SOME EFFECTS OF DATE OF CUTTING AND LOCATION ON THE NUTRITIONAL VALUE OF SELECTED INTERLAKE FORAGES

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ABSTRACT

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Digestibility studies with yearling wethers were conducted on native hays from three selected areas and on alfalfa from one. These samples were cut from adjacent plots at three monthly intervals, beginning about the third week in June. Digestibilities were determined by the conventional method and the results were compared with those obtained by the fecal nitrogen and forage protein indicator methods. Hay samples collected over a period of four years from various parts of the Interlake area were analysed for cobalt and copper. The effect of date of cutting on the level of cobalt and copper was also investigated.

The digestibility of crude fibre, nitrogen-free extract, organic matter and dry matter and the total digestible nutrients of the hays decreased significantly with successive dates of cutting. No significant differences in digestibility due to date of cutting were found for either crude protein or ether extract. The palatability of the samples decreased with advancing maturity. The samples of native hay from two of the three locations were found to be generally suboptimal in digestible protein and total digestible nutrients at the levels consumed.

The application of the forage protein and fecal nitrogen methods of estimating digestible organic and dry matter of forages to the data obtained by the conventional method indicated that the indirect methods were not sufficiently accurate to provide reliable estimates of digestibility.

The levels of cobalt and copper, as determined by chemical analysis, were found to be marginal when compared to recommended levels for cattle and sheep. Date of cutting had no consistent effect on the cobalt content of the samples but the copper content decreased with advancing maturity. Variations in cobalt content were found between locations and between years.

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INTRODUCTION

The Interlake District of Manitoba is situated directly north of Winnipeg. It may be defined as the area of land situated between Lake Winnipeg and Lake Manitoba.

Livestock production is the major farm enterprise of the district. In the areas nearest Winnipeg, dairy cattle constitute the major portion of the animal population. Farther north and in areas not readily accessible to the main highways beef cattle and sheep displace the dairy animals as the major source of income. Due to the generally poorly drained and stony land, dense bush and a large number of sloughs, little of this area has been broken. Consequently, the most important, and in many cases the sole feed for these animals is native hay.

Malnutrition, characterized by depraved appetite, retarded growth and in the most severe cases by death, has long been common among the herds of this area. In an effort to obtain more information concerning the nutritive value of the native forages, the Division of Animal Science of the University of Manitoba initiated a study of the problem in 1957. The work of Grieve (26) revealed the native hays to be generally deficient in digestible protein, total digestible nutrients and phosphorus.

In this study, further aspects of the problem have been investigated. Digestibility trials were conducted in order to determine the effect of the date of cutting on the digestibility of native hays from three selected areas. In addition, hay samples were collected from these areas over a period of four years and were analyzed for the trace elements, cobalt and copper.

REVIEW OF LITERATURE

Numerous investigations have been conducted to determine the effect of date of cutting on the chemical composition and digestibility of grass and legume hays. In the main, these have dealt with cultivated hays. Although it may be assumed that the effects would be similar, little information in this regard is available concerning Canadian hays in general and Manitoba hays in particular. This review covers the material relevant to this problem.

Very little attention has ever been given to the content of the trace elements, cobalt and copper, in native hays or to factors affecting this content.

Effect of Date of Cutting

Date of cutting appears to have a significant effect upon the overall nutritive value of prairie hays. Prince et al (43) showed that timothy hay gave the greatest yield of protein when the plants were coming into head. In addition, Bird (8) using a variety of grasses harvested at various stages of maturity made similar findings.

Following a study of native hays common to Alberta and Saskatchewan, Clarke and Tisdale (14) reported that the crude protein content was highest in the leaf stage and then decreased sharply. The content of crude fibre and N.F.E. increased with advancing maturity although the increase in the former was considerably more marked. Poijarvi (42) noted that the ash content generally decreased with advancing maturity.

Christensen and Hopper (13), in a study of North Dakota hays, found that hay cut in July, at the height of the growing season, had the highest digestibility and T.D.N. values. It was also more palatable than similar hay cut later in the season. Baker et al (5) also observed a reduced palatability in more mature hays and this, coupled with a decrease in the digestible nutrient content, greatly increased the amount of feed required to produce a pound of gain on the animals. This work was corroborated by Briggs et al (11).

Staples et al (51) made the following observations on the results of digestion trials using prairie hays cut at three stages of maturity: (1) The protein content was materially affected by maturity. Late cut hay contained only 50 - 70 per cent as much protein as early-cut. (2) The content of dry matter, ether extract, crude fibre and N.F.E. were not seriously affected by the date of harvest. They also found that protein digestibility showed the greatest decrease with the advance of maturity. The digestibility of dry matter, N.F.E., ether extract and crude fibre were only slightly reduced. Gallup and Briggs (25) found a significant decrease in T.D.N., crude fibre and crude protein digestibilities associated with maturity.

Digestibility Trials

Digestion trials have long been an important tool in the quest for more knowledge about the nutritive value of feeds. According to Schneider (47), the earliest recorded digestion trials were conducted at Goettingen, Germany, at the Weende Experiment Station by Henneberg and Stohman in 1864. Since that time Schneider estimates that over 25,000 trials have been conducted throughout the world. It is apparent, therefore, that this method is not only a well known but also a widely used technique for measuring nutritive value.

Basically, a digestion trial supplies information as to the dry matter of feed eaten and the dry matter of feces excreted. Chemical analysis is employed to determine the per cent of the various organic nutrients - carbohydrates, fats and protein - present in the feed and feces. By subtracting the amount in the feces from that ingested, the amount of each fraction that has been digested can be calculated. This value, given as a per cent of the amount ingested, is known as the digestibility coefficient.

The oldest and perhaps the most accurate type of trial is the total collection method. As the name implies, total fecal collection is involved. The fecal material is then weighed and representative samples composited for analysis at a later date.

In a conventional trial, the animals are closely confined, often in a metabolism cage, such as those described by Briggs and Gallup (12), Nelson _et al_ (38) and Erwin _et al_ (20). Each of these consists of an elevated cage, large enough to allow the animal to stand but not to turn around. Receptacles are provided for the separate collection of urine and feces. The feed containers are usually detachable and provision is made for a constant supply of water. By the use of this method, it is relatively easy to keep a record of the weight of feed consumed and of feces excreted.

The main disadvantage of the above method is that the animal is subjected to an unnatural environment. The loss of exercise occasioned by such close confinement generally results in a decrease in appetite. Digestibility is usually maximum at the maintenance level of feed intake. Watson et al (55) found that if the daily feed intake of steers weighing approximately 600 kilograms exceeded or fell below the range of 4.5 to 9.0 kilograms, significant differences in digestibility occurred. Lennerts (33) reached similar conclusions using wethers.

The chemical analyses usually involved in digestibility trials are dry matter, crude protein, crude fibre, ether extract and total ash. The nitrogen-free extract (N.F.E.) is determined by subtracting the values for crude protein, crude fibre, ether extract and total ash from the dry matter content.

The crude protein fraction includes all the nitrogenous compounds in the feed -- both protein and non-protein nitrogen. Crude fibre and N.F.E. constitute the carbohydrates. The crude fibre fraction consists primarily of cellulose and other polysaccharides including lignin and is generally less digestible than the N.F.E. which is composed of the sugars, starch, hemicellulose and small amounts of lignin. The N.F.E. value, since it is found by difference, contains the accumulated errors of the other determinations and this could account for some of these exceptions. The ether extract contains the true fats and other ether soluble substances. These other substances may constitute more than 50 per cent of the extract in the case of some forages (35).

The digestible nutrients are obtained by multiplying the various nutrient fraction values by their respective digestion coefficients. The digestible ether extract is then multiplied by 2.25 to give a more exact estimate of the energy supplied. These values are summed to give the amount of total digestible nutrients (T.D.N.) expressed as pounds per 100 pounds of feed.

There are two additional points concerning digestibility trials which also should be made. In every digestion trial a certain preliminary or adjustment period is required. This is necessary to allow the animal sufficient time to adjust to its cramped quarters, to excrete all remnants of the feed fed prior to the commencement of the trial and also to allow the microorganisms sufficient time to adjust to any change in the feeding regime. The length of time required for the preliminary period has been the subject of several investigations.

Staples and Dinusson (50) fed steers prairie hay supplemented with oats and soybean meal and compared the efficiency of seven and ten day adjustment periods. They found that except in the case of N.F.E., the seven day period gave results equal in accuracy to those given by the ten day. Crampton and Lloyd (15) stated that not less than five days must be allowed for a preliminary period. Nicholson et al (39) reported that for rations in which the basic components remain constant between trials, a seven day period is adequate for cattle, Grieve (26) compared six and seven day periods with sheep receiving an all hay ration and found no significant difference in the results obtained.

Ad libitum feeding of low quality roughages would appear to be desirable. Forbes et al (21) reported that sheep in metabolism cages did not consume enough hay to maintain their body weight. Watson et al (55) and Lennerts (33) found that, between rather wide levels of intake, the digestibility coefficients did not change significantly.

Blaxter et al (9) stated that frequent and regular feeding was important for greatest accuracy.

Use of Fecal Nitrogen and Forage Protein as Indicators.

The total collection method for determining digestibility is a long laborious method. For many years investigators have sought a less time consuming but equally accurate method. This search has led to the use of various indicators. An indicator is either present as a natural constituent of the feed or is added to it. Maynard and Loosli (34) give the following requirements of a satisfactory indicator: "It must be totally indigestible and unabsorbable; pass through the digestive tract at a uniform rate; be readily determined chemically and preferably be a natural constituent of the feed." The theory involved is that if the per cent of an indicator and a specified nutrient in the feed and in the feces are known, then by the use of a mathematical calculation, the digestibility of the nutrient in question can be determined. The following equation expressed the relationship:

$$\text{Digestibility} = 100 - 100 \frac{\text{Per cent of indicator in feed}}{\text{Per cent of indicator in feces}} \times \frac{\text{Per cent of nutrient in feces}}{\text{Per cent of nutrient in feed}}$$

This method dispenses with the measurement of both feed intake and fecal excretion.

Chromic oxide, plant pigments and lignin have been used as indicators with varying degrees of success. These substances are insoluble and unabsorbable. In contrast, fecal nitrogen, which constitutes the indigestible portion of the protein of the feed, has also been used as an indicator.

Lancaster (32), after analysing the data from a series of 52 digestion trials, formulated the hypothesis that the nitrogen excreted in sheep feces, per unit intake of pasture organic matter was constant. The following formula expresses this relationship:

$$\text{Digestibility of organic matter} = 100 \left(1 - \frac{C}{n} \right)$$

C equals the grams of nitrogen per 100 grams of pasture organic matter consumed and n equals the per cent nitrogen in the ash-free feces. The value of C was calculated to be 0.83 ± 0.102.

Homb and Breirem (30) discovered that the maturity of the hay affected the fecal nitrogen level. They concluded that by taking this point into consideration, Lancaster's formula would give estimated digestibility coefficients that agreed quite closely with those obtained by conventional methods. Gallup and Briggs (25) found that total fecal nitrogen excretion varied only slightly from 0.55 grams per 100 grams of dry matter intake when various samples of hay containing 3-6 per cent crude protein were fed. When rations containing 6-12 per cent protein were consumed, total fecal nitrogen excretion was about 0.71 grams per 100 grams of dry matter intake. To overcome the effect of the level of protein in the feed on the level of fecal nitrogen excretion, Lancaster (32) modified the value of C. Based on some 500 digestion trials in New Zealand, Australia and the United States he found that for forages containing less than 15 per cent protein on a dry matter basis, the constant C equalled 0.67 ± 0.12. If the protein content exceeded 15 per cent, C equalled 0.80 ± 0.08.

Forbes (22), on the other hand, was of the opinion that the total fecal nitrogen varied too widely to be of practical value in estimating the dry matter intake of animals. He developed a formula for predicting dry matter digestibility from protein content:

$$D = 100 - \frac{\text{per cent protein in feed}}{\text{per cent protein in feces}} \left((100-42.64(\text{per cent protein in feed} - 5 \text{ per cent})\ .2148) \right)$$

The latter portion of this formula, 42.64 (per cent protein in feed -- 5 per cent), represents the digestible protein of the feed sample (23). Subtracting this value from 100 would therefore give the amount of indigestible protein. The entire formula is therefore an adaptation of the general formula employed when using indicators. However, Forbes found that the expected accuracy was not attained in all cases, particularly with sheep, which seemed to be more efficient digesters of protein in low quality forage than cattle.

Cobalt

An awareness of the role of cobalt in the animal body is of relatively recent origin. In 1935, two Australian workers, Underwood and Filmer (53) found that the zinc extract group in an iron-free acid extract of limonite was of definite value in relieving the symptoms of a wasting disease of sheep known as enzootic marasmus. Cobalt chloride was found in the extract as an impurity and further tests using traces of cobalt chloride yielded positive results in the treatment of this disease. The same year, in New Zealand, Grimmett and Shorland (27) found that cobalt acetate had a similar effect on a local ailment of sheep known as bush-sickness. Askew and Dixon (3) produced similar results. It was soon recognized that cobalt deficiency was present in many localized areas throughout the world.

The function of cobalt in ruminants remained unsolved for many years. Several workers noted that oral administration of the element was very effective in the removal of cobalt deficiency symptoms (54). In 1948, Ray <u>et al</u> (44) compared oral administration of cobalt with injection and found that injected cobalt had little effect. They concluded that the beneficial effect of cobalt was probably linked with normal production of members of the Vitamin B complex in the rumen. Tosic and Mitchell (52) discovered that the rumen microorganisms had the ability to concentrate cobalt from their external environment.

The following year, Rickes et al (46) succeeded in crystallizing small amounts of a factor which stimulated the growth of lactobacillus lactis and was a hemopoietic factor in humans. This substance was vitamin B_{12} and cobalt was found to be present in the molecule. Further work by Anderson and Andrews (1) showed that the injection of vitamin B_{12} was as effective in treating cobalt deficiency as was the oral administration of cobalt.

Gall (24) reported marked alterations in the type and numbers of bacteria in the rumen of cobalt deficient sheep.

These findings led to the conclusion that vitamin B_{12} was a metabolic essential for many animal species, but if adequate cobalt was present in the diet of the ruminant, the rumen micro-organisms would produce B_{12} in amounts sufficient to meet the body requirements.

Cobalt deficiency is characterized by loss of appetite and/or a depraved appetite, lack of thrift and eventual death. Reproduction is impaired and the offspring that are born are generally small and weak. Anemia is a common symptom although the type appears to vary. Wool growth is retarded and the fibres are weak. Bowstead et al (10), Anderson and Andrews (1) and others have found that animals suffering from cobalt deficiency respond very rapidly to treatment. Appetite returns within a few days and weight gains and loss of anemia soon follow. Maynard and Loosli (34) state that this rapid response is the only certain diagnosis of cobalt deficiency.

Maynard and Loosli (34) reported that the average cobalt content of grasses from healthy areas was 0.1 p.p.m. on a dry matter basis. For "sick" areas the content was between 0.04 - 0.07 p.p.m. The cobalt requirement for cattle (41) is considered to be between 0.03 - 0.05 milligrams per pound of dry feed or approximately 0.07 - 0.10 p.p.m. and for sheep approximately 0.07 p.p.m. of the dry feed (40).

Cobalt has been administered by various means. It is most effective when given orally. Incorporation of the element into salt is quite effective and is probably the most practical method under most conditions.

Underwood (54) states that cobalt is not required by the plant for any life process. Its presence in the plant is due only to the fact that it is present in the surrounding soil and is absorbed along with those nutrients required by the plant. Beeson and MacDonald (6) in a study of the absorption of mineral elements by forage plants found no correlation between the cobalt content of legumes and the stage of maturity. However, the cobalt in the timothy samples studied increased with maturity.

<u>Copper</u>

In 1924 copper was first recognized as having a specific function within the animal body. In that year, Hart *et al* (28) found that copper, in addition to iron, was required by the rat for hemoglobin formation. Subsequent studies with other animals produced similar findings.

Neal, Becker and Shealy (37) were the first to associate a known disease with a copper deficiency. They found that nutritional anemia of young calves, particularly suckling animals, responded very markedly to treatment with ferric ammonium citrate fortified with copper sulfate. Iron supplements alone had not been effective.

Copper deficiency, like cobalt deficiency, is generally an area problem. The soils of most localities provide the plant with adequate copper to meet the requirement of animals which later consume the plants. However, other factors can cause a copper deficiency even though the plant may contain a normal amount of the element. Dick and Bull (18) found that an excess of molybdenum in forage containing normal amounts of copper and inorganic sulfate produced a significant decrease in the copper level in the liver and the amount stored in other parts of the body. High levels of lead and zinc in the forage can also reduce copper retention and result in a deficiency of this element.

Copper and cobalt deficiencies may both be responsible for certain diseases such as "coastiness" in cattle.

Elvehjem (19) found that copper was required to convert iron to forms which could be used for the construction of the hemoglobin molecule. In the absence of copper there was a reduction in the amount of iron absorbed and therefore in the amount retained by the body. Copper is also an essential part of several enzymes including ascorbic acid oxidase, cytochrome c, tyrosinase and catalase and has been shown to be necessary for the well-being of the central nervous system.

Underwood (54), in his review of trace elements gave the following symptoms of copper deficiency -- anemia, depressed growth, depigmentation of hair, and demyelination of the spinal cord. In sheep, depigmentation of the black wool is common and is usually accompanied by a loss of the normal crimp. As previously mentioned copper is an essential part of the enzyme tyrosinase and is believed to be required for melanin formation.

Enzootic ataxia, a disease of lambs, characterized by nervous conditions such as loss of coordination, was found to be due to a copper deficiency by Bennetts and Chapman (7). This is not surprising since it was found later that copper was necessary for the growth and repair of the myelin sheath--the protecting layer which surrounds the nerves.

Sjollema (48) found that hays from areas in which animals suffered from copper deficiency had copper contents of from 1 - 5 milligrams per kilogram of hay. Hays from normal areas contained at least 7.5 milligrams per kilogram of hay. Cunningham (16), in a study of hays from deficient areas, reported a mean copper content of 3.6 p.p.m. as compared to 11 p.p.m. in hays from healthy areas. Murty (36) concluded that the minimum copper requirement for sheep was 3.85 milligrams per sheep daily or 7 p.p.m. of ration dry matter. The publication, "Nutrient Requirements of Beef Cattle" (41), states that the copper requirement of beef cattle is between 4 - 8 p.p.m. of the total air dry ration and for sheep (40) is at least 5 p.p.m. As mentioned previously, excessive amounts of other elements such as molybdenum, zinc, and lead can increase the copper requirements.

The most convenient method for supplying additional copper to animals in deficient areas is by the addition of 0.5 per cent copper sulfate in the ration.

Unlike cobalt, copper is required by plants. However, it is seldom present in concentrations much in excess of animal requirements. In deficient areas, application of copper to the soil may benefit the growth of both plants and animals (54).

Beeson and MacDonald (6), in a study of the relation of stage of maturity to the micronutrient content of timothy and some legumes, found no general pattern in the variation in the copper content as the season advanced.