicting livestock management. pp. 4-7 In Monitoring Animal Performance and Production Symposium Proceedings. February 12, 1987, Boise, Idaho. Society for Range Management, Denver, Colorado.

TABLE OF CONTENTS

Monitoring for Successful Management 1

Donald A. Jameson, Colorado State University, Fort Collins

Herbage Yield and Cover Estimates as Guides for Predicting Livestock Management 4

P. O. Currie, USDA, Agricultural Research Service, Miles City, Montana

Plant Production Following Grazing: Carbohydrates, Meristems, and Tiller Survival Over Winter 8

J. H. Richards, M. M. Caldwell, and B. E. Olson, Utah State University, Logan

Indicators for Production Changes 12

John W. Menke, University of California, Davis

Direct Measures of the Nutritional Status of Grazing Animals . . . 17

M. M. Kothmann and R. T. Hinnant, Texas A&M University, College Station

Measures of Wild Ungulate Performance: Population Density and Condition of Individuals 23

John G. Kie, USDA, Forest Service, Fresno, California

Monitoring Changes in Animal Weights 37

R. H. Hart, USDA, Agricultural Research Service, Cheyenne, Wyoming

Direct Measures of the Grazing Animal's Nutritional Status . . . . 40 -57

D. M. Anderson, USDA, Agricultural Research Service, Las Cruces, New Mexico

DIRECT MEASURES OF THE GRAZING ANIMAL'S NUTRITIONAL STATUS

D. M. Anderson

ABSTRACT: Accurate, precise, rapid, and cost effective procedures must characterize the techniques used to measure an animal's nutritional status. The classical information on the grazing animal's nutritional status has been determined by monitoring the chemical composition of the standing crop, the botanical and chemical composition of diets using esophageally fistulated animals, and the use of physical measurements including liveweight. Tissue and body fluid analyses for the diagnosis of nutritional problems have been stimulated by the development of automated equipment. Techniques that use body condition scores, based on a visual appraisal or external palpation for subcutaneous fat, correlate well with stored energy in the animal. Body condition correlates with reproductive efficiency and milk production. Prepartum condition can be used to effectively manage fat and thin livestock according to their nutritional needs for optimum sustained production. To understand and accurately manage the complex relationships that exist at the plant-animal interface, no single measure will be adequate to describe the nutritional status of grazing animals. However, body condition scores should be considered as a cost effective tool that can be used by both the producer and researcher.

INTRODUCTION

Knowledge of the grazing animal's nutritional status is essential to modern man because much of his everyday life style is intrinsically linked to the ruminant animal. The life cycle of most ruminants begins and, in many instances, is carried out totally under range and pasture conditions (Van Dyne et al. 1980). Standing crop quantity and quality of range or pasture is by its very nature perishable; therefore, the problem facing all producers is how to efficiently harvest and sell forage through the animal to the best ecological, nutritional, and economic advantage. A complex problem unfolds when man tries to effectively manage the nutritional status of the grazing ruminant. This is due to a multifaceted set of interrelationships involving the environment, the plant, and the animal.

Early investigators tried to define what constitutes adequate range animal nutrition by determining the chemical composition of the standing crop (Watkins 1937, Fraps and Cory 1940). Because sheep (Milton 1933) and cattle (Hardison et al. 1954) graze selectively, knowing the chemical composition of the standing crop provides an incomplete representation of what the nutritional status is for the grazing animal. With the advent of the esophageal fistula technique, described by Torell (1954), a tool was developed to help the researcher determine what the botanical and chemical composition of the grazing animal's diet was at any particular point in time. With the fistula technique the influence of animal selectivity (Theurer et al. 1976) and preference (Skiles 1984) on diet composition was effectively addressed. Even though the esophageal fistula technique can give valuable answers, it is not free of bias. This technique has inherent factors that can reduce the accuracy in determining the botanical and chemical composition of the sample diet obtained (Lesperance et al. 1974). The fistula technique has substantially improved the science of grazing animal nutrition, yet the establishment (Harris et al. 1967, Little and Takken 1970, McManus 1981) and maintenance (Bredon and Short 1971) of these surgically prepared animals remains as much art as science.

Over the past 20 years there has been essentially no major developmental evolution within the esophageal fistula technique as evidenced by comparing the review by Van Dyne and Torell (1964) with the more recent review by Holechek et al. (1984). Most of the recent literature involving the esophageal fistula technique is accumulating on the design of plugs or cannulas (Ellis et al. 1984, Anderson et al. 1985, Forword et al. 1985, Walker et al. 1985, Grunwaldt and Sosa 1986), on devices that can reopen fistulas that have contracted (Anderson and Mertz 1982), and on devices to keep the opening from contracting during diet collections (J. C. Malachek, personal communication). Redesigned collection bags (Center and Jones 1984) and how bags might be attached to the animal (Kartchner and Adams 1983) have also been addressed.

All questions associated with evaluating the grazing animal's nutritional status involve measurement; i.e., what to measure and how to do it accurately. The most complete expression of adequate forage quantity and quality for the grazing animal should come from evaluating the animal itself because the animal is the final integrator of its diet. Therefore, the right measure or measures obtained directly from the animal should reflect the best, and most accurate, measure of the grazing animal's nutritional status.

Animal responses that are manifest in milk, wool, meat, hides, or offspring are useful for measuring forage quality and, hence, the nutritional status of the grazing animal (Cook and Stubbendieck, eds. 1986). Six direct measures taken from the animal to evaluate the grazing animal's nutritional status include: hair analysis (Haaland et al. 1977, Horn 1981, Jones 1981, Combs et al. 1982), blood analysis (Gossett 1960, Mufarrih 1964, Sides et al. 1978, Hinnant 1979, Rowlands 1980, Kronfeld et al. 1982, Garnsworthy and Topps 1982, Bines and Morant 1983, Bull et al. 1984, Selk et al. 1985), urine analysis (McCarthy et al. 1983), bone analysis (Read et al. 1986), milk analysis (Horn 1981, Robards 1981), and body water as a fat estimate (Bartle et al. 1983, Dunn et al. 1983). These analyses have several things in common: 1) they require varying amounts of sophisticated and expensive equipment to obtain and evaluate the samples collected, 2) operation of the equipment and interpretation of the data obtained requires special training, 3) constraints on the temporal and spatial sampling of material often introduces bias and prevents accurate conclusions on establishing cause and effect relationships, and

---

Paper presented at Symposium on Monitoring Animal Performance and Production at Society for Range Management meeting in Boise, Idaho. February 12, 1987. Symposium sponsored by Western Regional Coordinating Committee 40.

D. M. Anderson, USDA, Agricultural Research Service, Jornado Experimental Range, Las Cruces, NM.

4) none of the methods allow for immediate changes in management by the producer.

This paper concentrates on body condition scoring obtained either visually or by palpation of the animal's exterior. This tool, singly or in combination with other tools, is proposed for use by the producer as well as the researcher to rapidly evaluate and manage the grazing animal's nutritional status.

Body Condition

Body condition was defined by Murray (1919) as "the ratio of the amount of fat to the amount of non-fatty matter in the body of the living animal." Various methods have been used to assess body condition in live animals; however, most of them involve specialized and expensive equipment that limit the practical application of the techniques (Kirton 1964). Photogrammetry (Brinks et al. 1964), ultrasonic methods (Stouffer et al. 1961, Davis et al. 1964, Brown et al. 1980, Kempster et al. 1982, and Andersen et al. 1983), hypodermic thermistor needles (Watkins et al. 1967), measures of specific gravity (Kraybill et al. 1952), evaluation of body water (Garrett et al. 1959, Shebaite 1977), the use of tritiated water (Searle 1970), the use of ^{40}K (Kirton and Pearson 1963, Brooks et al. 1985), muscle biopsy (Everitt 1964 as cited in Preston and Willis 1970), deuterium oxide (Byers 1979), urea dilution (Bartle et al. 1983), and prediction equations (Yadava 1970 as cited by van Niekerk 1982a) have been tried. Physical measures have also been used to assess body condition in live animals. The lack of physical measurements to describe the animal in a complete manner is more the result of inadequacy rather than inaccuracy (Lush and Copeland 1930). The ratio of heart girth (Black and Knapp 1938) or chest girth (Preston and Aitken 1963, unpublished, as cited in Preston and Willis 1970) to height at withers has a significant correlation with percentage of fat. Chest girth is closely related to liveweight (Johansson and Hildeman 1954, Burt 1957, Brookes and Harrington 1960, Umoh and Buvanendran 1982) and empty body weight and may account of 86-96% of the variation in body weight (Buvanendran et al. 1980). When liveweight and height are expressed as a ratio, the value has been shown to correlate to fatness (Klosterman et al. 1968, D. Pruitt as stated in 1986, unpublished NCR-87 report). Body composition appears useful in predicting weight at puberty in beef heifers (Brooks et al. 1985).

Physical measurements should only be made when the animal is positioned in an even stance (Wagnon et al. 1957, Tulloh and Maritz 1964) because an incorrect position of the feet can affect accuracy of height measurements of the withers (Swett and Graves 1939). Yao et al. (1953) found wither height to be a better measure of height than height of chest floor, height at flank, or depth of chest in beef shorthorn and milking shorthorn steers. Cattle may stand more quietly for hip height measurements than height measurements of the withers (Williams et al. 1979), but both are accurate when measurements are carefully made.

The response of physical measurements such as height may (Neville et al. 1978) or may not (Lush et al. 1930) be affected by feeding regime. Good et al. (1961) found only 11.6% of the variation in fat cover at the 12th rib was significantly correlated (negatively) to the physical measurements of: width between eyes, width of muzzle, circumference of round, and circumference of cannon bone.

The trends for liveweight and fatness in beef cattle are similar throughout the year, with increases in fall and decreases in spring (Brown et al. 1980). Croxton and Stollard (1976) have shown positive correlations of .85 between changes in condition scores and liveweight during the winter for beef cattle. Changes in fatness, however, occur within a narrower range compared to liveweight changes. Russel et al. (1969) concluded that a body condition score is superior to liveweight in predicting body fat in sheep, even when liveweight is added as an independent variable in a multiple regression equation. Liveweight not only reflects body tissue but gut fill (Brown et al. 1980). Cows and calves may actually be gaining mass while losing condition; but if mass declines, condition will fall dramatically. Early in a calf's life, weight gain may be predominately protein (Applegate et al. 1986a). Especially during the later stages of pregnancy, liveweight may be increasing because of body fluids, membranes, and the fetus while body condition may actually be declining, depending on the nutritional status (Brown et al. 1980) and age (Frood and Croxton 1978) of the grazing animal. Liveweight may vary independently of body composition in lactating cows (Chigaru and Topps 1981) and in lactating sheep (Cowan et al. 1979). The non-nutritional increase in liveweight during later stages of pregnancy has been estimated to account for 45 kg in a 454 kg cow (Spitzer 1977) and between 9 and 14 kg in ewes (Jefferies 1961).

One technique that does not require specialized equipment, is repeatable (Graham et al. 1984, Woodburn et al. 1986), accurate (Gresham et al. 1986), and provides immediate management options is the use of body condition scores. A body condition score refers specifically to the subcutaneous fat covering the body (Thompson et al. 1983, Herd 1986). Fats in the body are in a constant state of flux as indicated by Schoenheimer (1942). Subcutaneous fat is late developing but appears to be a preferential source of mobilized fat (Russel et al. 1968) and, therefore, should be quite reliable in evaluating the grazing animal's nutritional status. It is not, however, the only body reserve that can be utilized (Macmillan and Bryant 1980). Conditioning scores for Angus and Angus x Hereford cows have been used to estimate ($r = .66$) the percentage of empty body fat (Thompson et al. 1981). Condition scores appear more useful as predictors (r^2 range = .82-.83) of carcass composition than lightweight or weight:height ratio (r^2 range = .58-.68) in mature Hereford cows (Wagner et al. 1985c). These data indicate 76% of the variation in carcass fat can be explained by body condition scores.

Changes in liveweight within an animal vary greatly relative to condition scores; therefore, it may be preferable to accept condition score as a separate parameter (Macmillan and Bryant 1980). Houghton et al. (1986) suggested that body condition scores and liveweight, when used together, are useful in determining energy requirements for cows in various production levels. Several researchers have regressed liveweight and body condition scores to predict the magnitude of a unit change in condition score (Table 1). The relationship between liveweight and body condition score, however, may not be positive (van Niekerk 1982a).

Table 1. Liveweight change (kg) per unit change in condition score.

Source	Scale	Breed or class of livestock	Liveweight change
Drumm-LaMontagne (1981)	1-10	Cattle	
		Beef	31 - 54
Frood and Croxton (1978)	0-5	Cattle	
		British Friesian	25 ± 1.6
Graham (1982)	0-9	Cattle	
		Beef	61.5 ± 5
Jefferies (1961)	0-5	Sheep	
		Merinos and Corriedale	7
Macmillan and Bryant (1980)	1-10	Cattle	
		Dairy	30 - 35
Morris et al. (1985)	1-10	Cattle	
		Beef and crossbreds with dairy genotype	25.2
Peart*		Cattle	
		Blue-Grey	83
		Herefore x Friesian	90
Russel and Wright (1982)	0-5	Cattle	
		Galloway	61
		Blue-Grey	97
		Herefore x Friesian	104
		Luing	106
		British Friesian	110

*Unpublished results cited in Russel and Wright 1982.

The simple, linear correlation between fat cover and condition score for mature *Bos taurus* cattle representative of beef in the United States was shown by Gresham et al. (1986) to be .74. Condition scores are a way of measuring the external body reserves (Frood and Croxton 1978) and are significantly correlated with all measures of carcass fatness (Bellows et al. 1979) or the energy content of the carcass (Dunn et al. 1983). Condition scores have been used to predict the killing out of dairy steers (Bailey et al. 1984) and to successfully estimate carcass fat depth in 18- to 24-month-old steers (Graham and Clark 1984). Condition scores, however, may be more accurately applied to adult than to juvenile animals because growing animals may actually be gaining in liveweight (e.g., via skeletal growth) while condition scores may be falling (Frood and Croxton 1978).

Dairy breeds deposit more fat in the abdominal cavity (internally) compared to beef breeds that deposit more fat subcutaneously (Callow 1961, Kempster 1980-81). Differences among breeds for internal fatness, therefore, are probably not reflected by condition scores (Long et al. 1979b). Herefords and Friesians represent the extremes of the beef and dairy types with respect to fat partitioning (Williams 1978 as cited in Truscott et al. 1983b). Herefords have approximately double (P < .001) the number of subcutaneous fat cells compared to Friesians, although both breeds have similar numbers of intra-abdominal and prescapular fat cells in relation to fat-free body weight (Truscott et al. 1983a). At all ages Herefords apparently have more (P < .001) of their fat in subcutaneous depots compared to Friesians (Truscott et al. 1983b). Subcutaneous fat deposits in cattle respond readily to the need for lipid storage by increasing cell diameter to a maximum size of approximately 250 μm or by recruiting cells through either pre-adipocytes or hyperplasia (Truscott et al. 1983a). It appears an average and critical fat cell diameter may act as the trigger mechanism for further increase in number of cells (Klyde and Hirsch 1979). For subcutaneous fat in cattle this critical diameter may be approximately 150 μm; however, the same diameter may not trigger new cells in all depots (Truscott et al. 1983a). Thin cows apparently have a faster rate of fatty acid synthesis in adipose tissue than do fat cows (Bines and Morant 1983). This permits higher food intake before short-term chemical regulation of intake starts to operate.

Body Condition Scores

Condition scores are subjective and are assigned to each animal after visual appraisal, external palpation, or both. Although numerical categories characterize all scoring systems, the number of categories and the criteria used to place an animal in a specific category vary widely among the various scoring systems (Table 2). If each body condition score has been adequately defined, repeatability should be high (Graham et al. 1984). The low repeatability reported from Everitt's (1962) 10-point system may have resulted from inadequately defined intermediate scores because only the extreme

Table 2. Body condition scoring criteria for bovines and ovines.

SOURCE	SCORE DESCRIPTION											
	0	1	2	3	4	5	6	7	8	9	10	Comments
Applegate et al. (1986b)		SEVERELY THIN- shrunken, and physically weak. All ribs and bone structure easily visible.	THIN- similar to 1, but not weakened. Little visible muscle tissue.	VERY THIN- no fat on ribs or brisket, and some muscle still visible. Backbone easily visible.	Thin, with ribs easily visible, but shoulders and hindquarters still showing fair muscling. Backbone visible.	MODERATE TO THIN- Last two or three ribs can be seen. Little evidence of fat in brisket, over ribs, or around tailhead.	Good smooth appearance throughout. Some fat deposition in brisket and over tailhead. Ribs covered back appears rounded.	Very good flesh, brisket full, tailhead shows pockets of fat. Back appears square, ribs very smooth.	OBESE (FAT)- back very square, brisket distended, heavy fat pockets around tailhead. Cow has square appearance as a result of excessive fat. Neck thick and short.	Seldom seen in commercial herds. Very obese. Heavy deposits of fat.		
Beverly (1981)		POOR- starving-bordering on inhumane survival questioned during stress. No palpable fat cover along backbone or ribs.	VERY THIN- poor milk production-changes for rebreeding slim to none. Some fat present along backbone but no fat cover over ribs.	THIN- lowered milk production-poor reproduction. Fat along backbone and slight amount of fat cover over ribs.	BORDERLINE- reproduction bordering on inadequate. Some fat cover over ribs.	MODERATE- minimum necessary for efficient rebreeding-good milk production-generally good overall appearance. Fat cover over ribs feels spongy.	MODERATE TO GOOD- milk production rebreeding very acceptable. Spongy fat cover over ribs and fat beginning to be palpable around tailhead.	GOOD- fleshy- maximum condition needed for effiecient reproduction. Spongy fat cover over ribs around tailhead.	FAT- very fleshy- unnecessary- no advantage in rebreeding from having cows in this condition. Cows had large fat deposits over ribs, around tailhead, and below vulva.	EXTREMELY FAT- extremely wasty and patchy-may cause calving problems. Cows extremely overconditioned.		
Drumm-LaMontagne (1981) Palpable		POOR- Shoulders, ribs and spinous processes very sharp.	VERY THIN- Shoulders, ribs and spinous processes fairly sharp.	THIN- Shoulders and spinous processes fairly sharp; however ribs only slightly prominent.	BORDERLINE- Shoulders and spinous processes rounded with ribs easily felt but no longer seen individually.	MODERATE- Same as number 4 only to a higher degree.	MOD-GOOD- shoulders rounded, ribs with spongy fat and spinous processes felt with firm pressure by finger tips.	GOOD- Same as number 6 only to a higher degree.	FAT- Shoulder rounded and smooth, ribs with folds of fat developing large deposits The spinous processes can not be felt.	EXTREMELY FAT- Same as number 8 only to a higher degree.		EXTREMELY FAT- Shoulders bulging, ribs with great folds of fat and the spinous processes cannot be felt.
Drumm-LaMontagne (1981) Visual		POOR- Brisket shows folds of skin only, lower surface of breastbone 1/4 the distance down on forearm to knee. No fat on tail head and twist "cut up" with skin only, stance, narrow.	VERY THIN- Same as number 1 only less severe.	THIN- Some fat on brisket. Tail head showing some tissue cover on top (prominence depends on conformation). Twist same as number 1 and 2.	BORDERLINE- Same as number 3 only more covering with the twist showing some tissue.	MODERATE- Lower surface of solid brisket 1/2 the distance down on forearm to knee. Tailhead showing fat cover on both sides (easily felt). The twist showing some tissue.	MOD-GOOD- Brisket and tailhead conditions similar to number 5. Twist with moderate fat depth.	GOOD- Brisket and twist similar to number 5 with tailhead showing fat "rounds" (soft to the touch).	FAT- Fat deposits in the brisket area becoming larger and lengthening. The tailhead similar to number 7 while the twist is full of fat. Stance is broad and animal is beginning to accumulate fat down to hocks.	EXTREMELY FAT- Brisket and twist similar to number 8 with the tailhead almost completely buried.		EXTREMELY FAT- Fat knee length, tailhead completely buried in fat with the twist showing fat down to hocks, mobility impaired.

Table 2. (continued)

SOURCE	SCORE DESCRIPTION											
	0	1	2	3	4	5	6	7	8	9	10	Comments
Dunn, et al. (1983)		The vertical and transverse processes of the vertebrae are sharp to the touch and can be distinguished visually.		The processes of the spine can be identified individually by touch. They feel rounded not sharp and the space between the processes is less pronounced.		The spinous processes can be felt with slight pressure. The ends feel rounded. Space between the processes can be distinguished only with firm pressure. Areas on either side of the tailhead filled.		The ends of the spinous processes can be felt only with firm pressure. Spaces between the processes cannot be distinguished at all. Abundant fat cover around the tailhead with some patchiness.		Bone structure cannot be felt. Tail head buried in fatty tissue.		
Ercanbrack (1986)^{t}		Finger tips receive a sensation of a soft, smooth almost jelly-like feel over the rib area. Ribs can not be felt and the skin moves freely over the ribs in almost a ripple-like fashion.	Finger tips receive a firm and smooth sensation as they are run over the rib area. Ribs can not be felt and the skin is tighter over the ribs.	Ribs can be felt with finger tips.	Ribs are prominent upon palpation and can be seen.	Ribs are extremely prominent to the touch and can be easily seen.						This palpation procedure concentrates on the rib area. Plus and minus designations can be assigned to each numerical value. A minus indicates a poorer condition than the base numerical score. A plus indicates a better condition than the base numerical score.
Graham (1984)	Obviously no fat cover at all.	The individual short ribs are sharp to touch and no tail head fat can be felt.	The individual short ribs can still be felt, but feel rounded rather than sharp. There is some tissue cover around the tail head.	The short ribs can only be felt with very firm thumb pressure. Areas either side of the tail head have some fat cover that can be easily felt.	The short ribs cannot be felt and fat cover around the tail head is easily seen as slight mounds. Folds of fat are beginning to develop over the ribs and thighs of the animal.	The bone structure of the animal is no longer noticeable and the tail head is almost completely buried in fatty tissue. Folds of fat are apparent over the ribs and thigh.						

Table 2. (continued)

SOURCE	SCORE DESCRIPTION											
	0	1	2	3	4	5	6	7	8	9	10	Comments
Herd and Sprott (1986) (Adapted from Lowman 1976)		Bone structure of shoulder, ribs, back, hooks and pins sharp to touch and easily visible. Little evidence of fat deposits or muscling.	Little evidence of fat deposition but some muscling in hindquarters. The spinous processes feel sharp to touch and are easily seen with space between them.	Beginning of fat cover over the loin, back, and forceribs. Backbone still highly visible. Processes of the spine can be identified individually by touch and may still be visible. Spaces between the processes are less pronounced.	Foreribs not noticeable; 12th and 13th ribs still noticeable to the eye particularly in cattle with a big spring of rib and ribs wide apart. The transverse spinous processes can be identified only by palpation (with slight pressure) to feel rounded rather than sharp. Full but straightness of muscling in the hindquarters.	12th and 13th ribs not visible to the eye unless animal has been shrunk. The transverse spinous processes can be felt with firm pressure to feel rounded- not noticeable to the eye. Spaces between the processes not visible and only distinguishable with firm pressure. Areas on each side of the tail head are fairly well filled but not mounded.	Ribs fully covered, not noticeable to the eye. Hindquarters plump and full. Noticeable sponginess to covering of foreribs and on each side of the tail head. Firm pressure now required to feel transverse processes.	Ends of the spinous processes can only be felt with very firm pressure. Spaces between processes can barely be distinguished at all. Abundant fat cover on either side of tail head with some patchiness evident.	Animal taking on a smooth, blocky appearance; bone structure disappearing from sight. Fat cover thick and spongy with patchiness likely.	Bone structure not seen or easily felt. Tail head buried in fat. Animal's mobility may actually be impaired by excess amount of fat.		
Jefferies (1961)	This is on the point of death when the sheep are extremely emaciated as occurs after an extended drought or disease.	POOR STORE CONDITION- The backbone will be prominent and sharp with virtually no meat covering around the bones. The lumbar processes will also be sharp at the ends and the fingers will easily pass under the ends. It will be possible to feel between each bone. The eye muscle will be very thin and there will be no fat at all. The skin will be very thin and possibly lacking in colour. This score should not occur under good management.	AVERAGE STORE CONDITION- The backbone will be prominent but smooth. It will be possible to feel between the bones but only as fine corrogations. The lumbar processes will be smooth and rounded on the ends. It will be possible to pass the fingers under the ends with a little pressure. The eye muscles will have moderate depth and there will be little fat. The skin will be thin. This is as low as sheep should be allowed to go under efficient management.	FORWARD STORE CONDITION- The backbone will have only a small elevation. It will be smooth and rounded over the top so that it will only be possible to feel the individual bones with pressure. The ends of the lumbar processes will also be smooth and well covered. It will require firm pressure to feel over the ends. The eye muscles will be full with a moderate fat coverage. The skin will be of medium thickness.	FAT- The backbone can just be detected with pressure as a small hard line between the large eye muscles. The lumbar processes cannot be felt as they are thickly covered and will feel as a block of meat. The eye muscles will be full with a thick fat coverage. The skin will be thick.	VERY FAT- The backbone cannot be felt even with firm pressure. There will be a depression between the layers of fat where the backbone would normally be. The ends of the lumbar processes cannot be felt because of the fat coverage. The eye muscles will be very full with a very thick fat coverage which may be flabby. There may even be large lumps of fat accumulated over the rump and tail. The skin will be thick. This condition is both unhealthy and inefficient in feed utilization.						

Table 2. (continued)

SOURCE	SCORE DESCRIPTION 0	1	2	3	4	5	6	7	8	9	10	Comments
Lowman et al. (1976)	The animal is emaciated with the spinous processes, hip bones, tail head and ribs projecting prominently. No fatty tissue can be detected and the neural spines and transverse processes feel very sharp.	The individual spinous processes are still fairly sharp to the touch and there is no fat around the tail head. The hip bones, tail head and ribs are still prominent but appear less obvious.	The spinous processes can be identified individually when touched, but feel rounded rather than sharp. There is some tissue cover around the tail head, over the hip bones and the flank. Individual ribs are no longer visually obvious.	The spinous processes can only be felt with firm pressure. The areas on either side of the tail head now have a degree of fat cover which can be easily felt.	Fat cover around the tail head is evident as slight "rounds", soft to the touch. The spinous processes cannot be felt even with firm pressure and folds of fat are beginning to develop over the ribs and thighs of the animal.	The bone structure is no longer noticeable and the animal presents a "blocky" appearance. The tail head and hip bone are almost completely buried in fatty tissue and folds of fat are apparent over the ribs and thighs. The spinous processes are completely covered by fat and the animal's mobility is impaired by the large amount of fat carried.						
Loxton et al. (1982)		End of transverse process of vertebrae very prominent; individual bones felt as deep corrugations. Ribs are prominent, clearly visible and are felt as deep corrugations.	End of transverse processes prominent. Individual bones are felt as corrugations. Some fat cover is detectable over the bones but individual ribs are felt easily as corrugations.	End of transverse processes slightly rounded by fat, felt with light pressure. Thin layer of fat is felt over the bones. Individual ribs felt with light pressure.	Ends of individual transverse processes are felt only with moderate pressure. Distinct layer of soft fat is felt over the bones. Individual ribs are felt only with moderate pressure.	Transverse processes are felt only with firm pressure. Thick soft fat covers ribs. Individual ribs are felt only with firm pressure.	Individual transverse processes cannot be felt. Rib cage is smooth to the touch with a tendency to patchiness. Individual ribs cannot be felt.					

Table 2. (continued)

SOURCE	SCORE DESCRIPTION 0	1	2	3	4	5	6	7	8	9	10	Comments
Morris (1985)tt	EMACIATED- Extensive reduction of all muscles.	VERY THIN- No apparent tissue over ribs on palpation, individual spinous processes and, transverse processes of lumbar vertebrae readily discernible, Longissmus dorsi concave, muscle of hind limb wasted.	THIN- Ribs readily discernible without application of pressure on palpation, spinous processes of vertebrae are readily distinguished on palpation, individual lateral processes of the lumbar vertebrae can be distinguished Longissmus dorsi flat, muscles of hind limb slightly reduced.	NORMAL- Ribs discernible only on application of moderate pressure during palpation, spinous processes of vertebrae not readily apparent on application of moderate pressure, transverse processes of lumbar vertebrae not apparent muscles of hind limb normal.	MODERATELY OBESE- Individual ribs and spinous processes of vertebrae cannot be discerned on palpation with moderate pressure.	OBESE- Palpation gives feeling of extensive fat cover over body, folds of fat can readily be located especially on ventral abdomen.						
Pullan (1978)	Emaciated animals with no apparent subcutaneous fat. The spinous processes in the lumbar region feel sharp. The gluteal muscles when assessed from the side are wasted to give a concave appearance.	The spinous processes are sharp but less so than in Score 0. There is some subcutaneous fat on these processes and on the points of the hips. The gluteal muscles are the same as in Score 0.	The individual spinous processes are still fairly sharp to touch and the ribs can be seen individually. The gluteal muscles when assessed from the side have a straight appearance.	The spinous processes can be felt but have a rounded feel and the ribs cannot be seen individually. The gluteal muscles are the same as in Score 2.	The individual spinous processes can only be felt with firm pressure and the points of the hips are covered with fat and are rounded. The gluteal muscles when assessed from the side bulge to give a convex lock.	The spinous processes cannot be felt even with firm pressure. The animal has a "blocky" appearance and the gluteal muscles are the same as in Score 4.						

Table 2. (continued)

SOURCE	SCORE DESCRIPTION 0	1	2	3	4	5	6	7	8	9	10	Comments
Richards, et al. (1986)		EMACIATED- Cow is extremely emaciated with no palpable fat detectable over spinous processes, transverse processes, hip bones or ribs. Tailhead and ribs project quite prominently.	POOR- Cow still appears somewhat emaciated but tailhead and ribs are less prominent. Individual spinous processes are still rather sharp to the touch but some tissue cover exists along the spine.	THIN- Ribs are still individually identifiable but not quite as sharp to the touch. There is obvious palpable fat along spine and over tailhead with some tissue cover over dorsal portion of ribs.	BORDERLINE- Individual ribs are no longer visually obvious. The spinous processes can be identified individually on palpation but feel rounded rather than sharp. Some fat cover over ribs, transverse processes and hip bones.	MODERATE- Cow has generally good overall appearance. Upon palpation, fat cover over ribs feel spongy and areas on either side of tailhead now have palpable fat cover.	HIGH MODERATE- Firm pressure now needs to be applied to feel spinous processes. A high degree of fat is palpable over ribs and around tailhead.	GOOD- Cow appears fleshy and obviously carries considerable fat. Very spongy fat cover over ribs and around tailhead. In fact "rounds" or "pones" beginning to be obvious. Some fat around vulva and in crotch.	FAT- Cow very fleshy and over-conditioned. Spinous processes almost impossible to palpate. Cow has large fat deposits over ribs, around tailhead and below vulva. "Rounds" or "pones" are obvious.	EXTREMELY FAT- Cow obviously extremely wasty and patchy and locks blocky. Tail head and hips buried in fatty tissue and "rounds" or "pones" of fat are protruding. Bone structure no longer visible and barely palpable. Animals motility may even be impaired by large fatty deposits.		
Russel et al. (1969)	Extremely emaciated and on the point of death.	Spinous processes prominent and sharp; transverse processes also sharp, the fingers pass easily under the ends, and it is possible to feel between each process; Mm. longissimus dorsi shallow with virtually no subcutaneous fat cover.	Spinous processes prominent but smooth, and individual processes can be felt only as fine corrugations; transverse processes smooth and rounded, and fingers can be passed under ends with little pressure; Mm. longissimus dorsi of moderate depth with little subcutaneous fat cover.	Spinous processes have only a small elevation, are smooth and rounded, and individual processes can be felt only with pressure; transverse processes smooth and well covered, and firm pressure is required to feel over ends; Mm. longissimus dorsi full with moderate subcutaneous fat cover.	Spinous processes can be detected with pressure as hard line between ends; Mm. longissimus and associated subcutaneous fat; transverse processes cannot be felt; Mm. longissimus dorsi full with thick subcutaneous fat cover.	Spinous processes cannot be felt even with firm pressure and there is a depression in subcutaneous fat where spinous processes would normally be felt; transverse processes cannot be felt; Mm. longissimus dorsi very full with very thick subcutaneous fat cover; there may be large deposits of fat over rump and tail.						It is possible to score to the nearest 0.25 or 0.5 unit depending upon the nature of the experimental work.

Table 2. (continued)

SOURCE	0	1	2	3	4	5	6	7	8	9	10	Comments
	SCORE DESCRIPTION											
Spitzer (1977)		POOR- Starving, bordering on inhumane, survival questioned during stress. No palpable fat cover along backbone or ribs.	VERY THIN- Poor milk production, chances for rebreeding slim to none. Some fat present along backbone but no fat cover over ribs.	THIN- Lowered milk production, poor reproduction. Fat along backbone and slight amount of fat cover over ribs.	BORDERLINE- Reproduction bordering on inadequate. Some fat cover over ribs.	MODERATE- Minimum necessary for efficient rebreeding, good milk production, generally good overall appearance. Fat cover over ribs feels spongy.	MODERATE TO GOOD- Milk production and rebreeding very acceptable. Spongy fat cover over ribs and fat beginning to be palpable around tailhead.	GOOD- Fleshy, maximum condition needed for efficient reproduction. Spongy fat cover over ribs and fat around tailhead.	FAT- Very fleshy, unnecessary, no advantage in rebreeding from having cows in this condition. Cow has large fat deposits over ribs, around tailhead, and below vulva.	EXTREMELY FAT- Extremely wasty and patchy, may cause calving problems. Cow extremely overconditioned.		
Wagner et al. (1985c)		SEVERELY EMACIATED. All ribs and bone structure easily visible and physically weak. Animals have difficulty standing or walking. No external fat present by sight or touch.	EMACIATED- Similar to 1, but not weakened.	VERY THIN- No palpable or visible fat on ribs or brisket. Individual muscles in the hind quarter are easily visible and spinous processes are very apparent.	THIN- Ribs and pin bones are easily visible and fat is not apparent by palpation on ribs or pin bones. Individual muscles in the hind quarter are apparent.	MODERATE- Ribs are less apparent than in a 4 and have less than 1/2 cm of fat on them. Last 2-3 ribs can be felt easily. No fat in the brisket. At least 1 cm of fat can be palpated on pinbones. Individual muscles in hind quarter are not apparent.	GOOD- Smooth appearance throughout. Some fat deposition in brisket. Individual ribs are not visible. About 1 cm of fat on the pin bones and on the last 2-3 ribs.	VERY GOOD- Brisket is full, tailhead and pin bones have protruding deposits of fat on them. Back appears square due to fat. Indentation over spinal cord due to fat on each side. One to two cm of fat on last 2-3 ribs.	OBESE- Back is very square. Brisket is distended with fat. Large protruding deposits of fat on tailhead and pin bones. Neck is thick. Three to four cm of fat on last 2-3 ribs. Large indentation over spinal cord.	VERY OBESE- Description of 8 taken to greater extremes.		
Wetteman and Lusby (1986)[†††]		SEVERELY EMACIATED- All ribs and bone structure easily visible and physically weak. Animals have difficulty standing or walking. No external fat present by sight or touch.	EMACIATED- Similar to 1, but not weakened.	VERY THIN- No palpable or visible fat on ribs or brisket. Individual muscles in the hind quarter are easily visible and spinous processes are very apparent.	THIN- Ribs and pin bones are easily visible and fat is not apparent by palpation on ribs or pin bones. Individual muscles in the hind quarter are apparent.	MODERATE- Ribs are less apparent than in a 4 and have less than 1/2 cm of fat on them. Last 2-3 ribs can be felt easily (less than .5 cm of fat). No fat in the brisket. At least 1 cm of fat can be palpated on pinbones. Individual muscles in hind quarter are not apparent.	GOOD- Smooth appearance throughout. Some fat deposition in brisket. Individual ribs are not visible. About 2 cm of fat on the pin bones and about 1 cm of fat on last 2-3 ribs.	VERY GOOD- Brisket is full, tailhead and pin bones have protruding deposits of fat on them. Back appears square due to fat. Indentation over spinal cord due to fat on each side. One to two cm of fat on last 2-3 ribs.	OBESE- Back is very square. Brisket is distended with fat. Large protruding deposits of fat on tailhead and pin bones. Neck is thick. Three to four cm of fat on last 2-3 ribs. Large indentation over spinal cord.	VERY OBESE- Description of 8 taken to greater extremes.		

Table 2. (Continued)

SOURCE	SCORE DESCRIPTION											
	0	1	2	3	4	5	6	7	8	9	10	Comments
Wright and Russel (1984) (After Lowman et al. 1976)	The animal is emaciated. No fatty tissue can be detected and the neural spines and transverse processes feel very sharp.	The individual transverse processes are sharp to the touch and easily distinguished.	The transverse processes can be identified individually when touched, but feel rounded rather than sharp.	The transverse processes can only be felt with firm pressure and the areas on either side of the tail head have some fat cover.	Fat cover around the tail head is easily seen as slight mounds, soft to the touch. The transverse processes cannot be felt.	The bone structure of the animal is no longer noticeable and the tail head is almost completely buried in fatty tissue.						The animals are handled on the lumbar region and around the tail-head.

---

[t] Ercarbrack, K. S. 1986. Body condition scoring of sheep (Phone communication) U.S. Dept. Agr., Agr. Res. Ser., U.S. Sheep Exp. Sta. Dubois, ID.

[tt] Morris, J. G. 1986. Body condition scoring of cattle p. 1 (Unpublished) U.C. Davis Dept. of Anim. and Physiological Sci., Davis, CA.

[ttt] Wettemann, R. P. and K. S. Lusby. 1986. Oklahoma State University condition scoring system p. 1 (unpublished) O. S. U. Dept. of Anim. Sci., Stillwater, OK.

conditions were defined. Visually assigned scores are normally based on the amount of subcutaneous fat present around the base of the tail and over the hips, back, and ribs (Macmillan and Bryant 1980). It is possible, if only visual appraisal is used, heavy hair coats (Good et al. 1961), wool (Ercanbrack, personal communication), full digestive tracts, or the large conceptus of late pregnancy (Dziuk and Bellows 1983) may bias the scoring. Jefferies (1961), however, did not find wool length to bias visual appraisal if a subsample of Merino and Corriedale sheep to be scored were first externally palpated.

One of the earliest, most frequently quoted, and the standard for scoring *Bos taurus* cattle in Britain (Pullan 1978) was a palpation procedure developed by Lowman et al. (1976). They used a 0 (emaciated) to 5 (excessively fat) point scale to describe fat cover. In practice the system uses 1/2-unit scores for animals whose condition is intermediate. Pullan (1978) states five areas of the body are evaluated for fat cover using Lowman's system on the spinous processes of the lumbar vertebrae, over the lower rib cage, at the hip bones (tuber coxae), around the tail head, and at the second thigh (gluteal muscles). The fingers are placed on the neural region of the spinous processes of the fourth and fifth lumbar vertebrae while the thumb is used to palpate the transverse processes (Fig. 1). The prominence of the spinous process is the main measurement; however, if it cannot be felt as a result of fat disposition, additional assessment is made around the tail head and over the hip bones.

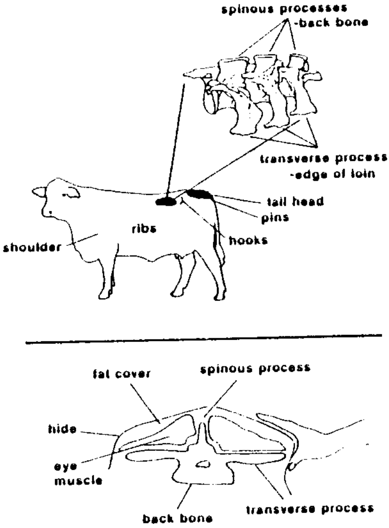

Figure 1. Anatomic areas that are used for scoring body condition in beef cows. (Source: Herd and Sprott 1986).

In the procedure given by Dunn et al. (1983), a nine-point scale was proposed to evaluate fat cover over the loin area. Based on this scale, scores accounted for between 77% and 86% of the carcass energy content and fatness when 51 mature beef cows were evaluated. They advocated the loin area as the most important area to palpate in thin animals to obtain accurate scores. Graham and Clark (1984) showed a significant relationship ($P < .001$) between body condition and subcutaneous fat depth at the 12/13 rib, with correlation coefficients between .85 and .87 for cows. This may reflect the closeness to the loin area where animals are scored and the fat depth at the 12th and 13th ribs. The low correlations between body condition scores and ultrasonic methods normally arise when extremely thin animals are evaluated. Preston and Willis (1970) indicate ultrasonics require $\geq$ 10 mm of fat cover for efficient estimates.

Nelsen et al. (1985) combined palpated and visual scoring to evaluate 2- to 6-year-old Hereford and mixed breed cows. The two scoring methods were positively and linearly correlated ($P < .01$) but not equal. Only 50% to 60% of the variation in one score could be accounted for by the other score. In the palpation procedure, two persons using a 10-point scale (1 = emaciated, 10 = fat) examined each animal on the spinous process of the lumbar vertebrae, over the lower rib cage, at the hip bones, around the tail head, and at the upper rear of the hind legs while in a chute. Visual scoring was done by two observers, also using the 10-point scale, as the animals walked away from the scale. The linear regression coefficients for the two procedures were similar ($P < .05$) and positively correlated ($P < .01$) for the Hereford and crossbred cows.

Several scoring systems, including the 9-point system used by Whitman (1975), are often quoted but have not been published. Table 2 lists 19 systems found in the literature or obtained from individual researchers. In addition to the 5- and 9-point systems described in Table 2, Bailey et al. (1984) described a 7-point system; Filho and Ray (1985) used an 11-point system with categories between 5 and 15; Gresham et al. (1986) used but did not describe a system having 17 categories with 17 being the fattest score. All systems reviewed in this paper, except the 5-point system used by Ercanbrack (1986) at the U.S. Sheep Experiment Station, Dubois, Idaho, indicated fatter animals with higher numbers; the Idaho system ranks rather than quantifies body conditions.

Use of Body Condition Scores

The sole function of a grazing cow is to produce a large calf early in the calving season, raise it to a heavy weaning weight successfully, and repeat the process every 12 months throughout her productive life. This often is not realized under free-ranging conditions, and in many instances the cause can be traced back to inadequate nutrition at critical stages in the cow's reproduction cycle (Spitzer 1977, van Niekerk 1982b).

Feed requirements are influenced by age, breed, stage of pregnancy, level of production, stage of lactation, and conformation (Macmillan and Bryant 1980). Fatness is closely ($P < .01$) related to dry matter intake (Brown et al. 1980). Thin cows consume more ($P < .01$) dry matter than cows in higher body condition (van Niekerk 1982a). Adult sheep in poor body condition also increase their food intake by eating faster or grazing longer than fat sheep (Arnold and Birrell 1977). This increase may be up to 24% more if thin and fat cows are fed *ad libitum* (Bines and Morant 1983). Intake may not be influenced by pregnancy because van Niekerk (1982b) was not able to show significant differences in dry matter intake between pregnant and nonpregnant cows. Condition scores have been used to identify the need for different feeding requirements (Croxton and Stollard 1976) and are advocated for use in feeding fat and thin cows according to their nutritional needs (Dziuk and Bellows 1983). Wagner et al. (1985a) indicate the highest metabolizable energy (ME) per kilogram of metabolic weight occurs at a body condition score of 4.68 (9-point system) and that a thin cow (3) or a fat cow (7) would require 4.4% and 8.9% less ME per kilogram of metabolic weight. They also found the effect of temperature on ME required for maintenance was dependent on body condition score. Their data suggests the effect of temperature on ME required for maintenance may be greater for thin cows than for cows having a moderate or fat condition score. Although maintenance costs can be reduced in thin cows, the savings probably have little value based on the substantial amount of data that connects reproductive performance to proper (not thin) body condition.

Body condition ultimately influences reproductive performance (Richards et al. 1986). A cow's body condition is highly correlated with the length of interval from calving to first estrus (D. C. Adams, personal communication). Most studies show a positive relationship between condition score at calving and subsequent production. The interval from parturition to estrus and subsequent pregnancy in beef cattle appears to be influenced more by prepartum nutrition as reflected in body condition scores at parturition than by postpartum nutrition (Dunn et al. 1983; Spitzer 1977; Macmillan and Bryant 1980; Graham 1982; van Niekerk 1982a, 1982b; Richards et al 1986). Some evidence exists, however, that postpartum nutrition may influence production (Macmillan and Bryant 1980) including the postpartum interval to estrus (Graham 1982, Rutter and Randel 1984) and total pregnancy rate (Spitzer 1977). Graham (1982) was unable ($P > .05$) to show pregnancy rates to be affected by cow condition score at calving. Changes in body fat, as indicated from body condition scores, may have little effect on the likelihood of pregnancy in non-lactating and late-lactating Brangus cows once estrus cycles are reinitiated after parturition (Filho and Ray 1985). Horstman et al. (1986) were unable ($P > .10$) to show body condition or percent body lipid had any effect on reproduction or calf gain.

Based on data compiled from six states on postpartem diet and calf separation, Wettemann et al. (1986) concluded that providing additional energy (flush) for 28 d, beginning an average of 30 d postpartum, along with short-term (48 h) calf separation at 14 and 28 d after the beginning of flush, did not enhance reproductive performance or the initiation of the breeding period if cows were in thin to moderate body condition (1-9 point scale).

If cattle have adequate body reserves going into late pregnancy, the incidence of dystocia and calf mortality should be reduced (Russel and Wright 1982), while fat cows need help calving (Kilkenny 1982). Dziuk and Bellows (1983) advocate separating pregnant dams into management-nutrition groups that give thin females more nutrition than fat females. Thompson et al. (1983) indicate visual appraisal is adequate to separate Angus and Angus-Hereford cows into fat and thin groups.

Australian research has shown that the cow's condition at calving is more important than liveweight gain on milk production (Ellinbank Dairy Research Station 1976). The dams postpartum nutrition may (Richards et al. 1986) or may not (Whittier et al. 1986) have an important effect on calf weights. Research by Broster (1971) suggests a cow's milk production is maintained by mobilization of body reserves (fat), even if her appetite is low 2 mo postpartum when energy requirements are high. Cows in poor condition at calving persistently gave low, late-peak milk yields while cows in good condition at calving gave high, early-peak milk yields. If cows in moderate to good condition lose some weight postpartum but are flushed for a period 2 weeks before breeding and on through breeding, the kilograms of calf weaned will not differ from cows that were maintaining or gaining weight from parturition through weaning (Richards et al. 1986). In Holstein cows it has been demonstrated that the fat corrected milk yield from fat condition cows was greater ($P < .01$) than the milk yield from thin condition cows (Davenport and Rakes 1969). Likewise, it has been shown that cows grazing low-quality pasture, giving relatively large amounts of milk, maintained less fat during the middle and last part of lactation than those that give smaller amounts of milk (Brown et al. 1980). On a within-herd basis dairy cows that lost one unit of condition produced 10 g more milk fat per day ($P < .05$) and 2.4 kg more milk fat ($P < .01$) for the whole of lactation than herd mates that maintained condition (Mcmillan and Bryant 1980).

Dairy cows apparently sacrifice maintenance and tissue storage for lactation (Flatt 1966, Moe et al. 1971); however, it appears Angus cows on high-quality pasture maintain large amounts of fat instead of producing large amounts of milk. This difference may reflect a different metabolic priority between dairy and beef breeds (Brown et al. 1980). Thin cows probably produce more milk than fat cows. Thus, at weaning cows in thinner body condition should be the best producers. Applegate et al. (1986b) have shown that cow body condition score was not a significant source of variation in calf average daily gain but that thin cows produced calves with a higher ($P < .05$) average daily gain than fat cows.

Cows in high body condition tend to lose more weight following parturition than cows in a lower body condition (Davenport and Rakes 1969). In beef herds, utilization of body reserves during winter is common so body condition should not be considered as static throughout the year. The cow's condition may be most critical at mid-pregnancy (Kilkenny 1982). Wagner et al. (1985b) found that losses in condition score taken in winter were not influenced by cow breed or calving date. However, cows nursing male calves (bull or steer) lost more condition ($P \leq .10$) than cows nursing heifer calves, and cows giving birth to heavier calves tended to lose more condition ($P \leq .10$) than cows giving birth to lighter calves. These researchers concluded that fat Hereford and Angus cows lost more weight ($P \leq .10$) and condition ($P < .001$) than thin cows during winter, and manipulation of body condition during the winter under Oklahoma range conditions appeared limited.

Breed, management, and month of birth appear to influence body condition scores in heifers between 450 and 630 d of age with traditional beef breeds being fatter than the traditional dairy breeds while *Bos indicus* were intermediate in condition scores (Long et al. 1979a). Information on breed effects on condition score is limited, however (Long et al.

1979b). The use of a single equation to predict body fat for all beef genotypes and one for all sheep genotypes from condition scores may not be possible because different breeds of sheep (Palsson 1940, Russel et al. 1969, Russel et al. 1971) and cattle (Wright and Russel 1984) distribute body fat in different proportion to the various fat depots.

Conclusions

Accurately evaluating the free-ranging animal's nutritional status is difficult. Forage analysis is time consuming and, at best, only gives a partial answer because grazing animals are selective when choosing their diets. Esophageal fistula data has helped the researchers sort out animal selectivity and preference. This kind of information, however, can only be incorporated into management strategies after laborious laboratory analyses and data summarization. This often occurs in a time frame that may separate cause and effect responses outside the realm of practical management. All samples of body tissue or fluids taken from the animal provide a limited amount of immediate information useful for making management decisions. Analysis requires expensive equipment and specialized training to operate the equipment and interpret the data.

The use of body condition scores obtained either visually or by palpation of the animal's exterior appear to offer a reliable assessment of the animal's energy reserves (fat). Because subcutaneous fat appears to be one of the initial depots mobilized by the body, it provides an excellent means of immediately evaluating an animal's nutritional status. The use of body condition scores should be considered in the design and interpretation of nutritional experiments, especially when pregnant animals are being used in light of how incomplete a nutritional picture liveweight changes or physical measures can be, especially during the later stages of pregnancy. Because body condition scoring systems do not require sophisticated equipment to obtain the data, the tool can effectively be used by the producer as well as the researcher. One factor that has prevented the widespread acceptance of body condition scoring has been the lack of a scoring system that has been adequately defined. A written and pictorial description of each condition class within a breed type offers the best chance for a system that will have widespread acceptance and repeatability. In addition to adequately defining each condition class in terms of what should be observed or palpated, it would be preferable to use a system with a standard scale. This would be especially convenient in providing adequate documentation within scientific papers because most material and methods sections of papers where condition scores were used do not have an adequate description of the scoring system, especially for those categories between the extreme values. Based on the literature reviewed for this paper, the number of scales used by the various systems vary between 5 and 17. Most systems, however, appear to have either 6 or 9 points. Visual appraisal may be adequate for cattle with smooth hair coats or for recently shorn sheep. Finger tip palpation may always be preferable but should always be used on wooled sheep and where long winter hair coats can mask conformation. No literature was found in which goats were scored for body condition; however, with appropriate modification, any present scoring system could be successfully adapted.

Body condition can be used effectively to control behavioral overfeeding by separating fat and thin cows and managing according to nutritional needs (Dziuk and Bellows 1983). The influence of postpartum and prepartum nutrition, as it affects the overall production efficiency, is not clear cut. It appears, however, prepartum nutrition is probably the most important stage to establish the proper body condition in cattle to ensure a minimum postpartum interval that results in the highest number of weaned calves. Van Niekerk (1982a) states the relationship simply as the lower the condition score at breeding, the fewer the number of calves at weaning. Postpartum nutrition has the most influence on the calf through the milk production. Monitoring the reproductive and lactational stages in the range animal's life cycle using body condition scores offers a cost effective and easy to use tool. Body condition scores can be used independently or in combination with other techniques to accurately monitor the grazing animal's nutritional status.

LITERATURE CITED

Andersen, B. B., H. Busk, J. P. Chadwick, A. Cuthbertson, G. A. J. Fursey, D. W. Jones, P. Lewin, C. A. Miles, and M. G. Owen. 1983. Comparison of ultrasonic equipment for describing beef carcass characteristics in live cattle (Report on a joint ultrasonic trial carried out in the U.K. and Denmark). Liv. Pro. Sci. 10:133.

Anderson, D. M., and D. L. Mertz. 1982. An esophageal fistula dilator. J. Range Manage. 35:125.

Anderson, D. M., D. L. Mertz, W. E. Franklin, and P. J. Manz. 1985. Improved esophageal fistula closure devices for cattle and sheep. USDA-ARS, ARS-26.

Applegate, G. D., R. E. Morrow, C. A. Tucker, J. J. Chewning, L. S. Coffey, M. J. McClure, A. Decker, and B. Martin. 1986a. Relationships between body composition changes and cow-calf performance. Univ. Missouri Anim. Sci. Rep. 111.

Applegate, G. D., R. E. Morrow, C. A. Tucker, L. S. Coffey, J. L. Ellis, B. Booker, and M. J. McClure. 1986b. Relationships between cow condition and calf performance. Univ. Missouri Anim. Sci. Rep. 111.

Arnold, G. W., and H. A. Birrell. 1977. Food intake and grazing behavior of sheep varying in body condition. Anim. Prod. 24:343.

Bailey, P. J., G. L. Cook, A. J. Kempster, and A. G. Sains. 1984. The estimation of killing out in cattle from knowledge of breed, and visual appraisal of external fat cover and conformation. Anim. Prod. 38:391.

Bartle, J. J., R. Males, and R. L. Preston. 1983. Evaluation of urea dilution as an estimator of body composition in mature cows. J. Anim. Sci. 56:410.

Bellows, R. A., R. B. Staigmiller, J. B. Carr, and R. E. Short. 1979. Beef production from mature cows on range forage. J. Animal Sci. 49:654.

Beverly, J. R. 1981. Relationship of nutrition to physiological and reproductive function in cows. In: L. D. White and A. L. Hoermann (eds). Proc. Int. Rancher's Roundup. Tex. Agr. Ext. Ser. pp. 38-45.

Bines, J. A., and S. V. Morant. 1983. The effect of body condition on metabolic changes associated with intake of food by the cow. Brit. J. Nut. 50:81.

Black, W. H., and B. Knapp, Jr. 1938. Correlation of body measurements of slaughter steers with rate and efficiency of gain and with certain carcass characteristics. J. Agr. Res. 56:465.

Bredon, R. M., and A. M. Short. 1971. Oesophageal fistulation of cattle for pasture utilization studies, post-fistulation care and use of animals and sampling procedures. Agroanimalia 3:141.

Brinks, J. S., R. T. Clark, N. M. Kieffer, and J. J. Urick. 1964. Predicting wholesale cuts of beef from linear measurements obtained by photogrammetry. J. Anim. Sci. 23:365.

Brookes, A. J., and G. Harrington. 1960. Studies in beef production, II. The estimation of live weight of beef steers from chest girth and other body measurements. J. Agr. Sci. 55:207.

Brooks, A. L., R. E. Morrow, and R. S. Youngquist. 1985. Body composition of beef heifers at puberty. Theriogenology 24:235.

Broster, W. H. 1971. The effect on milk yield of the cow of the level of feeding before calving. Dairy Sci. Abstr. 33:253.

Brown, W. F., J. W. Holloway, and W. T. Butts, Jr. 1980. Patterns of change in mature Angus cow weight and fatness during the year. J. Anim. Sci. 51:43.

Bull, R. C., D. O. Everson, D. P. Olson, L. F. Woodard, and L. C. Anderson. 1984. Blood metabolite levels in pregnant beef heifers restricted prepartum in protein and/or energy. Proc. West. Sec. Am. Soc. Anim. Sci. 35:234.

Burt, A. W. A. 1957. The comparative efficiency of some methods of estimating the live weight of dairy cows. J. Dairy Res. 24:144.

Buvanendran, V., J. E. Umoh, and B. Y. Abubakar. 1980. An evaluation of body size as related to weight of three West African breeds of cattle in Nigeria. J. Agr. Sci., Camb. 95:219.

Byers, F. M. 1979. Measurement of protein and fat accretion in growing beef cattle through isotope dilution procedures. Ohio Beef Cattle Res. Prog. Rep., pp. 36-47.

Callow, E. H. 1961. Comparative studies of meat, VII. A comparison between Hereford, Dairy Shorthorn and Friesian steers on four levels of nutrition. J. Agr. Sci., Camb. 56:265.

Center, D. M., and M. B. Jones. 1984. An improved esophageal fistula bag for sheep. J. Range Manage. 37:476.

Chigaru, P. R. N., and J. H. Topps. 1981. The composition of body-weight changes in underfed lactating beef cows. Anim. Prod. 32:95.

Cook, C. W., and J. Stubbendieck, eds. 1986. Range research: basic problems and techniques. Soc. Range Manage. Josten, Colo. 317 pp.

Combs, D. K., R. D. Goodrich, and J. C. Meiske. 1982. Mineral concentration in hair as indicators of mineral status: a review. J. Anim. Sci. 54:391.

Cowan, R. T., J. J. Robinson, J. F. D. Greehalgh, and I. McHattie. 1979. Body composition changes in lactating ewes estimated by serial slaughter and deuterium dilution. Anim. Prod. 29:81.

Croxton, D., and R. J. Stollard. 1976. Use of body condition scoring as a managment aid in dairy and beef herds. Anim. Prod. 22:146 (Abstr.).

Davenport, D. G., and A. H. Rakes. 1969. Effects of prepartum feeding level and body condition on the postpartum performance of dairy cows. J. Dairy Sci. 52:1037.

Davis, J. K., R. A. Long, R. L. Saffle, E. P. Warren, and J. L. Carmon. 1964. Use ultrasonic and visual appraisal to estimate total muscling in beef cattle. J. Anim. Sci. 23:638.

Drumm-Lamontagne, F. A. 1981. Response of cull cows to different ration concentrate levels. M. S. Thesis Montana State Univ., Bozeman.

Dunn, T. G., M. L. Riley, and W. J. Murdoch. 1983. Body fatness, body condition scores, and the post-partum interval. Proc. Range Beef Cow Symposium VIII. Sterling, Colo.

Dziuk, P. J., and R. A. Bellows. 1983. Management of reproduction of beef cattle, sheep and pigs. J. Anim. Sci. 57:355.

Ellinbank Dairy Research Station. 1976. Ann. Rep. 27:23.

Ellis, W. C., E. M. Bailey, and C. A. Taylor. 1984. A silicone esophageal cannula; its surgical installation and use in research with grazing cattle, sheep or goats. J. Anim. Sci. 59:204.

Evans, D. G. 1978. The interpretation and analysis of subjective body condition scores. Anim. Prod. 26:119.

Everitt, G. C. 1962. On the assessment of body composition in live sheep and cattle. Proc. Aust. Soc. Anim. Prod. 4:79.

Everitt, G. C. 1964. Component analysis of meat production using biopsy techniques. Tech. Conf. Carcass Composition and Appraisal of Meat Animals (D. E. Tribe, ed.), CSIRO, Melbourne.

Filho, C. G., and D. E. Ray. 1985. Reproductive performance as affected by lactation status and body fat in beef cows. Pesq. Agropec. Bras., Brasilia 20:699.

Flatt, W. P. 1966. Energy metabolism results with lactating dairy cows. J. Dairy Science 49:230.

Forwood, J. R., J. L. Ortbals, G. Zinn, and J. A. Paterson. 1985. Cannula adaptations for esophageally fistulated cattle. J. Range Manage. 38:474.

Fraps, G. S., and V. L. Cory. 1940. Composition and utilization of range vegetation in Sutton and Edwards Counties. Tex. Ag. Exp. Sta. Bull. 586.

Frood, M. J., and D. Croxton. 1978. The use of condition-scoring in dairy cows and its relationship with milk yield and live weight. Anim. Prod. 27:285.

Garnsworthy, P. C., and J. H. Topps. 1982. The effects of body condition at calving, food intake and performance in early lactation on blood composition of dairy cows given complete diets. Anim. Prod. 35:121.

Garrett, W. M., J. H. Meyer, and G. P. Lofgreen. 1959. An evaluation of antipyrine dilution technique for determination of total body water in ruminants. J. Anim. Sci. 18:116.

Good, D. L., G. M. Dahl, S. Wearden, and D. J. Weseli. 1961. Relationships among live and carcass characteristics of selected slaughter steers. J. Anim. Sci. 20:698.

Goodchild, A. V. 1985. Gut fill in cattle: effect of pasture quality on fasting losses. Anim. Prod. 40:455.

Gossett, W. H. 1960. The blood composition and growth of weanling Hereford heifers as affected by plane of nutrition. M. S. Thesis, New Mexico State Univ., Las Cruces.

Graham, J. F. 1982. The effect of body condition of beef cows at calving and post calving nutrition on calf growth rate and cow fertility. Proc. Aust. Soc. Anim. Prod. 14:309.

Graham, J. 1984. The scoring system used at Hamilton. Agnote 1859/182.

Graham, J. F., and A. J. Clark. 1984. The relationship of condition score to carcass data in beef cattle. Aust. Soc. Anim. Prod. 15:369.

Graham, J. G., A. J. Clark, and S. A. Spiker. 1984. The repeatability and accuracy of condition scoring beef cattle. Aust. Soc. Anim. Prod. 15:684.

Gresham, J. D., J. W. Holloway, W. T. Butts, Jr., and J. R. McCurley. 1986. Prediction of mature cow carcass composition form live animal measurements. J. Anim. Sci. 63:1041.

Grunwaldt, E. G., and R. Sosa. 1986. Construction of an inexpensive liquid resin esophageal cannula for goats. J. Range Manage. 39:93.

Haaland, G. L., J. K. Matsushima, C. F. Nockels, and D. E. Johnson. 1977. Bovine hair as an indicator of calorie-protein status. J. Anim. Sci. 46:626.

Hardison, W. A., J. T. Reed, C. M. Martin, and P. G. Woolfolk. 1954. Degree of herbage selection by grazing cattle. J. Dairy Sci. 37:89.

Harris, L. E., G. P. Lofgreen, C. J. Kercher, and others. 1967. Techniques of research in range livestock nutrition. Utah State Agr. Exp. Sta. Bull. 471.

Herd, D. B. 1986. Relationship of body condition scores (BCS) to measures of body composition for beef cows--a suggestion for use in extension programs. J. Anim. Sci. 63:(Suppl. 1) 25. (Abstr.).

Herd, D. B., and L. R. Sprott. 1986. Body condition, nutrition and reproduction of beef cows. Tx. Agr. Ext. Ser. B-1526.

Hinnant, T. R. 1979. Blood, rumen liquor, and fecal components as affected by dietary crude protein. M.S. Thesis, Texas A&M Univ., College Station.

Holecheck, J. L., M. Vavra, and R. D. Peiper. 1984. Methods for determining the botanical composition, similarity, and overlap of range herbivore diets. In: Developing Strategies for Rangeland Management. Westview Press, Boulder, Colorado. pp. 425-471.

Horn, F. P. 1981. Basic animal performance criteria for range and humid pastures. In: J. L. Wheeler and R. D. Mochrie (eds.), Forage Evaluation: Concepts and Techniques. CSIRO and American Forage and Grassland Council, Melbourne, Australia. pp. 299-312.

Horstman, L. A., K. S. Hendrix, B. J. Wesley, and G. E. Moss. 1986. Effect of body composition, pre- and postpartum energy level and calf removal on reproductive performance of beef cows and preweaning calf gain. J. Anim. Sci. 63 (Suppl. 1):400. (Abstr.).

Houghton, P. L., R. P. Lemenager, G. E. Moss, B. J. Wesley, and K. S. Hendrix. 1986. Prediction of postpartum beef cow body composition using comparative slaughter, weight to height ratio and visual condition score. J. Anim. Sci. 63 (Supple. 1):87. (Abstr.).

Jefferies, B. C. 1961. Body condition scoring and its use in management. Tasm. J. Agr. 32:19.

Johansson, I., and S. E. Hildeman. 1954. The relationship between certain body measurements and live and slaughter weight n cattle. Anim. Breeding Abstr. 22:1.

Jones, R. J. 1981. The use of natural carbon isotope ratios in studies with grazing animals. In: J. L. Wheeler and R. D. Mochrie (eds.), Forage Evaluation: Concepts and Techniques. CSIRO and American Forage and Grassland Council, Melbourne, Australia. pp. 277-286.

Kartchner, R. J., and D. C. Adams. 1983. An improved method for attaching the esophageal fistula bag. J. Range Manage. 36:405.

Kempster, A. J. 1980-81. Fat partition and distribution in the carcasses of cattle, sheep and pigs: a review. Meat Sci. 5:83.

Kempster, A. J., D. Arnall, J. C. Alliston, and J. D. Barker. 1982. An evaluation of two ultrasonic machines (Scanogram and Danscanner) for predicting the body composition of live sheep. Anim. Prod. 34:249.

Kilkenny, J. B. 1982. Target condition scores for beef cows. Anim. Prod. 34:392. (Abstr.).

Kirton, A. H. 1964. Assessment of body composition in the live animal. Proc. NZ Soc. Anim. Prod. 24:77.

Kirton, A. H., and A. M. Pearson. 1963. Comparison of methods of measuring potassium in pork and lamb and prediction of their composition form sodium and potassium. J. Anim. Sci. 22:125.

Klosterman, E. W., L. G. Sanford, and C. F. Parker. 1968. Effect of cow size and condition and ration protein contact upon maintenance requirements of mature beef cows. J. Anim. Sci. 27:242.

Klyde, B. J., and J. Hirsch. 1979. Increased cellular proliferation in adipose tissue of adult rats fed a high-fat diet. J. Lipid Res. 20:705.

Kraybill, H. F., H. L. Bitter, and O. G. Hankins. 1952. Body composition of cattle, II. Determination of fat and water content from measurement of body specific gravity. J. Appl. Physiol. 4:575.

Kronfeld, D. S., S. Donoghue, R. L. Copp, F. M. Stearns, and R. H. Engle. 1982. Nutritional status of dairy cows indicated by analysis of blood. J. Dairy Sci. 65:1925.

Lesperance, A. L., D. C. Clanton, A. B. Nelson, and C. B. Theurer. 1974. Factors affecting the apparent chemical composition of fistula samples. Univ. of Nevada, Reno, Agr. Exp. Sta., West. Reg. Coord. Comm. No. 8, Bull. T18.

Little, D. A., and A. Takken. 1970. Preparation of oesophageal fistulae in cattle under local anesthesia. Aust. Vet. J. 46:335.

Long, C. R., T. S. Stewart, T. C. Cartwright, and J. F. Baker. 1979a. Characterization of cattle of a five breed diallel: II. Measures of size, condition and growth in heifers. J. Anim. Sci. 49:432.

Long, C. R., T. S. Stewart, T. C. Cartwright, and T. G. Jenkins. 1979b. Characterization of cattle of a five breed diallel: I. Measures of size, condition and growth in bulls. J. Animal. Sci. 49:418.

Loxton, I. D., J. A. Lindsay, and M. A. Toleman. 1982. A tactile method modified to assess the finish of beef cattle in marketable condition in North Queensland. Proc. Anim. Soc. Prod. Sci. 14:265.

Lowman, B. G., N. Scott, and S. Somerville. 1976. Condition scoring of cattle. Bull. E. Scotl. Coll. Agr. No. 6.

Lush, J. L., and O. C. Copeland. 1930. A study of the accuracy of measurements of dairy cattle. J. Agr. Res. 41:37.

Lush, J. L., J. M. Jones, W. H. Dameron, and O. L. Carpenter. 1930. Normal growth of range cattle. Tex. Agr. Exp. Sta. Bull. 409.

Macmillan, K. L., and A. M. Bryant. 1980. Cow condition and its relation with production and reproduction. Porc. RFC. pp. 165-171.

McCarthy, F. D., W. G. Bergen, and D. R. Hawkins. 1983. Muscle protein turnover in cattle of differing genetic bakgrounds as measured by urinary N methylhistidine excretion. J. Nut. 113:2455.

McManus, W. R. 1981. Oesophageal fistulation technique as an aid to diet evaluation of the grazing ruminant. In: J. L. Wheeler and R. D.

Mochrie (eds.), Forage Evaluation: Concepts and Techniques. CSIRO and American Forage and Grassland Council, Melbourne, Australia. pp. 249-260.

Milton, W. E. J. 1933. The palatability of self-establishing species contributing to different types of grassland. Emp. J. Exp. Agr. 1:347.

Moe, P. W., H. F. Tyrrell, and W. P. Flatt. 1971. Energetics of body tissue mobilization. J. Dairy Sci. 54:548.

Morris, C. A., N. G. Cullen, P. A. Carson, and G. A. Morley. 1985. Differences among and within crossbred beef cow groups in body condition and liveweight. Proc. N. Z. Soc. Anim. Prod. 45:167.

Mufarrih, M. E. 1964. The effect of plane of nutrition upon the levels of certain blood consituents in weanling Hereford heifers in southern New Mexico. M.S. Thesis, New Mexico State University, Las Cruces.

Murray, J. A. 1919. Meat production. J. Agr. Sci., Camb. 9:179.

Nelsen, T. C., R. E. Short, W. L. Reynolds, and J. J. Urick. 1985. Palpated and visually assigned condition scores compared with weight, height and heart girth in Hereford and crossbred cows. J. Anim. Sci. 60:363.

Neville, W. E., Jr., B. G. Mullinix, Jr., J. B. Smith, and W. C. McCormick. 1978. Growth patterns for pelvic dimensions and other body measurements of beef females. J. Anim. Sci. 47:1080.

Palsson, H. 1940. Meat qualities in the sheep with special reference to Scottish breeds and crosses, Part III. Comparative development of selected individuals of different breeds and crosses as lambs and hoggets. J. Agr. Sci., Camb. 30:1.

Preston, T. R., and J. N. Aitken. 1963. Unpublished data. (Not available, cited in Preston and Willis 1970).

Preston, T. R., and M. B. Willis. 1970. Intensive Beef Production, 2nd Edition. Pergamon Press, New York.

Pullan, N. B. 1978. Condition scoring of white Fulani cattle. Too. Anim. Hlth. Prod. 10:118.

Read, M. V. P., E. A. N. Engels, and W. A. Smith. 1986. Phosphorus and the grazing ruminant. 3. Rib bone samples as an indicator of the P status of cattle. S. Afr. Tydskr. Veek. 16:13.

Richards M. W., J. C. Spitzer, and M. B. Warner. 1986. Effect of varying levels of postpartum nutrition and body condition at calving on subsequent reproductive performance in beef cattle. J. Anim. Sci. 62:300.

Robards, G. E. 1981. Techniques used in practice in forage evaluation in Australia. In: J. L. Wheeler and R. D. Mochrie (eds.), Forage Evaluation: Concepts and Techniques. CSIRO and American Forage and Grassland Council. Melbourne, Australia. pp. 461-472.

Rowlands, G. J. 1980. A review of variations in the concentrations of metabolites in the blood of beef and dairy cattle associated with physiology, nutrition and disease, with particular reference to the interpretation of metabolic profiles. Wld. Rev. Nutr. Diet. 35:172.

Russel, A. J. F., J. M. Doney, and R. G. Gunn. 1969. Subjective assessment of body fat in live sheep. Agr. Sci., Camb. 72:451.

Russel, A. J. F., J. M. Doney, and R. G. Gunn. 1971. The distribution of chemical fat in the bodies of Scottish Blackface ewes. Anim. Prod. 13:503.

Russel, A. J. F., R. G. Gunn, and J. M. Doney. 1968. Components of weight loss in pregnant hill ewes during winter. Anim. Prod. 10:43.

Russel, A. J. F., and I. A. Wright. 1982. Utilization of body reserves in pregnancy. Anim. Prod. 34:393. (Abstr.)

Rutter, L. M., and R. D. Randel. 1984. Postpartum nutrient intake and body condition: effect on pituitary function and onset of estrus in cattle. J. Anim. Sci. 58:265.

Schoenheimer, R. 1942. The Dynamic State of Body Constituents. Harvard Univ. Press, Cambridge, Mass.

Searle, T. W. 1970. Body composition in lambs and young sheep and its prediction in vivo from tritiated water space and liveweight. J. Agr. Sci., Camb. 74:357.

Selk, G. E., R. P. Wettemann, and K. S. Lusby. 1985. The relationship between prepartum nutrition and postpartum plasma glucose, body weight changes, body condition score changes and reproductive performance in beef cows. Okla. Agr. Exp. Sta. Anim. Sci. Res. Rep. 1985:92.

Shebaite, M. K. 1977. Evaluation of water conept for in-vivo body composition. World Rev. Anim. Prod. 8:65.

Sides, G. E., J. D. Wallace, and E. E. Parker. 1978. Blood urea nitrogen levels in beef heifers fed different amounts of protein. Proc. West. Sec. Amer. Soc. Anim. Sci. 29:448.

Skiles, J. W. 1984. A review of animal preference. In: Developing Strategies for Rangeland Management. Westview Press, Boulder, Colo. pp. 153-214.

Spitzer, C. 1977. Body condition and rebreeding in the cow. Tex. Anim. Agr. Conf. Tex. Agr. Ext. Ser. Beef Cattle Short Course Proc. 17-1 through 17-6.

Stouffer, J. R., M. V. Wallentime, G. H. Wellington, and A. Diekmann. 1961. Development and application of ultrasonic methods for measuring fat thickness and rib-eye area in cattle and hogs. J. Anim. Sci. 20:759.

Swett, W. W., and R. R. Graves. 1939. Relation between conformation and anatomy of cows of unknown producing ability. J. Agr. Res. 58:199.

Theurer, C. B., A. L. Lesperance, and J. D. Wallace. 1976. Botanical composition of the diet of livestock grazing native ranges. Univ. Ariz. Agr. Exp. Sta. Tech. Bul. 233.

Thompson, W. R., D. H. Theuninck, J. C. Meiske, and R. D. Goodrich. 1981. Linear measurements and visual appraisal as estimators of body composition of beef cows. J. Anim. Sci. 53(Suppl. 1):72 (Abstr.).

Thompson, W. R., D. H. Theuninck, J. C. Meiske, R. D. Goodrich, J. R. Pust, and F. M. Byers. 1983. Linear measurements and visual appraisal as estimators of percent empty body fat of beef cows. J. Anim. Sci. 56:755.

Torell, D. T. 1954. An esophageal fistula for animal nutrition studies. J. Anim. Sci. 13:878.

Truscott, T. G., J. D. Wood, and H. R. Denny. 1983a. Fat deposition in Hereford and Friesian steers. 2. Cellular development of major fat depots. J. Agr. Sci. Camb. 100:271.

Truscott, T. G., J. D. Wood, and H. J. H. Macfie. 1983b. Fat deposition in Hereford and Friesian steers. 1. Body composition and partitioning of fat between depots. J. Agr. Sci. Camb. 100:257.

Tulloh, N. M., and J. S. Maritz. 1964. Comparative breed studies of beef cattle. Aust. J. Agr. Res. 15:316.

Umoh, J. E., and V. Buvanendran. 1982. Relationships between body measurements and liveweight of the crossbreeds Friesian x White Fulani and Charolois x White Fulani cattle in Nigeria. Beitrage trop. Landwirtsch. Veterinarmed. 20:413.

Van Dyne, G. M., N. R. Brockington, Z. Szocs, J. Duek, and C. A. Ribic. 1980. Large herbivore subsystem. In: A. I. Breymeyer and G. M. Van Dyne (eds.) Grasslands, Systems Analysis, and Man. Cambridge Univ. Press. pp. 269-537.

Van Dyne, G. M., and D. T. Torell. 1964. Development and use of the esophageal fistula: a review. J. Range Manage. 17:7.

van Niekerk, A. 1982a. Condition scoring as a guide to the nutritional status of the beef cow and its implications in reproductive performance. S. Afr. J. Anim. Sci. 12:79.

van Niekerk, A. 1982b. The effect of body condition as influenced by winter nutrition on the reproductive performance of the beef cow. S. Afr. J. Anim. Sci. 12:383.

Wagner, J. J., K. S. Lusby, J. W. Oltjen, J. Rakestraw, and L. E. Walters. 1985a. Relationship between body condition score and daily metabolizable energy requirement of mature, nonpregnant, nonlactating Hereford cows during winter. Okla. Agr. Exp. Sta. Anim. Sci. Res. Rep.

Wagner, J. J., K. S. Lusby, and J. Rakestraw. 1985b. The influence of body condition score on winter weight and condition losses by spring calving cows. Okla. Agr. Exp. Sta. Anim. Sci. Res. Rep.

Wagner, J. J., K. S. Lusby, J. Rakestraw, R. P. Wettemann, and L. E. Walters. 1985c. Body condition score, liveweight and weight:height ratio as estimates of carcass composition in nonpregnant, nonlactating, mature Hereford cows. Okla. Agr. Exp. Sta. Anim. Sci. Res. Rep.

Wagnon, K. A., H. R. Guilbert, and G. H. Hart. 1957. Beef cattle investigations on the San Joaquin Experiment Range. Calif. Exp. Sta. Bull. 765.

Walker, J. W., J. W. Stuth, R. K. Heitschmidt, and S. L. Dowhower. 1985. A new esophageal plug. J. Range Manage. 38:185.

Watkins, W. E. 1937. The calcium and phosphorous contents of important New Mexico range grasses. NMSU Agr. Exp. Sta. Bull. 246.

Watkins, J. L., G. W. Sherritt, and J. H. Ziegler. 1967. Predicting body tissue characteristics using ultrasonic techniques. J. Anim. Sci. 26:470.

Wettemann, R. P., G. M. Hill, M. E. Boyd, J. C. Spitzer, D. W. Forrest, and W. E. Bell. 1986. Reproductive performance of postpartum beef cows after short-term calf separation and dietary energy and protein supplementation. Theriogenology (In press).

Whittier, J. C., D. C. Clanton, and G. H. Deutscher. 1986. Effect of varying level of nutrient intake during the first 90 days of lactation on productivity of two-year-old heifers. J. Anim. Sci. 63(Suppl. 1):97(Abstr.).

Whitman, R. W. 1975. Weight change, body condition and beef-cow reproduction. Ph.D. Dissertation, Colo. State Univ., Fort Collins.

Williams, D. R. 1978. Partition and distribution of fatty tissues. In: H. de Boer and J. Martin (eds.) Patterns of Growth and Development in Cattle. Current Topics in Veterinary Medicine, Vol. 2:219-229. Martinus Nkjhoff, The Hague.

Williams, J. H., D. C. Anderson, and D. D. Kress. 1979. Milk production in Hereford cattle, II. Physical measurements: repeatabilities and relationships with milk production. J. Anim. Sci. 49:1443.

Woodburn, D. A., R. E. Taylor, and J. D. Tatum. 1986. Identifying beef cattle muscularity using subjective estimates and objective measurements. CSU Beef Pro. Rep. pp. 141-147.

Wright, I. A., and A. J. F. Russel. 1984. Partition of fat, body composition and body condition score in mature cows. Anim. Prod. 38:23.

Yadava, R. K. 1970. The effect of body condition at calving upon the productivity of the dairy cow. Ph.D. Thesis. Ohio State Univ. (Unable to obtain).

Yao, T. S., W. M. Dawson, and A. C. Cook. 1953. Relationships between meat production characteristics and body measurements in beef and milking shorthorn steers. J. Anim. Sci. 12:775.