NUTRITIONAL STATUS OF BEEF COWS GRAZING RECLAIMED STRIP MINED PASTURES

by

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INTRODUCTION

Surface mining occurs in nearly every state in the United States. States along the Appalachian mountains in the East and along the Rocky mountains in the West are major areas for the surface removal of coal. Coal mining is responsible for almost one half of the disturbed mine land in the United States (Barrows, 1979).

Most coal mining in Virginia is concentrated in the Southwestern counties of Dickinson, Buchannan, Wise and Russell where over 32,000 ha have been disturbed since strip mining began in 1946 (Barrows, 1979). Land that was mined prior to 1977 was generally reclaimed by methods resulting in long benches surrounded by a high wall on one side and a steep outslope on the other side. Surface mine lands reclaimed since 1977 are required to be returned to the approximate original contour (Surface Mining Control and Reclamation Act, 1977). Much of the reclaimed land in Virginia is in remote areas of low economic value for industrial development and housing.

Strip mine soils are usually revegetated with mixtures of grasses, legumes and trees that are easily established, control erosion and are tolerant of low fertility and acid soils. Species such as tall fescue (Festuca arundinacae), serecia lespedeza (Lespedeza cuneata), and black locust (Robinia pseudoacacia) are suitable for revegetation of strip mined lands (Ruffner, 1977; Holmberg, 1983). In southwestern Virginia, mine lands reclaimed with tall fescue and serecia lespedeza have produced significant yields of forage dry matter that can be utilized by grazing livestock. Grazing is recognized as a potentially important use of reclaimed strip mined lands throughout the United States (Holmberg, 1983).

Beef cattle are particularly suited to an extensive type of grazing management because they require little management and are not as subject to predators as small ruminants. Essentially, all feeds consumed by mature beef cows are forages, wastes and by-product feeds with little or no concentrates fed (Wilson and Watson, 1985). If expenses for supplemental feed, buildings and equipment can be controlled, a beef cow can produce a feeder calf economically each year, thereby, providing a profitable return on investment.

The Powell River Project was begun in 1980 by Virginia Polytechnic Institute and State University in conjunction with Penn Virginia Resources Corporation of Duffield, Virginia. The project site is approximately 13 km north of Norton in Wise County, Virginia. Mining on the project began about 25 y ago and continues today along with natural gas exploration. The goal of the project is to conduct research programs to delineate economic uses for reclaimed mine land and to disseminate information about economically important opportunities for the industries, agencies and people in the Virginia coal fields. Eight departments in the College of Agriculture and Life Sciences are investigating various aspects and uses of reclaimed surface mined lands.

The objective of this study was to evaluate the nutritional status of mature beef cows that had been grazing forage grown on reclaimed strip-mined pastures since 1980. Specific objectives were to estimate forage digestibility, forage dry matter intake and fecal output of the cows over the grazing season, and to identify potential nutritional deficiencies and(or) toxicities that cattle may encounter while grazing forages grown on reclaimed strip-mined lands.

Chapter II

LITERATURE REVIEW

Forage Utilization by Beef Cows

The objective of any commercial livestock operation is to make a profit on an investment. In a cow/calf operation a major goal is for each cow to produce one live feeder calf per year (Beal, 1982). In order to make a profit in a cow/calf operation, calving percentage and weaning weight need to be maximized while costs for buildings, equipment, labor, herd health, bull power and feed need to be minimized. Feed costs account for 50 to 70% of the total cost of maintaining beef cows (Minish and Fox, 1982; Wilson and Watson, 1985). In order to reduce feed costs, cows can be maintained on high forage diets which limit the need for purchased feeds.

Cows that calve in early spring are particularly suited to an all forage system. Spring calving matches the period of highest nutritional needs of the cow with maximum forage production and quality. In addition, the period of lowest nutritional demand is in the winter which permits the use of low quality stored feeds. On the average, a 454 kg cow requires 56.6% TDN and 9.6% total protein in diet dry matter to meet her nutritional needs in the first 3 to 4 mo after calving (NRC, 1984). Cows must regain weight lost at calving in addition to producing milk for the calf and repairing of the reproductive tract. Limiting energy in the postpartum period can result in decreased fertility and longer calving intervals (Beal, 1982). Cows placed on new growth pasture forage 3 to 4 wk prior to the breeding season started gaining weight and showed improved reproductive performance compared with cows in dry lot (Clanton, et al., 1971). In order to improve conception rates, cows should be in good condition prior to calving. Cows in the last third of gestation require 53.6% TDN and 7.9% total protein in the diet dry matter and should gain .4 kg/day (NRC, 1984). On high forage diets, cows may require supplemental feed in the last 6 wk of gestation when stored feeds may not be adequate to meet nutritional needs and pasture is not yet available. Supplemental energy and possibly protein are the nutrients most often required (Wilson and Watson, 1985). Dry, pregnant cows require 48.8% TDN and only 7.0% total protein in the diet dry matter (NRC, 1984). Crop residues, low quality hay, and stockpiled forages are adequate to meet the nutritional needs of beef cows in this production stage (Wilson and Watson, 1985).

Salt is necessary for all cows and is best if available at all times in block or loose form (Wilson and Watson, 1985). Calcium and P should be provided in ratio of 1:1 to

7:1 in the diet (NRC, 1984). Most grasses have adequate proportions of Ca and P, but legumes are usually high in Ca, whereas, concentrates are low in Ca (Wilson and Watson, 1985). In general, P is usually lower than animal requirements in mature forages and crop residues (NRC, 1984). Deficiencies of other minerals may occur in certain areas of the country and usually can be supplemented in the salt mixture (Minish and Fox, 1982). Vitamins are usually obtained in adequate amounts in the diet and rarely require supplementation (NRC, 1984).

Tall Fescue in Pastures

Tall fescue, a cool-season perennial grass, has gained wide acceptance as a forage for breeding and lactating ruminants. Areas of primary adaptation and use of tall fescue extend from eastern Kansas to the eastern edge of the Piedmont in Virginia (Buckner, 1985). Tall fescue is found as far south as Macon, Georgia and north into Indianapolis, Indiana. Within areas of adaptation, tall fescue is a major cool-season grass species. Areas of secondary use of tall fescue extend from Florida to Canada and in parts of California and Washington (Buckner, 1985). Overall, tall fescue occupies about 14 million ha of land in the United States (Hemken et al., 1984).

Tall fescue alone or in combination with other grasses and legumes is widely used for stabilization of disturbed lands (Buckner, 1985). Tall fescue is acceptable for re-vegetation because it competes aggressively with other plant species (Bennett, 1979). Bennett et al. (1972) indicated that Kentucky 31 tall fescue produced excellent growth on low pH strip-mined areas. Fescue has a very extensive root system and forms a dense ground cover rapidly. Because of wide adaptation to soil conditions, productivity, persistence, response to fertilizer, and ease of management, tall fescue is widely used as a forage (Asay et al., 1979). Beef cows can best utilize tall fescue because of their lower critical nutrient requirements when compared to sheep or dairy cattle (Van Keuren and Studemann, 1979).

Dry matter production of tall fescue ranges from 5000 to 9000 kg/ha depending on the management practices employed (Matches, 1979). Tall fescue in the fresh, vegetative stage provides an average of 67% TDN, 14.5% crude protein and 24.6% crude fiber to ruminants (NRC, 1982). Crude protein content is usually highest in the spring, intermediate in the fall, and lowest in the summer. Stritzke and McMurphy (1982) reported CP contents over 24% in March and April, 9% CP in May and 13% CP in December. Water soluble carbohydrate content was higher in cooler months than in warmer months (Hannaway and Reynolds, 1979). Eighty percent shade decreased the water soluble carbohydrate content to 8 mg/g from 21 mg/kg when tall fescue was grown in full sun (Stritzke et al., 1976). Total nonstructural carbohydrate content was 17% in stockpiled tall fescue that was sampled in December (Matches, 1979). The IVDMD averaged 43.7% and the crude protein was 7.6% in stockpiled tall fescue reported by Collins and Balasko (1981), whereas, Matches (1979) obtained 68.4% IVDMD and 10.1% crude protein in stockpiled tall fescue forage. The quality of tall fescue can be maintained and improved if grazed frequently to prevent accumulation of old leaves and fertilized according to soil survey recommendations (Matches, 1979).

While tall fescue has excellent agronomic characteristics, animal performance has not been optimum in all cases when animals consume tall fescue forage (Bush et al., 1979). Specific syndromes associated with tall fescue include fescue foot, summer syndrome and fat necrosis (Bush et al., 1979).

Signs of fescue foot include reduced weight gain, rough hair coat, arched back and soreness in the rear feet (Jacobson et al., 1963). A characterisitic sign is a red line forming at the coronary band of the hind feet. Early clinical signs may appear 3 to 7 d after cattle graze tall fescue and signs of advanced fescue foot as soon as 2 wk after initial grazing of the toxic forage (Bush et al., 1979). Fescue foot occurs most frequently in late fall and winter but signs have been reported at other times of the year (Hemken et al., 1984).

Summer toxicosis is the most consistently related syndrome to tall fescue and probably results in the greatest loss of income (Hemken et al., 1984). Summer syndrome is related to high environmental temperatures (Bush et al., 1979). Signs include reduced growth, decreased feed intake, elevated body temperatures, rough hair coat, increased repiration rate, low serum prolactin levels, excessive salivation, reduced reproductive performance and animals seeking wet or shady areas (Hemken et al., 1984).

Fat necrosis is caracterized by hard masses of fat in the adipose tissue of the abdominal cavity (Bush et al., 1979). Digestive upsets are common with severity depending on degree of intestinal constriction by the necrotic fat. Other symptoms include elevated body temperature, rough hair coat, lameness and cattle wanting to stand in mud or water. Fat necrosis has been associated with high rates of N fertilizer application to tall fescue (Bush et al., 1979).

Although researchers have not positively identified to cause of these tall fescue syndromes, recent studies have related the summer syndrome to the presence of an endophytic fungus in the tall fescue plant (Schmidt et al., 1982). The fungus, Epichloe typhina, appears to be involved with the toxicity problem but it has not been shown whether the toxic compound(s) is produced by the fungus or needs to be associated with the tall fescue plant to produce the toxic effect (Hemken et al., 1984).

Serecia Lespedeza in Pastures

Serecia lespedeza is planted widely for forage and soil conservation and for protection of highway road cuts. Serecia lespedeza is adapted and widely used in the southeastern section of the United States extending from Texas, Oklahoma and Kansas east to the Atlantic coast (Hoveland and Donnelly, 1985).

Serecia lespedeza is very drought tolerant because of a long taproot (Hoveland and Donnelly, 1985). Although serecia lespedeza is a summer perennial legume, bloat is not a problem. Serecia lespedeza is tolerant of acid soils and low fertility and, therefore, has been used for soil conservation on eroded land and for establishing vegetative cover on surface mine soils. Serecia lespedeza is the most widely used herbaceous legume in Appalachian surface mine reclamation (Plass, 1978).

Serecia lespedeza is recognized as low in palatability and low in nutritive value to livestock (Cope and Burns, 1971: Cope et al., 1974). The low quality of the serecia lespedeza forage has been attributed to high tannin content and coarse, woody stems. Serecia lespedeza in the fresh, vegetative stage provides and average of 55% TDN, 18% crude protein and 23 % crude fiber. Serecia lespedeza hay cut in the late, vegetative stage has approximately 16% lignin (NRC, 1982).

Tannin reduces the dry matter digestibility and digestibility of protein (Donnelly and Anthony, 1973). Tannin levels are higher in leaves than stems (Donnelly and Wear, 1972) but, intake of leaves by dairy steers was greater than the stem fraction (Hawkins, 1955). In a study with low and high tannin serecia lespedeza varieties, tannin content was found to be 76% lower in the low tannin varieties (Donnelly et al., 1971). Crude protein levels exceeded 16% and did not differ significantly between groups. Low tannin serecia averaged 20% higher in dry matter digestibility and slightly higher in crude protein digestibility (Donnelly et al., 1971). In another study with low and high tannin serecia lespedeza, high tannin plants were 58% digestible, whereas, low tannin serecia lespedeza was 65% digestible (Donnelly and Anthony, 1970). Leaf digestibility declined sharply as tannin level increased to 10% (Cope and Burns, 1974).

High lignin values have been associated with low nutritive value of serecia lespedeza (Hawkins, 1955). Apparent lignin values have been reported ranging from 16.8 to 23.7%. Hawkins (1955) recognized tannin as a possible contributor to high lignin values determined by 72% sulfuric acid method (Ellis et al., 1946). Acid detergent determination of lignin by the method of Van Soest (1963) reduced leaf lignin values by 51% and stem lignin values by 26.5% compared to the 72% H_2SO4 method. These results indicated that tannin did interfere with lignin determination in serecia lespedeza forage (Donnelly ane Wear, 1972).

Serecia lespedeza should be grazed to leave 10 to 15 cm stubble in order to obtain maximum forage utilization (Hoveland and Anthony, 1974). Excessive grazing may injure the stand and reduce forage yield. Digestible dry matter of serecia lespedeza is unaffected by by stubble height. Grass species included in a serecia lespedeza pasture can extend the grazing season and will not adversely affect the stand (Hoveland et al., 1975). Tall fescue and orchardgrass seeded with serecia lespedeza extended the grazing season by 3 mo and resulted in 2200 kg/ha of additional forage dry matter (Hoveland et al., 1975).

Factors Affecting Forage Intake

The factors affecting voluntary forage intake by grazing animals are many and complexly interrelated. Minson (1982) attributed the quantity of herbage eaten by the grazing animal to three factors: 1) pasture availability, 2) nutrient requirements of the animal and 3) physical and chemical composition of the forage. These factors cannot be considered as independent and further research is needed to determine the relative importance of each in affecting forage intake before intake predictions can be made using laboratory analyses of forage samples.

Hodgson (1982), in reviewing the influence of sward characteristics on diet selection and herbage intake in grazing animals, indicated that there are many practical problems in obtaining information. Sward characterisitics such as mass, leafiness and height are difficult to independently evaluate and to discern their influence on intake. Intake was shown to be higher on erect spring pastures of perennial ryegrass (*Lolium perenne*) than on short summer or autumn regrowth when herbage mass and digestibility were equivalent (Hodgson et al., 1977). Intake was maximized at a sward height of 40 to 45 cm and tended to decline with increasing plant height. It is possible that excessively long and very short leaves are hard to prehend and ingest by grazing animals.

The magnitude of genetic variation in ability of animals to consume feed has been difficult to establish. Frisch and Vercoe (1977) indicated that Bos taurus cattle had significantly increased voluntary consumption compared to Bos indicus cattle under minimal environmental stress. A crossbred animal between the two species had consumption values between those of the parents.

Physiologic state has a very decisive influence on voluntary forage intake. Factors such as age, pregnancy, lactation and disease contribute to intake variations (NRC, 1984). Langlands (1968) observed higher intake on pasture with young sheep, when compared with adults. The decrease in voluntary intake with advancing age may be due to a decrease in basal metabolism (Weston, 1982). In ruminants, voluntary feed intake slightly decreases throughout pregnancy with a substantial drop in intake the last few days before parturition (Campling, 1966). Intake was shown to decrease similarly with diets based on forages or concentrates (Forbes, 1970; 1971). Reduction in feed intake in late pregnancy when energy demand is high has not been fully explained. Possibly pressure on the rumen, abdominal wall distension by the calf or high estrogen levels caused a decrease in energy use (Forbes, 1980) adversely affected intake. Ruminants consume maximum quantity of feed during lactation (Campling, 1966). Voluntary intake increases after parturition, reaches a maximum and slowly declines following a pattern similar to a lacation curve (Weston, 1982).

Any disease state usually results in decreased feed intake. Heavy internal or external parasite load, pregnancy toxemia , hypocalcemia or hypomagnesemia have been shown to reduce voluntary intake significantly (Hodgson, 1982).

Various components of climate are known to affect voluntary intake. High day time temperature, above 27 to 35 C, has been shown to reduce voluntary intake in dry, nonpregnant cows (Martz et al., 1971; Olbrick et al., 1973). A 30% increase in feed consumption was shown at environmental temperatures of 9 compared to 18 C (Olbrick et al., 1973). Studies by Lippke (1975) with dairy cattle and Kennedy et al. (1976) with sheep showed that temperature affects rumen function. In cold temperatures, rumen propulsion activity increased and with high temperatures propulsive activity declined.

Researchers have extensively investigated the effect of physical and chemical composition of the forage on voluntary intake. Physical factors such as rumen size, rate of passage out of the rumen and proportion of undigested feed feed residue in the rumen are main controllers of voluntary intake on pastures (Conrad et al., 1964; Ellis, 1978; Minson, 1982). Blaxter et al. (1961) demonstrated that intake was positively related to digestibility and inversely related to rate of passage through the digestive tract. Further studies showed that rate of passage and amount of undigested material in the digestive tract determined intake of feeds that were less than 66% digestible (Conrad et al., 1964). Other physiological factors limited intake of feeds above 66% dry matter digestibility. Therefore, with grazing animals, rumen fill and passage rate are primary controllers of intake.

Differences between plant species and plant part are factors that affect intake due to differences in rate of breakdown and passage in the rumen. (Laredo and Minson, 1973). Leaves of temperate grasses are consumed in greater quantities than stems with similar dry matter digestibilities (Laredo and Minson, 1973). In a summary of 30 experiments by Minson (1982), the mean difference in intake between leaf and stem was 42%, whereas, digestibility differed by only 1%. Stems are retained longer in the rumen compared to leaf tissue possibly due to resistence of the stem to physical breakdown (Laredo and Minson, 1975). Crampton (1957) was the first to report higher voluntary intake of legumes than grasses with the same digestibilities. Sheep ate 28% more legume than grass when 8 grasses and 6 legumes were compared (Thornton and Minson, 1973). Increased legume intake was due to higher packing density of the legumes in the rumen and 17% shorter retention time.

Intake and digestibility have been shown to be positively correlated (Blaxter et al., 1961; Conrad et al., 1964; Minson et al., 1964), but Laredo and Minson (1975) have reported deviation from this trend. Much research has been initiated to establish relationships between voluntary intake and chemical composition of forages (Van Soest, 1965).

Cell wall constituents (lignin, cellulose, hemicellulose and lignin bound protein) were the only chemical components consistently related to voluntary intake (Van Soest, 1965). In forages such as orchardgrass (Dactylis glomerata), bromegrass (Bromus inermus), and sudangrass (Sorghum bicolor) where cell wall constituents were greater than 50 to 60%, intake and digestibility were negatively correlated with cell walls. These data support the theory that intake is inhibited in forages with a high cell wall content. In forages with a low cell wall content, such alfalfa (Medicago sativa) and bluegrass (Poa pratensis) digestibility and intake were not closely related. Donefer et al. (1963) reported significant correlations between intake and dry matter disappearance in certain enzyme and aqueous solutions. The rate of digestion of cellulose was also correlated with forage intake (Gill et al., 1969). Therefore, as plants mature, reduced intake can be associated with an increase in fiber, lignin, cellulose and a reduction in protein and non-structural carbohydrates (Conrad et al., 1964).

Fiber content limits intake of forages only if all other chemical components such as protein, vitamins and minerals are present in sufficient amounts (Minson, 1982). Blaxter and Wilson (1963) found that if crude protein content of a pasture fell below 6 to 8%, appetite was depressed and intake reduced. Grinding and pelleting protein deficient forage had no affect on intake (Minson, 1967). Increasing the protein content of the diet by feeding a protein supplement increased intake by 16 to 18% (Minson, 1982). Deficiencies of S, Na, P, Mg and certain trace minerals also depress intake on pasture, whereas, supplementation will increase intake (Rees et al., 1974; Joyce and Brunswick, 1975; Minson, 1982).

Factors Affecting Forage Digestibility

Dry matter digestibility is a common measure of forage quality since energy intake often limits animal performance in grazing situations. Climatic factors, fertilization practices and inherent differences in plant species influence forage digestibility, cell-wall and lignin content and plant morphology, which in turn, may affect animal productivity.

Individual climatic factors such as temperature, light, and soil moisture have been extensively studied and found to have profound influence on digestibility of pasture herbage (Wilson, 1982). Ambient growth temperature has the most effect on nutritive quality of forages. High temperature decreased dry matter digestibility of tall fescue from .52 to 1.08% (Allinson, 1971; Smith, 1977) and alfalfa from .18 to .56% (Garza et al., 1965; Smith, 1969; Vough and Marten, 1971; Greenfield and Smith, 1973. Generally, in temperate grasses, high temperature causes decreased cell contents (Allinson, 1971), low accumulation of soluble carbohydrates (Smith, 1973) and decreased cell wall digestibility (Moir, et al., 1977). Vough and Marten (1971) suggested low digestibility of temperate grasses was due to greater lignification. Wilson et al. (1976) noted that high growth temperature accelerates maturation of leaves and stems, therefore, leaves of similar size but grown at low temperatures had higher digestibility. Hoveland and Monson (1980) found that high temperatures decreased the level of tannins in serecia lespedeza and thus decreased digestibility.

Light intensity also has an effect on the nutritive value of forage. Dry matter digestibility of alfalfa was reduced when grown under low light intensity (Garza et al., 1965). Shading tends to decrease soluble carbohydrates (Smith, 1973), increase cell wall contents (Hight et al., 1968), and increase lignin and silica (Van Dyne and Heady, 1965), which contribute to reducing forage quality. Sheep grazing in shaded perennial ryegrass pasture were observed to consume 9 to 15% less dry matter and had 38% lower gain than sheep grazed on pastures recieving full sunlight (Hight et al., 1968).

Severe moisture stress is commonly known to stop plant growth and limit animal production. But short, moderately severe droughts may have a positive effect on forage quality. A summary of published literature by Wilson (1982) revealed that low soil moisture either has little effect or increases the dry matter digestibility of cell wall contents and percent lignin. In addition, nitrogen concentration (Gifford and Jensen, 1967), soluble carbohydrate levels (Blaser et al., 1966) and concentration of most minerals (Gerakis et al., 1975) have been shown to increase in forage species grown under drought stressed conditions. Palatability problems may arise from increased levels of alkaloids or acids in some water stressed species and, therefore, may limit voluntary intake (Hoveland and Monson, 1980).

Van Soest and Marcus (1964) stated that dry matter digestibility of forages is dependent on proportion of: 1) cell contents composed of totally available lipids, soluble carbohydrates, proteins and other water soluble matter, and 2) cell walls in which digestibility depends on extent of lignification. Cell walls are usually labelled as the total fiber fraction (Van Soest, 1966) which include cellulose, hemicellulose and lignin. Hemicellulose tends to be the most variable fraction and prevents the use of lignin, cellulose and crude fiber as estimators of cell wall content. A negative association between lignin and digestibility has been documented (Van Soest, 1966), but Gaillard (1962) showed a strong correlation between organic matter digestibility and crude fiber, lignin and cellulose for 10 forage crops examined.

Most prediction equations for nutritive value are based on digestibility correlated with one or more chemical components. Crude protein and other soluble cell contents are not reliable predictors of digestibility because the content is affected by many factors such as fertilization, species and climate (Mott and Moore, 1985). In addition, the amount of available component (cell contents) does not form a fixed relationship with digestibility of the cell wall components (Van Soest, 1966).

Digestibility of forages is known to decrease as plants mature. Lignin content increases faster than cellulose or hemicellulose content, therefore, plants are more lignified at maturity (Van Soest, 1965). Lignin is often used as a predictor of digestibility because extent of lignification influences digestibility of forage dry matter. Cellular contents are nearly 100% available, not lignified, and often exceed 60% of the forage dry matter thus, confounding the use of lignin as sole predictor of forage digestibility. Sullivan (1964) showed different regression equations between lignin and digestibility for every species of forage evaluated. Therefore, since no fixed relationship exists between percent cell walls and cell contents, the use of single chemical factors to predict whole plant dry matter digestibility is limited (Van Soest, 1966).

Indicators for Estimating Forage Intake and Digestibility

Indirect measurements of dry matter digestibility and voluntary intake involve the use of inert reference substances as indicators. Qualities of a useful indicator include: 1) inert, not metabolized or absorbed, 2) pass through the digestive tract at a uniform rate and be completely recovered in the feces, and 3) subject to easy and precise methods of assay (Kotb and Luckey, 1972).

In grazing experiments, indicators are used to estimate digestibility, forage inatke and fecal output (Harris et al., 1959). An external indicator is dosed orally, then analyzed in the feces which provides an estimate of fecal output. Fecal dry matter is equal to the amount of indicator fed / percent indicator in the feces sample. Digestibility is estimated using an internal marker that occurs naturally in the forage and analyzed in both forage and feces. Percent digestibility is equal to 100 X (1- percent internal indicator in feed / percent indicator in the feces) (Penning and Johnson, 1983). Fecal output in conjunction with digestibility values are used to estimate voluntary intake. Organic matter intake = fecal organic matter output / percent organic matter indigestibility (Cordova et al., 1978).

Ytterbium as an external indicator. Rare earth elements have gained considerable attention in recent years for use as external particulate bound markers (Ellis, 1968; Ellis et al., 1979; Teeter et al., 1979; Ellis et al., 1980; Teeter et al., 1984). Ytterbium has several advantages over other rare earths for use as an external indicator. Ytterbium binds very tightly to the indigestible particulate matter of a feedstuff (Teeter et al., 1979). There is little migration of the bound Yb to other feed particles during the digestive process (Lascano and Ellis, 1979; Teeter et al., 1979). Lascano and Ellis (1979) bound Yb to the cell wall contituents of esophageal masticated hay and mesured Yb concentration of fecal particles of various sizes. The Yb concentration was similar across fecal particle sizes ranging from 1600 to less than 160 um. The authors concluded that migration to unlabeled particles was negligible. The large particles originally labelled were broken down such that the surface made a proportional contribution to all fecal particles and digestion of noncell-wall components did not affect fragmentation of Yb labelled feed. Ytterbium was also found to be completely recovered in the feces when applied to forage as Yb salts (Ellis, 1968).

The administration and analysis of Yb is easily accomplished. Nitrate salts of Yb are very soluble and easily sprayed or soaked onto feed particles. The easiest and least expensive method of analysis is by atomic absorption spectophotometry using a nitrous oxide flame. Ytterbium is easily solubilized from dry ashed feed, digesta or feces samples by 3 M HNO_3 and 3 M HCl (Ellis et al., 1980). Feed particles marked with Yb should be thoroughly washed before dosing to remove excess Yb and prevent loss of Yb in the fluid phase of the digesta. Yb can be administered in a pulse dose technique for measurement of particulate flow rates (Ellis et al., 1979; 1980) or in a continuous dose for estimation of fecal output (Pond and Ellis, 1979; Thompson, 1982).

Internal Indicators. Internal indicators occur naturally in plant material and are used to estimate digestibility (Harris et al., 1959). Internal indicators commonly used include lignin, plant chromagens, silica, indigestible acid detergent fiber (IADF), and indigestible neutral detergent fiber (INDF) (Kotb and Luckey, 1972; Penning and Johnson, 1983; Ellis et al., 1984).

Lignin and silica tend to be the most unreliable estimators of digestibility (Kotb and Luckey, 1972). Lignin is known to be partially digestible in forages at certain stages of maturity (Wallace and Van Dyne, 1970). In addition, lignin recovery rates are variable due to differences in analytical methods (Kane et al., 1953; Elam and Davis, 1961). Silica recovery in feces of grazing animals is not quantitative in all cases (Gallup et al., 1945). Silica may be absorbed and excreted through the urine, and soil and dust contamination can increase silica excreted above that in the forage (Foreman and Sauer, 1962).

The use of plant chromagens was introduced by Reid et al. (1950). Chromagens were defined as nondigestible plant pigments, such as chlorophylls, that solubilize in acetone and absorbed light at 406 nm. (Reid et al., 1950). Chromagen was found to compare well with standard total feces collection in predicting digestibility (Kane et al., 1953). Cook and Harris (1951) recovered less chromagen in feces than was eaten when sheep grazed winter range forage. Reid et al. (1952) suggested that the chromagen method is only accurate when feed samples analyzed accurately represent feed eaten by the animals.

Indigestible acid detergent fiber and INDF are relatively new internal markers used in grazing studies (Pond and Ellis, 1979; Penning and Johnson, 1983; Ellis et al., 1984). Acid detergent fiber consists of cellulose, lignin and lignified nitrogenous compounds which are essentially indigestible to ruminant animals. Indigestible acid detergent fiber is the fiber fraction that remains after digestion with cellulase (Penning and Johnson, 1983). Organic matter digestibility estimates determined by IADF were more precise than in vitro digestion estimates by the Tilley and Terry (1963) procedure and correlated well with in vivo digestibility estimates (Penning and Johnson, 1983). Neutral detergent fiber is defined as cell wall constituents insoluble in neutral detergent solution and consists of hemicellulose, cellulose, lignin, fiber bound protein, and lignified nitrogenous compounds (Van Soest, 1963). Indigestible neutral detergent fiber is the neutral detergent fiber residue that remains after digestion by rumen microbes, pepsin and HCl in vitro (Ellis et al., 1984). Indigestible neutral detergent fiber worked well to estimate digestibility of coastal bermudagrass and and perennial ryegrass pastures grazed by esophageal fistulated steers (Pond and Ellis, 1979).

Numbers Required for Sampling. One of the major factors affecting precision of estimating intake, fecal output, and digestibility using indicators is individual animal variability (Van Dyne and Meyer, 1964). Therefore, in order to adequately evaluate pastures and forages, large numbers of animals and(or) samples must be used to detect significant differences between treatments. Several researchers have shown that more animals are needed to estimate intake than to estimate other parameters (Van Dyne and Meyer, 1964; Obioha et al., 1970). Variations in intake estimates may result from differences in 1) dietary composition, 2) excretion rate, and 3) fecal composition (Van Dyne, 1969). Assuming constant dietary composition and constant digestibility and fecal composition within short periods of time, it follows that fecal excretion rate is the main source of error. Errors due to irregularity in excretion rate are inversely proportional to length of fecal collection period (Cordova et al., 1978). Using a 7 d preliminary period followed by 7 d collection period, Van Dyne (1969) found five steers per treatment were necessary to estimate fecal output within 10% of the mean and at 95% confidence. Under grazing conditions, eight steers were necessary to estimate intake within 10% of the mean and 90% confidence in a 7 d trial period (Van Dyne and Meyer, 1964). In contrast, three to five animals for 5 d of sampling would be enough to estimate digestibilty (Obioha et al., 1970). In determining forage chemical composition, six to eight esophageal fistulated steers were required to estimate the composition within 10% of the mean with 90% confidence (Van Dyne and Heady, 1965; Harniss et al., 1975; Rosiere et al., 1975). High cattle numbers are needed to estimate lignin with the same precision as compared with crude protein, NDF and ADF (Rosiere et al., 1975).

Forage Sampling Using the Esophageal Fistula

Several methods have been used in grazing experiments to obtain forage samples representative of the grazing animal's diet. Clipping or mowing techniques have been used because they require little equipment and time to obtain samples. However, numerous studies have indicated that grazing animals usually select forage higher in quality than was indicated on the basis of clipped samples (Hardison et al., 1954; Weir and Torrell, 1959; Van Dyne et al., 1980).

Therefore, use of esophageal fistulated animals is considered the best way to estimate intake of grazing animals (Van Dyne and Torrell, 1964; Holechek et al., 1982). The technique has been used widely for the last 20 y after development of the basic surgical procedure by Torrell (1954).

Primary problems associated with esophageal fistula sampling are salivary contamination, rumen contamination, incomplete recovery and obtaining a truly representative sample (Holechek et al., 1982). Salivary contamination increases the ash content of esophageal masticate samples (Bath et al., 1956). Ash content of samples may increase from 1 to 4 % due to salivary contamination (Lesperance et al., 1974; Scales et al., 1974). Salivary contamination significantly increases the phosphorus content of forages (Lesperance et al., 1960; Little, 1972; Scales et al., 1974). In addition, N content may also increase in the forage sample due to saliva (Little, 1972; Cook et al., 1961). Barth et al. (1970) and Barth and Kazzal (1971) noted little difference in crude protein content of esophageal samples compared with pasture clippings. Rumen fistula samples contained significantly higher concentrations of Si, Na, Zn and Co but less Mg and Ca than forages offered (Mayland and Lesperance, 1977). A simple method to eliminate bias due to salivary contamination is to express data on an ash free basis (Cook, 1964). Presenting data on an ash free basis is desirable because of soil contamination when the animals are grazing (Van Dyne, 1963). Mesh screen collection bags have been shown to reduce salivary contamination (Hoehne et al., 1967). As a result of leaching, samples collected in screen bottom collection bags had higher crude protein and lignin values and lower total nonstructural carbohydrate level than samples collected in water tight bags (Acosta and Kothmann, 1978).

Rumen contamination of esophageal fistula samples can pose problems in accurate chemical analysis (Holechek et al., 1982). Length of collection period and time of day of collection are important considerations to minimize rumen contamination (Bath et al., 1956). Cattle normally ruminate between 1000 and 1600 h (Arnold and Dudzinski, 1963). Major grazing periods are in the early morning and evening hours. Bath et al. (1956) reported that collection periods longer than 30 min increase the chances of contamination with rumen contents. Cattle penned up overnight graze more vigorously and have less chance of contamination with regurgitated material (Bath et al., 1956; Weir and Torrell, 1959; Arnold and Dudzinski, 1963). However, withholding feed may influence selectivity (Arnold and Dudzinski, 1963).

Incomplete recovery of esophageal samples could possibly bias the composition of forage collected. Degree of sample recovery is highly related to size of fistula opening (Blackstone et al., 1965). The primary cause of incomplete recovery is plugging of the fistula opening with a forage bolus. Campbell et al. (1968) found 26 to 34% recovery of clipped bermudagrass and native range grass compared to 81 and 80% recovery of long alfalfa hay and cottonseed hulls when fed to esophageal fistulated steers. Grimes et al. (1965) recovered 53 to 73% of ingested forage and found that botanical composition was unaffected compared to hay samples.

In order to obtain representative esophgeal masticate samples, the sampling procedure used is very important. Esophageally fistulatd animals should graze during the same time and in same location as the rest of the herd (Van Dyne, 1962; Van Dyne et al., 1964). Van Dyne and Heady (1965) indicated that cattle graze differently between morning and evening, therefore, collections should be rotated between the two periods. Lesperance et al. (1960) found that variation in esophageal samples was much greater between animals than between samples from individual animals. Therefore, multiple collections over several days may provide a more representative sample. Holechek et al. (1982) indicated that at least 4 d of collection with four cattle were needed to estimate CP, ADF, NDF and in vitro dry matter digestibility.

Esophageal sample preparation may affect the precision with which fistula samples represent chemical composition of the diet. Drying method influences chemical composition (Acosta and Kothmann, 1978). Freeze dried samples were higher in total nonstructural carbohydrates and hemicellulose and lower in acid detergent lignin than (60 C) samples of bermudagrass. Scales et al. (1974) found that oven drying (55 C) increased crude protein, ADF and in vitro digestibility compared with freeze drying. Because chemical composition differences were small and variable, oven drying at less than 55 C appears to be satisfactory for esophageal masticate and forage samples.

Despite problems with precision and accuracy of esophageal fistula sampling, it is widely accepted that esophageal samples are a better estimate of the diet of grazing animals than clipped or hand plucked forage samples (Holechek et al., 1982).

Metabolic Profiles as Indicators of Nutritional Status

A metabolic profile test is designed to monitor the metabolic state of a group of animals and in particular to assess the adequacy of dietary intake for production and prevention of nutritional metabolic disease (Payne et al., 1970). The metabolic profile is based on the analysis of blood chemistry of various groups of animals in the herd. In a complete test, packed cell volume (PCV), blood glucose, blood urea nitrogen (BUN), serum inorganic P, Ca, Mg, Cu, Na, K, serum total protein, albumin and globulin are determined. The normal values for the concentrations of the various constituents are based on individual animals which are free from any disease that may affect laboratory results. Normal range is commonly calculated as the mean value ±2 standard deviations (Ekman, 1976).

A number of factors limit the usefulness of blood profiles. Limitations include sampling problems, low correlations with nutrient intake, inconsistent patterns of disease and difficulties in interpreting results (Adams et al., 1978). Despite these problems, metabolic profiles have been used very successfully in reducing problems in dairy herd when conventional analysis of feed, disease testing and checking of management practices did not pinpoint herd problems (Payne et al., 1970; Norman, 1976; Adams et al., 1978).

Although less information is available on the metabolic profiles of beef herds, similar blood tests can be used to evaulate nutritional status of these animals.

Correlations of blood parameters with nutrient intake have been reported in the literature (Lane et al., 1968; Payne et al., 1970; Blowey, 1973). Energy intake has been related to blood glucose levels (Blowey, 1973). In a study with 72 dairy herds, low plasma glucose levels indicated a low starch intake (Blowey et al., 1973). Better indicators of a cow's energy balance include bloood acetate, ketone bodies and free fatty acid levels although methods of assay are difficult (Kronfeld, 1971; 1972). Nutritional protein status has been correlated with BUN, total protein, albumin and hemoglobin. Low BUN indicated low protein intake or high starch intake (Blowey et al., 1973). Blood urea nitrogen values were low on indoor winter rations but high in grazing conditions in the summer (Rowlands et al., 1974).

Packed cell volume or hematocrit has been shown to be influenced by milk yield, lactation, season of the year and Mg status. Beef cows grazing grass tetany prone areas (112 mg soil Mg/ha) had a depressed PCV compared with cows grazing non tetany areas, with 157 mg soil Mg/ha (Adams et al., 1978). Lactating cows averaged 3.3% higher PCV than nonlactating cows when 24 herds were examined (Rowlands et al., 1974). Packed cell volume was shown to be related to milk yield in dairy cows where high producing cows had higher PCV than dry cows within the same herd (Payne et al., 1970). In addition, PCV was lower in herds sampled in the winter but increased when animals were turned out to pasture.

Minerals in the body exist in a series of interconnected reservoirs, each with a different size and availability. The readily-available reserves are in the blood and extra-cellular fluids, and the larger less rapidly available reserves are in tissue and skeleton (Sansom, 1973). Variations from normal ranges in blood concentrations are indicators of possible metabolic disease.

Age, stage of pregnancy, lactation and diet affect blood mineral concentration, therfore, interpretation of results is difficult. Serum Ca has been negatively correlated with ration Ca (Adams et al., 1978). Inorganic P has been negatively correlated with age in dairy cattle (Ekman, 1976) and beef cattle (Bide and Tumbleson, 1976). Bide (1978) reported that inorganic phosphorus decreased from 8.7±.8 mg/dl in young Hereford calves to 4.6±1.4 in 3 yr old cows. Calcium was highest in young calves, 11.3±.7 mg/dl, and fell to 10.2±.5 mg/dl in 12 yr old cows. Excitation at the time of sampling has been shown to increase serum inorganic phosphorus in cattle (Ekman, 1976). Normal blood plasma P levels vary from 4 to 8 mg/dl (NRC, 1984). Low serum Ca levels have been seen in dairy herds with low production (Adams et al., 1978). At parturution, dairy cows exhibited a drop of 1 to 2 mg Ca/dl plasma Ca (Jacobson et al., 1975). In cattle, the normal blood Ca concentration is about 10 mg/dl and milk fever may develop if plasma Ca drops below 5 mg/dl (NRC, 1984). Serum Ca, P, and Mg levels have shown inconsistent correlations in animals with hypocalcemia. In a herd of 100 beef cows, two cases of clinical hypocalcemia occurred (Church et al., 1978). Although the diet fed was well above the minimum nutrient levels for TDN, Ca and P, seven cows had Ca levels lower than normal, four had low P levels and one cow had low Mg levels. Kronfeld (1972) stated that low Mg or P levels in preparturient cows may indicate a higher incidence of downer cows in the herd. Low serum Ca may indicate potential parturient paresis in cows about to calve but low levels of Ca could be due to insufficient dietary Ca or excess dietary Ca. In addition, anestrus, low conception rates and reduced milk production have been associated with low P diets (Teleni et al., 1977).

Serum Mg levels have been positively correlated with ration Mg (O'Kelley and Fontenot, 1968). Usually low serum Mg levels are indicators of winter and grass tetany (Payne et al., 1970; Fontenot et al., 1973; Adams et al., 1978). Mean concentrations of serum Mg were lower in nonlactating dairy cows than lactating cows when 24 herds were compared (Rowlands et al., 1974). O'Kelley and Fontenot (1969) reported that the Mg requirement of the gestating cow is lower than that of the lactating cow.

Sodium and Cu are two of the least variable minerals in the metabolic profile test. Sodium levels were not affected by age of animals but K levels tend to decrease as animals matured (Bide and Tumbleson, 1976). Sodium level was positively correlated with lactation and negatively correlated with month of pregnancy. In contrast, serum K was negatively correlated with lactation and positively associated with month of pregnancy (Lane et al., 1968). Normal serum Na levels are about 140 meq/l and normal K levels are about 4.7 meq/l (NRC, 1984). Copper levels of nonlactating dairy cows were lower in the autumn and winter than those of lactating cows during the same period (Rowlands et al., 1974). There is little excretion of Cu into the milk therefore, lower serum Cu levels of dry cows in the winter may be attributed to consumption of lower quality, possibly Cu deficient, feed (Sansom, 1973). Normal blood Cu levels range from 70 to 170 ug/dl in most ruminants (NRC, 1984) and levels below 60 ug/dl are indicative of Cu deficiency (Underwood, 1977).

Interpretation of metabolic profile data must take into consideration milk production, stage of lactation, season of the year, age and diet of the animals evaluated. Careful selection of normal values with which to compare test results must be employed. The use of metabolic profiles alone cannot provide adequate information about the nutritional or health status of a herd. Close observation of feeding and management practices, diet evaluation and disease testing are recommended when a metabolic profile is used to predict the nutritional status of a group of animals (Adams et al., 1978).

Chapter III

EVALUATION OF NUTRITIONAL STATUS OF BEEF COWS GRAZING RECLAIMED STRIP-MINED PASTURES

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Abstract

A series of four trials over the grazing season were conducted to evaluate the nutritional status of beef cows grazing reclaimed strip-mined pastures in southwestern, Virginia. Blood samples, esophageal fistula forage samples and hand plucked forage samples were taken in each trial. An external marker, Ytterbium, and an internal marker, indigestible neutral detergent fiber (INDF) were used to estimate organic matter intake, fecal output and digestibility. In addition to samples taken during the trials, blood samples and hand plucked forage samples were taken monthly for 11 mo prior to the trial periods. In late summer esophageal masticate samples had a lower fiber fraction (ADF and NDF), high crude protein and total nonstructural carbohydrates (TNC) which contributed to a high organic matter digestibility. Hand plucked forage samples had higher TNC than esophageal masticate samples. Organic matter digestibility predicted by the internal marker was highest in late summer 61.6%, similar in spring and late fall, and lowest in mid-summer, 52.6% ($p < .01$). Fecal output was highest in mid-summer and lowest in spring ($p < .05$). Estimated intake was not significantly different in any of the trials. Although data was variable, forage quality was higher in May, June, October and November samplings, as indicated by highest CP, TNC, and lower NDF and ADF values, compared with July and August data when forage quality was lowest. Packed cell volume, BUN and serum P and Mg concentrations fell within normal ranges for beef cattle. Low BUN values were observed in spring and late fall which corresponded to low crude protein values observed in the esophageal masticate samples for the same trials. Serum Cu was on the low end of normal values in the late spring and decreased to .6 ppm by late fall. Serum K levels were above the expected values for beef cattle. Serum Na concentrations were lower than normal with lowest values observed throughout spring and summer months.

(Key Words: Reclaimed Strip-Mined Pastures, Markers, Strip Mine Soils, Metabolic profiles)

Introduction

Surface mining of land occurs in many states in the United States. States along the Appalachian mountains in the East and along the Rocky mountains in the West are major areas for the surface removal of coal. Coal mining is responsible for almost one half of the disturbed mine land in the United States (Barrows, 1979).

Most coal mining in Virginia is concentrated in the Southwestern counties of Dickinson, Buchannan, Wise and Russell, where over 32,000 ha have been disturbed since strip mining began in 1946 (Barrows, 1979). Much of the reclaimed surface mined land in Virginia is in remote areas of low economic value for housing and industrial development.

Strip mine soils in Virginia are usually revegetated with mixtures of grasses, legumes and trees that are easily established, control erosion well and tolerate low fertility and high acid soil. Species such as tall fescue (Festuca arundinacae), serecia lespedeza (Lespedeza cuneata), and black locust (Robinia pseudoacacia) are suitable for revegetation of strip mine lands (Ruffner, 1977; Holmberg, 1983). In southwestern Virginia, mine lands reclaimed with tall fescue and serecia lespedeza have produced significant yields of forage dry matter that can be used by grazing livestock. Grazing is recognized as a potentially important use of reclaimed strip-mined lands throughout the United States (Holmberg, 1983).

Beef cattle are particularly suited to an extensive type of grazing management because they require little management and are not subject to predators as with other livestock, such as sheep. Essentially, all feeds consumed by mature beef cows are forages, wastes and by-product feeds with liitle or no concentrates fed (Wilson and Watson, 1985). If expenses for supplemental feed, buildings and equipment can be controlled, a beef cow producing a feeder calf each year can generally provide a profitable return on investment.

The objective of this study was to evaluate the nutritional status of beef cows that had been grazing on reclaimed strip-mined pastures since 1980. Specific objectives were to estimate organic matter digestibility, fecal output and intake over the grazing season, and to identify potential nutritional deficiencies and(or) toxicities that may affect beef cattle grazing forages grown on reclaimed strip-mined pastures.

Materials and Methods

Mature Angus x Hereford crossbred cows suckling calves were brought to the Powell River Project in Wise County, Virginia in 1980. The initial herd size was 25 with approximately 25 additional cows of similar breeding and age added in 1981. The herd is maintained in two separate breeding groups from mid-May until December and then combined throughout the winter and calving season. While separated, one group of approximately 30 cows is grazed on the lowest Taggart bench and the remaining 20 cows are grazed on the uppermost Phillips bench. Each year cows have been pasture bred to either a Polled Hereford or Polled American Redneck bull (5/8 Polled Hereford, 1/4 Simmental, 1/8 Red Angus). In the spring of 1984, the cows were estrus synchronized and artificially inseminated.

Management practices for the entire beef herd follow recommendations put forth by the Virginia Cooperative Extension Service. The calving season extends from March 1 to April 15 with calves weaned and sold during November. Cows are palpated for pregnancy at weaning time. Before breeding, cows are vaccinated for BVD, IBR, PI_3, vibriosis and leptospriosis. In the fall, cows are treated for internal and external parasites. During the summer, insecticidal eartags are used to control horn and face flies.

Cows are grazed on serecia lespedeza and tall fescue pastures year round. Cows are supplemented with an average of 318 kg of medium quality grass hay per head during the winter months. Approximately 91 kg of grain concentrate is fed during the calving season. Cows are fed .9 kg corn/d for 6 wk prior to calving and .9 kg/d of a corn and soybean meal supplement (20% CP) after calving until turned out on fresh spring pasture. During the winter and calving season, cows are fed ad libitum a mineral mix consisting of trace mineralized salt, magnesium oxide, dicalcium phosphate and soybean meal in equal parts by weight. During the rest of the year cows are fed trace mineralized salt weekly.

In order to determine forage digestibility, intake and nutritional status of the beef cows over the grazing season, four trials were conducted from July, 1984 through June, 1985 as follows:

SEASON	DATES
Late spring	June 28-June 8, 1985
Mid-summer	July 24-August 4, 1984
Late summer	September 7-18, 1984
Late fall	November 2-13, 1984

All trials were conducted on approximately 20 ha of the Phillips bench near the headwaters of the Powell River in Wise County, Virginia on lands owned by Penn Virginia Resources Corporation of Duffield, Virginia. The bench used for the experiments had been strip mined approximately 20 y prior to this experiment. The plant species composition was predominately tall fescue and serecia lespedeza with some ladino clover and orchardgrass. Black locust and white pine trees were scattered throughout the pasture area. The soil in the pasture area is loamy skeletal in texture with coarse fragments ranging from 30 to 60% (Daniels and Amos, 1981;

1982). The pH varies widely but averages 5.7. Phosphorus levels are extremely low with zones of compacted soil within 1.5 m of the surface. Since the reclaimed soil is rocky, shallow and compacted, it tends to be droughty.

Prior to the initiation of the trials in July, 1984, a hand plucked forage sample was taken on a monthly basis. In addition, blood samples from 20 to 50 cows were taken during the same time period. Samples were taken starting in May, 1983 once monthly through February, 1984 and again in May, 1984.

During the trial periods, 20 cows with their calves, one bull and two or three esophageal cannulated steers grazed on the test pasture. In April, 1984, three yearling steers were esophageally cannulated by the procedure of Van Dyne and Torrell (1964). Cannula used were T-shaped and made of moulded silicone (Ellis et al., 1984). Ten cows used for test purposes ranged in age from three to ten y old and 220 to 454 kg. Each trial had a 5 d preliminary period followed by a 7 d collection period. Ten cows were dosed daily between 1000 and 1100 h with 2 g hydrous ytterbium nitrate ($Yb(NO_3)_3 5H_2O$) as the external indicator.[1] The 2 g of $Yb(NO_3)_3 5H_2O$ was weighed into #7 gelatin capsules then dosed by balling gun to the cows for the 5 d preliminary period

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[1] RC Research Chemicals, NUCOR Corp., Phoenix, Ariz.

and the first 6 d of the collection period. Dosing in the preliminary period allowed the cattle to adjust to the treatment and equalized the indicator throughout the digestive tract. One fecal grab sample was collected daily at dosing time from each of the ten test cows during the 7 d collection period. Cattle were moved daily to a corral area with a head catch to facilitate dosing of the Yb marker and collection of feces. Fecal samples were conposited for each cow over the 7 d collection period.

Esophageal forage samples were collected twice daily, morning and evening, via the esophageal fistula during the 7 d collection period. Care was taken to ensure that steers grazed in the same pasture area and same time of day as the cows in order to obtain a representative sample of the forage. Mesh collection bags were used which permitted saliva to drain from the esophageal samples. Steers usually filled the mesh bags within 30 to 40 min thus minimizing contamination of the grazed forage with regurgitated material from the rumen (Bath et al., 1956). During the summer and fall trials in 1984 three esophageal steers were used for collection. In January, 1985 one steer died, therefore two esophageal fistulated steers were used in the spring, 1985 trial. Dried esophageal samples were composited for each steer for the AM and PM sampling times over the 7 d collection period.

In addition to esophageal forage samples, hand plucked forage samples were taken during the afternoon grazing period for the 7 d collection period. Daily hand plucked forage samples were composited for the entire collection period resulting in one forage sample per season. All esophageal, hand plucked and fecal samples were labelled, frozen immediately and then transported to Blacksburg, Virginia for analysis. Esophageal masticate, feces and hand plucked forage samples were dried at 55 C in a forced air oven for 24 to 48 h.

Blood samples were taken from 20 cows once during the 7 d collection period. One 10 ml blood sample was allowed to clot, centrifuged for 15 min (3000 x g) and the serum decanted and frozen. A 5 ml sample of whole blood was used for determination of packed cell volume (PCV) and blood urea nitrogen (BUN).

Blood samples were analyzed individually for each cow and made up a partial metabolic profile test, which is an indicator of nutritional status (Payne et al., 1970). Packed cell volume was measured using an Adams micro-hematocrit II centrifuge. Blood urea nitrogen was determined by a colormetric reaction of urea with diacetyl monoxime and thiosemicarbizide in an acid medium. A red color complex forms which is read on a spectrophotometer at 520 um (Coulombe and

Favreau, 1963). Serum inorganic phosphorus was estimated by a colormetric reaction involving an acid molybdate reduction (Fiske and Subbarrow, 1926). Serum was diluted 1:50 with $LaCl_3$ for Ca and Mg analysis. A 1:2500 and 1:500 dilution of serum in deionized water was used for Na and K analysis respectively. Serum filtrates were used for Cu and Zn determination. Serum proteins were precipitated with 20% trichloracetic acid and the resultant supernatant was used for Cu and Zn analysis. Serum Ca, Mg, Na, K, Cu and Zn were measured on a Perkin Elmer Model 403 atomic absorption spectrophotometer. Calcium, Mg, Cu and Zn were analyzed using a hollow cathode bulb with air-acetylene flame. Sodium and K were analyzed with flame emission.

Hand plucked forage and esophageal composited samples were analyzed for dry matter, ash, crude protein (A.O.A.C., 1980), neutral detergent fiber, NDF (Van Soest and Wine, 1967), acid detergent fiber, ADF (Goering and Van Soest, 1970), permanganate lignin (Van Soest and Wine, 1968), total nonstructural carbohydrates, TNC (Lever, 1973; Wolf and Elmer, 1975; Davis, 1976), and in vitro dry matter digestibility (Tilley and Terry, 1963). In addition, esophageal and fecal samples were analyzed for indigestible neutral detergent fiber (INDF). Indigestible neutral detergent fiber was defined as the organic matter insoluble in neutral detergent solution after a 4 d in vitro fermentation (Ellis et al., 1984). Indigestible neutral detergent fiber as % of dry organic matter is calculated as follows: INDF = [(crucible wt. + INDF wt.) - crucible wt. / initial OM wt] x 100. Percent digestibility of the forage was calculated using the following formula: OM digestibilty, percent = 1 - (INDF as percentage of esophageal masticate OM / INDF as percentage of fecal OM) x 100.

Fecal samples were analyzed for dry matter, ash, INDF and Yb concentration. Ytterbium concentration in feces was determined by atomic absorption specrophtometry using a nitrous oxide flame. One g of feces was ashed in porcelein crucibles in a muffle furnace at 500 C for 3 h. The ash was then digested with 20 ml of 3 N HCl and 3 N HNO_3 (Ellis et al., 1980). Ytterbium standards were prepared in a similar manner containing one g feces without Yb. Fecal output was then determined by the formula: fecal output, kg OM /d = Yb dosed, mg/d / Yb in feces, mg/kg OM. Forage intake was then calculated using indigestibility and fecal output values. Forage intake, kg OM /d = (fecal output, kg/d / indigestibility, %) x 100.

Statistical Analysis. All data were analyzed by least squares analysis of variance using the general linear models procedure of SAS (1979). Mean separations for the composition of the esophageal masticate, organic matter intake, fecal output, digestibility and metabolic profile were based on t-tests of the least significant difference (alpha =.05). No statistical analyses were performed on hand plucked samples because composition data were based on a single composited sample.

Results

Chemical Composition. Chemical composition of the esophageal masticate samples taken during the four seasons is listed in table 1. Data are presented on an ash free basis to correct for salivary contamination. The ADF content of the esophageal samples was highest in late spring and lowest in late summer ($p < .05$). Neutral detergent fiber content followed a similar pattern with highest fiber in the late spring and less fiber in the late summer. Lignin content was highest in late spring and decreased throughout the the grazing season although differences were not significant. Crude protein tended to be highest in late summer and lowest in late spring. Total nonstructural carbohydrate content was similar in all seasons. The in vitro organic matter digestibility tended to be highest in late summer, 60.4%, similar in late spring and late fall and lowest in mid-summer, 54.4%.

When comparing the chemical composition of esophageal masticate samples to hand plucked forage samples (table 2) collected during the trials, several observations can be made. The total non-structural carbohydrate content of the hand plucked forage was higher than in the esophageal masticate samples. Neutral detergent fiber, ADF and lignin values

tended to be lower in hand plucked forage samples. Lignin values were very similar for all seasons. The in vitro organic matter digestibility of the hand plucked samples was highest in late spring (64.1%) and and lowest in mid-summer (53.4%). Crude protein content was very similar in all hand plucked samples over the grazing season and was similar to the values determined in the esophageal masticate samples for all trials.

Chemical composition of hand plucked forage samples taken at monthly intervals from May, 1983 through May, 1984 are presented in table 3. Overall, quality of forage tended to higher in the spring and fall months. In vitro organic matter digestibility was very high in May, 1983 and 1984, 74.0 and 80.6% respectively, followed by October, 1983 (70.0%). Crude protein contents over 13.0% were observed in August, October, May, 1983 and May 1984. Crude protein was lowest in February, 1984 (6.1%). Total nonstructural carbohydrate

TABLE 1. CHEMICAL COMPOSITION OF ESOPHAGEAL MASTICATE SAMPLES

	Composition of OM,[a] %					
Season	CP[b]	TNC[c]	NDF[d]	ADF[e]	LIGNIN	IVOMD[f]
Late spring	14.0	2.8	81.3	54.3[g]	16.9	59.7
Mid-summer	15.9	3.2	79.7	51.2[gh]	16.4	54.4
Late summer	16.9	3.3	73.7	45.1[i]	12.8	60.4
Late fall	14.1	2.3	75.7	46.2[hi]	11.7	59.3
SE	1.0	.3	1.5	1.3	1.1	2.3

[a]Organic matter basis

[b]Crude protein

[c]Total nonstructural carbohydrates

[d]Neutral detergent fiber

[e]Acid detergent fiber

[f]In vitro organic matter digestibility

[ghi]Means in the same column with different superscripts are different ($p < .01$)

TABLE 2. CHEMICAL COMPOSITION OF HAND PLUCKED FORAGE SAMPLES

	Composition of OM,[a] %					
Season	CP[b]	TNC[c]	NDF[d]	ADF[e]	LIGNIN	IVOMD[f]
Late spring	14.8	6.7	71.2	43.0	8.4	64.1
Mid-summer	13.7	3.3	76.1	44.2	9.5	53.4
Late summer	14.6	6.9	63.9	38.4	7.6	60.3
Late fall	13.1	8.5	69.0	40.7	8.7	55.4

[a]Organic matter basis

[b]Crude protein

[c]Total nonstructural carbohydrates

[d]Neutral detergent fiber

[e]Acid detergent fiber

[f]In vitro organic matter digestibility

TABLE 3. CHEMICAL COMPOSITION OF HAND PLUCKED FORAGE SAMPLES TAKEN AT MONTHLY INTERVALS

	Composition of OM,[a] %					
Date	CP[b]	TNC[c]	NDF[d]	ADF[e]	LIGNIN	IVOMD[f]
5-5-83	15.3	7.4	59.9	36.8	8.4	74.0
6-7-83	7.2	11.1	70.4	43.4	8.1	67.9
7-6-83	11.1	3.9	66.3	48.8	8.9	63.4
8-5-83	12.7	7.2	42.6	34.6	9.8	36.9
8-31-83	16.2	3.0	60.5	41.9	9.7	69.7
10-4-83	15.8	9.8	60.0	38.2	7.6	70.0
11-2-83	8.5	8.3	67.8	46.7	11.8	53.7
12-6-83	11.5	12.4	61.7	39.1	6.7	69.9
1-9-84	8.2	8.8	69.4	41.4	7.7	64.0
2-3-84	6.1	4.5	73.8	45.3	7.8	55.6
5-11-84	13.6	15.2	52.9	31.8	4.4	80.6

[a]Organic matter basis

[b]Crude protein

[c]Total nonstructural carbohydrates

[d]Neutral detergent fiber

[e]Acid detergent fiber

[f]In vitro organic matter digestibility

was low during July and August, 1983 samplings with high carbohydrate contents seen in May, 1984, December and June, 1983. Acid detergent fiber ranged from a low of 31.4% in June, 1984 to a high of 48.8% in July, 1983. Neutral detergent fiber was highest in February, 1984 and lowest in August, 1983. Lignin values ranged from a high of 11.7% in November, 1983 to a low of 4.4% in May, 1984. Although data are variable, forage quality appeared higher in May, June, October and November and lowest in July and August of the the sampled years.

Intake, Fecal Output and Digestibility. The OM digestibility was highest in late summer, 61.6%, similar in late spring and late fall and lowest in mid-summer, 52.6% ($p < .01$, table 4) The OM digestibility results predicted by the internal marker compared favorably with the results obtained by in vitro digestion of esophageal masticate samples (table 1). Fecal output was highest in mid-summer which also had the lowest organic matter digestibility. Fecal output was lowest in late spring ($p < .05$).

Organic matter intake was highest in late fall, followed by mid-summer an and late summer and was lowest in late spring.

Metabolic Profile. The blood profile results obtained for the seasons are presented in table 5. Packed cell volume, BUN, and serum P and Mg values fell within the normal

TABLE 4. ORGANIC MATTER INTAKE, DIGESTIBILITY AND FECAL OUTPUT OF BEEF COWS GRAZING RECLAIMED STRIP-MINED PASTURES

Season	Fecal Output kg/d	OM Digestibility %	OM Intake kg/d
Late spring	5.1^{a}	57.5^{a}	12.0
Mid-summer	6.9^{b}	52.5^{b}	14.5
Late summer	5.4^{a}	61.6^{c}	14.0
Late fall	6.7^{b}	56.9^{a}	15.5
SE	.4	.4	.9

[abc]Means in the same column with different superscripts are different ($p < .01$)

ranges for cattle. Blood urea nitrogen was significantly lower in late fall and late spring compared to mid-summer and late summer ($p < .01$). Low BUN values in the late spring and late fall corresponded to the lower crude protein values observed in the esophageal masticate samples for the same seasons. Serum Ca was lower than normal in late spring sampling but was normal for the remainder of the grazing season ($p < .01$). Serum Cu was on the low end of normal values in late spring and decreased to .6 ppm by late fall. Serum Zn concentration was highest in late spring followed by late fall and late summer, but was well within the normal range. Serum K were similar for mid-summer, late summer and late fall and significantly lower in late spring. All serum K levels were higher than expected serum K levels for beef cattle. Serum Na levels observed in late spring and late summer samplings were on the low end of the normal range. Highest serum Na values were obtained in mid-summer and lowest values in the late spring ($p < .01$).

Serum biochemistry values for the monthly samples are presented in tables 6, 7, and 8. Packed cell volume, serum P, Ca and Mg were within the normal ranges for all sampling dates. Blood urea nitrogen showed a distinct pattern over the 11 mo sampling period. Blood urea nitrogen was highest in May and June, fell slightly in the summer months of July and August and continued to decline slightly throughout the fall and winter. Blood urea nitrogen levels lower than expected values were seen in October and November, 1983 and January and February, 1984. Serum Cu levels were on the low end of normal with levels below .6 ppm in December, 1983 and May, 1984. Serum Zn were variable over the sampling periods with values above 2 ppm obtained in August, October and November, 1983. Serum Na levels were lower than normal with lowest values observed throughout the spring and summer months. Serum K levels were above the normal expected values for beef cattle.

Discussion

Chemical composition of hand plucked forage samples were similar to the chemical composition of the esophageal masticate samples. The sampling procedure of observing the cows grazing and then sampling forage similar to what the cows were eating, worked well to obtain forage samples similar to what the animals were selecting. Weir and Torell (1959) and Van Dyne et al. (1980) indicated that grazing animals usually select forage higher in quality than is available and subsequently hand clipped. One difference was noted between hand plucked and esophageal masticate samples. The total nonstructural carbohydrate content of the hand plucked for-

TABLE 5. METABOLIC PROFILE RESULTS OF BEEF COWS GRAZING RECLAIMED STRIP-MINED PASTURES

Item	Season				SE	Normal values
	Late spring	Mid-summer	Late summer	Late fall		
PCV,[a] %	38.1^{cd}	33.7^{e}	37.4^{d}	40.1^{c}	.9	32.3
BUN,[b] mg/dl	10.1^{d}	16.6^{c}	15.6^{c}	8.4^{d}	.8	10-25
P, mg/dl	4.4^{d}	4.1^{d}	6.1^{c}	4.4^{d}	.3	4-7
Ca, mg/dl	6.6^{e}	9.5^{c}	8.9^{d}	8.9^{d}	.1	8-10.5
Mg, mg/dl	2.4^{f}	2.1^{g}	2.3^{f}	2.2^{fg}	.1	1.2-3.5
Cu, ppm	$.9^{f}$	*	$.7^{g}$	$.6^{g}$	.1	.7-1.7
Zn, ppm	1.4^{f}	*	1.1^{g}	1.2^{fg}	.1	.8-1.2
K, meq/l	5.1^{d}	6.9^{c}	7.1^{c}	6.8^{c}	.1	4.7
Na, meq/l	120.2	132.3^{c}	120.5^{d}	127.4	2.2	140

[a]Packed cell volume

[b]Blood urea nitrogen

[cdefg]Means in the same row with different superscripts are different ($p < .01$)

*Values not obtained

TABLE 6. PACKED CELL VOLUME (PCV) AND BLOOD UREA NITROGEN (BUN) VALUES OF BEEF COWS GRAZING RECLAIMED STRIP-MINED PASTURES

Date	PCV, %	BUN, mg/dl
5-5-83	32.6[f]	32.2
6-7-83	34.9[def]	38.3
7-6-83	35.3[cde]	12.5
8-5-83	33.9[ef]	11.1
8-31-83	35.3[cde]	11.4
10-4-83	35.3[cde]	8.2
11-3-83	43.7[a]	8.0
12-6-83	36.8[bcd]	13.4
1-9-84	36.4[bcd]	8.0
2-3-84	38.6[b]	6.6
5-11-84	37.3[bc]	17.6
SE	.7	.8
Normal values	32.3	10-25

[abcdef]Means in the same column with different superscripts are different ($p < .01$)

TABLE 7. SERUM MACROMINERAL CONCENTRATIONS OF BEEF COWS GRAZING RECLAIMED STRIP-MINED PASTURES

Date	P	Ca	Mg	Na	K
	mg/dl			meq/l	
5-5-83	3.3[f]	8.7[cde]	2.0	85.1[d]	5.4
6-7-83	*	8.9[bcd]	2.0	85.6[d]	5.4
7-6-83	6.0[ab]	8.9[bcd]	2.1	86.5[d]	5.3
8-5-83	4.7[de]	9.1[bc]	2.2	106.7[c]	8.4
8-31-83	5.4[bcd]	8.2[de]	2.4	119.0[b]	7.1
10-4-83	5.1[bcd]	8.1[e]	2.0	82.0[d]	8.5
11-3-83	5.5[bc]	8.5[cdee]	4.7	125.5[ab]	6.1
12-6-83	6.6[a]	10.5[a]	2.5	130.9[a]	5.0
1-9-84	4.9[cde]	8.8[bcde]	1.7	87.2[d]	6.3
2-3-84	4.7[de]	9.5[b]	2.0	129.1[a]	8.0
5-11-84	4.5[e]	9.2[bc]	1.7	118.0[b]	6.8
SE	.2	.2	.1	1.7	.2
Average values	4-7	8-10.5	1.2-3.5	140	4.7

[abcdef]Means in the same column with different superscripts are different ($p < .01$)

*Value not obtained

TABLE 8. SERUM CU AND ZN VALUES OF BEEF COWS GRAZING RECLAIMED STRIP-MINED PASTURES

Date	Cu, ppm	Zn, ppm
5-5-83	$.8^{bc}$	1.0
6-7-83	$.9^{a}$	.8
7-6-83	$.7^{def}$	1.1
8-5-83	$.7^{cd}$	2.0
8-31-83	$.7^{de}$	1.0
10-4-83	$.8^{bc}$	2.0
11-3-83	$.6^{efg}$	2.1
12-6-83	$.6^{fg}$	1.1
1-9-84	$.8^{bcd}$	1.0
2-3-84	$.8^{ab}$	1.0
5-11-84	$.6^{g}$	1.3
SE	.1	.1
Normal values	.7-1.7	.8-1.2

[abcdefg] Means in the same column with different superscripts are different ($p < .01$)

age was generally higher than in the esophageal masticate samples. The low TNC concentration in the esophageal masticate may be due to cell breakage during mastication and leaching of the sugars by saliva through the mesh collection bags. In studies by Acosta and Kothmann (1978), esophageal forage samples collected in screen bottom bags had higher crude protein and lignin values and lower total nonstructural carbohydrates than samples collected in water tight bags.

Esophageal masticate samples collected in the late summer had lower fiber fraction (ADF and NDF) and lignin along with higher digestibility than samples collected in the early spring. Brown et al. (1963) reported than tall fescue pastures maintained high digestibility in the fall and this lack of decline in digestibility was attributed to increased soluble carbohydrate content in the absence of an increase in crude fiber and lignin. Matches (1979) showed that Kentucky 31 tall fescue pastures had ADF contents of about 33% and NDF contents of nearly 55% in the spring and fall samplings. Crude protein content was over13% in spring and fall but declined to 11% crude protein in the summer. Summer samples had higher ADF and NDF fraction than either spring or fall and showed only 59% digestibility compared to 62 and 66% digestibility in the spring and fall, respectively.

The decrease in percent lignin in the esophageal samples over the grazing season may be an indication of change in proportion of grass and legume selected by the grazing animals. Typically, lignin content of a forage increases as the forage matures (Van Soest, 1966) which causes a decrease in forage digestibility. Since legumes usually have higher lignin contents than grasses (Van Soest, 1965), the low lignin content in the esophageal samples in the late summer and late fall may be attributed to animals selecting less legume and more grass as a proportion of their daily intake.

Organic matter digestibility predicted by the internal marker was similar to that obtained by the in vitro procedure. Van Soest (1965) reported that the percentage of cell wall constituents or NDF is the only chemical factor consistently related voluntary intake. The present study supports these findings, since there was an inverse relationship between NDF content and intake. Similar trends were observed for the relationship between ADF and organic matter intake. Lignin is generally thought to be one factor which limits intake of forages that are less than 66% digestible (Conrad et al., 1964). In this study, high lignin contents were associated with low intake and low lignin contents of the forage was associated with high intake. Since protein content of the forage was very similar over the grazing season, no relationship between intake and protein content was noted. Blaxter and Wilson (1963) found that if crude protein content of a pasture fell below 6 to 8%, appetite was depressed and intake reduced. The crude protein content of the strip-mined pasture forage does not approach this level, therefore, the fiber fraction of the diet is most influential in determining forage intake.

Organic matter digestibility of the forage was not related to intake. Also, organic matter digestibility was not consistently related to any of the chemical components of the forage. Van Soest (1966) stated that since no fixed relationship exists between percent cell walls and cell contents of forages, the use of single chemical factors to predict whole plant dry matter digestibilities is limited. In addition, the strip-mined pasture in which these cattle grazed consisted of several species of grasses and legumes which may mask relationships between chemical composition and digestibility.

Dry matter intake of beef cows reported in the literature is extremly variable. Dry matter intakes of lactating cows ranges from 4.5 to 15.5 kg/d (Johnstone-Wallace and Kennedy, 1945). Dry matter intake of the ten test cows ranged from 10.5 to 13.5 kg/d which corresponded to daily dry matter intakes of 3 to 4% of body weight.

The total protein requirements for beef cows range from 7.0% to 9.6% over the production year. The crude protein of the forage on a dry matter basis, ranged from 12.5 to 14.9% which was well above the animal requirements for all phases of production and over the entire grazing season.

Data presented on the metabolic profile of the beef cows for the four seasons and monthly samplings are generally within normal expected values for grazing beef cows. Although no unanticipated or unusual nutritional problems have been observed in the cows grazing on reclaimed strip-mined pastures, a few of the mineral results do require additional comment.

Blood urea nitrogen levels fell below 10 mg/dl in the late fall trial and in October and November, 1983 and January and February, 1984. Nutritional protein status has been correlated with BUN, total protein, albumin, and hemoglobin (Blowey et al., 1973). Low BUN also indicated low protein intake or high starch intake. Rowlands et al. (1974) found that BUN values were low on indoor winter diets but high in grazing conditions in the summer. Although crude protein content of the forage was well above animal requirements, digestibility of protein may have been low which contributed to low BUN values observed. High tannin varieties of serecia lespedeza, like that found on the test pasture, has been shown to have lower protein digestibility than low tannin varieties (Donnelly and Anthony, 1973).

Blood Ca levels of the test cows were low, 6.6 mg/dl in the late spring trial. At parturition, dairy cows exhibited a drop of 1 to 2 mg Ca/dl plasma Ca and if plasma Ca drops below 5 mg/dl there is potential for development of milk fever. Low serum Ca may indicate a potential for milk fever, but low serum Ca levels may be due to insufficient dietary Ca or excess dietary Ca (Kronfeld, 1972). High rates of gain, milk production, and pregnancy increase Ca requirements (NRC, 1984).

Normal blood Cu levels range from 70 to 170 ug/dl in most ruminants (NRC, 1984). Underwood (1977) stated that Cu levels below 60 ug/dl are indicative of Cu deficiency. Since serum Cu levels were on the low end of the normal range and several sampling periods showed Cu levels below .7 ppm, Cu deficiency may be a potential problem in cows grazing forages grown on reclaimed strip-mined soils. Plants that contain high levels of Mo, S, phytate or lignin may reduce Cu absorption (Underwood, 1977). Also, if soil Mo levels are high or if plant sources of Cu are unavailable to the animal, Cu supplementation may be necessary. The first clinical sign of Cu deficiency is lack of pigmentation in the hair (Underwood, 1977) although this sign has not been observed in the cattle on the Powell River Project.

Serum K levels were noted to be higher than normal values for beef cows. High serum K levels are not likely to occur under normal grazing conditions, but Wright et al. (1971) showed that after periods of moderately high K intake, animals can survive K intakes that would otherwise be lethal.

Serum Na levels were on the low end of the normal range for the cows in the spring and summer months. Variable and low Na levels may have been related to salt supplementation practice. During the grazing season, salt was supplied to the cows once weekly as a management tool in order to observe the cows. In contrast, during the winter months cows had free choice access to a mineral and salt mixture. Plants are usually high in K but low in Na (NRC, 1984), therfore, grazing ruminants usually require salt supplementation. Sodium needs increase during lactation and during periods of rapid growth (Underwood, 1977). Animals can usually be maintained for long periods of time on low Na diets because of efficient conservation mechanisms in the body. In severe Na deficiencies, animals may crave salt and are seen constantly licking, may lose weight and have a rough hair coat (Underwood, 1977).

Previous studies by Gerken et al. (1984) have shown that the beef cows used in this study are in excellent reproductive health. Calving intervals of 45 d have been maintained since 1981 and an average of 95% of the cows exposed to the bulls have weaned calves since the study began in 1980. The cows maintained typical weight loss and gain patterns, with cows losing weight just after calving and gradually increasing in weight over the grazing season. The average weaning weight for heifer and steer calves over the 5 y period was 228 kg. These data indicate that the beef cows performing normally while grazing on forages grown on reclaimed strip-mined pastures.

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Appendix A

TABLE 9. EXAMPLE ANALYSIS OF VARIANCE, ACID DETERGENT FIBER (%)

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F
Seasons	3	139.5	46.5	6.8**
Steers	7	47.9	6.8	
Total	10	187.4		

**($p < .01$)

TABLE 10. EXAMPLE ANALYSIS OF VARIANCE, BLOOD UREA NITROGEN (mg/dl)

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F
Seasons	3	778.8	259.6	26.7***
Cows	62	602.0	9.7	
Total	65	1888.8		

***($p < .001$)

TABLE 11. EXAMPLE ANALYSIS OF VARIANCE, ORGANIC MATTER DIGESTIBILITY (%)

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F
Seasons	3	413.8	137.9	93.5***
Cows	36	53.1	1.4	
Total	39	466.9		

***($p < .001$)

TABLE 12. AVERAGE DOSE OF YB (mg/d), YB CONCENTRATION IN FECES (mg,kg), AND PERCENT INDF[a] IN ESOPHAGEAL MASTICATE SAMPLES

Season	Yb Dosed[b] mg/d	Yb Feces mg/kg	INDF in esophageal masticate %	INDF in feces %
Late spring	777.5	155.5	35.2	82.9
Mid-summer	777.5	117.0	40.5	85.5
Late summer	777.5	149.4	30.7	80.2
Late fall	777.5	122.8	34.9	81.1

[a]Indigestible Neutral Detergent Fiber

[b]2 g $Yb\ (NO_3)_3 \cdot 5\ H_2O$ daily

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EVALUATION OF NUTRITIONAL STATUS OF BEEF COWS GRAZING RECLAIMED STRIP-MINED PASTURES

by

Kathy L. Gross

(ABSTRACT)

A series of four trials over the grazing season were conducted to evaluate the nutritional status of beef cows grazing reclaimed strip-mined pastures in southwestern, Virginia. Blood samples, esophageal fistula forage samples and hand plucked forage samples were taken in each trial. An external marker, Ytterbium, and an internal marker, indigestible neutral detergent fiber (INDF) were used to estimate organic matter intake, fecal output and digestibility. In addition to samples taken during the trials, blood samples and hand plucked forage samples were taken monthly for 11 mo prior to the trial period. In late summer esophageal masticate samples had a low fiber fraction (ADF and NDF), high crude protein and total nonstructural carbohydrates (TNC) which contributed to a high organic matter digestibility. Hand plucked forage samples had higher TNC than esophageal masticate samples. Organic matter digestibility predicted by the internal marker was highest in late summer 61.6%, similar in spring and late fall, and lowest in mid-summer, 52.6% ($p < .01$). Fecal output was highest in mid-summer and

lowest in spring ($p < .05$). Estimated intake was not significantly different in any of the trials. Although data was variable, forage quality was higher in May, June, October and November samplings, as indicated by highest CP, TNC, and lower NDF and ADF values, compared with July and August data when forage quality was lowest. Packed cell volume, BUN and serum P and Mg concentrations fell within normal ranges for beef cattle. Low BUN values were observed in spring and late fall which corresponded to low crude protein values observed in the esophageal masticate samples for the same trials. Serum Cu was on the low end of normal values in the late spring and decreased to .6 ppm by late fall. Serum K levels were above the expected values for beef cattle. Serum Na concentrations were lower than normal with lowest values observed throughout spring and summer months.