12-9-1997

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Proceedings, The Range Beef Cow Symposium XV
December 9, 10 and 11, 1997, Rapid City, South Dakota

Ingestion of Ponderosa Pine Needles by Cattle[1]

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INTRODUCTION

Given the relatively high fiber and moderate crude protein concentrations in Ponderosa pine needles (Adams et al., 1992; Pfister et al., 1992) and their potential negative effect on organic matter digestibility and nitrogen retention in ruminants (Adams et al., 1992), it is not readily apparent why cattle eat them. However, there are a number of ideas that may help explain why they do. Ponderosa pine needles contain a variety of nutrients and precursors including glucose, fructose, galactose, sucrose, citric acid, shikimic acid (a precursor in the biosynthesis of the amino acids phenylalanine, tyrosine and tryptophan), crude protein (Pfister et al., 1992; Adams et al., 1992), a variety of minerals (Kronberg, unpublished data), and probably some vitamins. The needles also contain large amounts of phytochemicals including monomeric phenolics, flavonoids, terpenes, and tannins (Pfister et al., 1992; Adams et al., 1992).

Five potential reasons for ingestion of Ponderosa pine needles by cattle include: 1) inadequate availability of alternative vegetation or supplements that could satisfy their hunger, 2) to obtain needed nutrients that are not available from alternative feeds, 3) to reduce negative physiological consequences resulting from their ingestion of other feeds (self medication) , 4) they find the flavor of needles desirable for reasons unrelated to those listed above so they eat them, and 5) they are bored with other vegetation or feeds that are available to them and therefore eat the needles because they are novel.

Numerous observations by ranchers and scientists support the idea that cattle will eat Ponderosa pine needles even when other forages and (or) concentrates are available. Whether or not these alternative feeds usually meet their nutrient requirements is unknown because the nutrient content of ranch feeds is often not known, and even in research situations, our understanding of cattle nutrition and feed quality is imperfect. If hungry cattle are eating the needles because there is little available alternative feed in their pastures because it has been grazed out, covered by snow, or is not being supplemented to them, then the solution is obvious.

RESEARCH SUMMARY

Ruminants that are experiencing nutrient deficiencies will eat unusual materials that appear to help rectify their deficiencies (Provenza, 1995). Goats consuming nitrogen-deficient vegetation ingested woodrat dwellings that were high in nitrogen-containing excreta (Provenza, 1977).

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Cattle with mineral deficiencies ate rabbit flesh and bones while non-deficient cattle did not eat them and ignored the bones (Wallis de Vries, 1994). Sheep grazing mineral-deficient pastures ate parts of infant birds (Furness, 1988). Bighorn sheep ingested rodent middens with high mineral content (Coates et al., 1991). Phosphorus-deficient cattle ate bones (Pamp et al., 1976). These observations do not show, however, that ruminants have a true appetite (or "nutritional wisdom") for any of these nutrients. Ruminants, like other animals, can withstand inadequate daily intake of macro- and micro-nutrients; consequently, they do not have to optimize their daily intake of any particular nutrient (Booth, 1985). Instead, as Provenza (1995) states "homeostatic regulation needs only some increasing tendency, as a result of a gradually worsening deficit of some nutrient or of an excess of toxins or nutrients, to generate behavior to correct the disorder."

There appears to be considerable variability in the amount of needles that cattle will eat, and only a few studies report the nutritional conditions for cattle that are consuming pine needles. Cattle on Colorado Ponderosa pine-bunchgrass rangeland did not eat pine needles while grazing this range from May to November (Currie et al., 1977). On rangeland in the Black Hills of South Dakota, cattle increased the amount of Ponderosa pine needles in their diets from 4.5 to 6.7 to 8.7 and to 9.4% in June, July, August, and September, respectively, while the amount of grass in their diets remained near 54% during these months (vegetation from a variety of forb, shrub, and tree species compose the remainder of their summer diet; Uresk and Painter, 1985). By comparing the proportion of a plant species in cattle diets in August in respect to the proportion of that plant species in the total plant cover, Uresk and Painter (1985) observed that cattle were clearly selecting for or avoiding most grass and browse species; thus, their ingestion of pine needles in August can not simply be attributed to decreased availability of alternative plants. In other words, cattle were deliberately eating pine needles. In late summer, the crude protein content of grasses is often much lower than it is in tree leaves; therefore, it is possible that the cattle in this study increased their ingestion of pine needles in order to acquire more crude protein (CP).

During a fall and winter, MacDonald (1952) offered 6 gestating cows free access to fresh Ponderosa pine needles stripped daily from live trees. Each day, these cattle also were offered 17 pounds of poor-quality grass hay (6.2% CP), 3 pounds of alfalfa hay (12% CP), and one half pound of "oilcake" meal (33% CP). The cows had free access to a mineral mix composed of bonemeal, salt, iron sulfate, cobalt sulfate, copper sulfate, and potassium iodide, and were supplemented daily with 3000 I.U. of vitamin A per 100 pounds of body weight. Although pine needle intake was not measured, only one cow in this group produced a normal calf; all others produced calves that were born dead or died shortly after birth. A control group of cows that were offered the same diet and minerals, but not pine needles, produced normal healthy calves. This was early scientific evidence that cattle would consume Ponderosa pine needles even when well fed.

Pfister and Adams (1993) observed grazing cattle in the same area of Ponderosa pine-occurring rangeland in eastern Montana during portions of two winters. Thirty-two and 13% of observed bites (about 6.3 and .69 lb. per day, respectively) by gestating cows were of pine needles on the ground or on trees, respectively, during the first winter, but less than 1% of bites were of pine needles during the second winter. During the first winter, cows consumed more needles from trees as the snow depth increased and presumably reduced availability of needles on the

ground. The authors attributed the higher intake of pine needles in the first winter primarily to colder temperatures and much lower availability of alternative forage (mainly dead grass). Cattle consumed the higher amounts of pine needles during the first winter even though they were offered 15.4 lb. of alfalfa-grass hay per animal each morning of the trial. Pfister and Adams (1993) noted that the cows ate the hay in the morning and never started grazing before noon. They also observed that pregnant cows consumed 33% more pine needles than open cows did. In a more recent study by Pfister(1997), he observed that grazing cattle in the Black Hills of South Dakota ate more pine needles during a colder versus a mild winter.

In another pen trial, gestating cows consuming 25.1 lb./d of grass hay (that gave them 1.6 lb./d of CP) ate 1.6 lb. of air-dried Ponderosa pine needles per day (Short et al., 1994). Gestating cows on the same diet of grass hay with *ad libitum* access to wheat straw ate 1.3 lb/d of air-dried needles, and cows offered a high-protein diet (2.3 lb/d of CP) of grass hay and soybean meal ate 2.9 lb of air dried needles per day (Short et al., 1994). Thus, the cows on the higher protein diet ate considerably more pine needles than did cows on the diet with the moderate crude protein level. However, cows in all treatments ate enough pine needles to induce abortions. In another experiment, these investigators found that interval to parturition in cows exposed to pine needles was not affected by protein level of the diet or having *ad libitum* access to a salt-sulfur block (Short et al., 1994).

Pine needles contain high levels of condensed tannins (Adams et al., 1992; Pfister et al., 1992). These compounds can increase the amounts of ingested protein escaping ruminal degradation, and increase amino acid absorption by ruminants (Waghorn et al., 1987; McNabb et al., 1993). Cattle that consumed oat hay *ad libitum*, 2.2 lb of soybean meal, 2.7 lb of molasses and 1.1 lb of ground air-dried Ponderosa pine needles had elevated serum levels of many essential amino acids compared to control cattle that ingested the same daily diet except no pine needles (Kronberg and Short, 1997). In a winter pen trial recently conducted in Montana, individual intake of Ponderosa pine needles by late-term cows was measured (Kronberg et al., unpublished data). Four groups of cows were supplemented daily with one of the following diets developed with NRC (1996) models: 1) high levels of ruminally degradable and escape protein, or 2) high levels of energy, or 3) high levels of ruminally degradable and escape protein and energy, or 4) low levels of ruminally degradable and escape protein and energy (control). These cows were penned individually from about 0800 to 1700 and had *ad libitum* access to water, trace-mineralized salt, Ponderosa pine needles (6.6% CP, 51% NDF and 42% ADF) and barley straw (4.8% CP, 74% NDF and 48% ADF; which is similar in nutritional quality to standing dead grass in winter) during these hours. They were offered their supplement between 0830 and 1000 and cleaned it up quickly. Between 1700 and 0800 they had access to everything but pine needles. Mean daily pine needle intake for the last seven days of gestation was low (.3 lb/d), and did not differ statistically among the four groups of cows. Cattle may derive some benefit from consuming smaller amounts of Ponderosa pine needles, but we have no evidence to support the hypothesis that they consume them to improve their nutritional status. In fact, average pine needle intake of cows consuming the supplements with high levels of degradable and escape protein was numerically greater than that of the cows consuming the high energy or low protein and low energy supplements. Mean daily temperature was at or near 40º F for all but 4 days of the 26-day trial (March l0th to April 4th). This may help explain the low intake of pine needles.

Ned Westphal, a rancher in the Black Hills of South Dakota, has observed that late-term cows fed alfalfa hay tend to eat more Ponderosa pine needles than cows fed grass hay. He also found that his incidence of abortion decreased dramatically after he began to feed his cows grass hay in the afternoon (instead of the morning) and offered then natural protein/molasses lick tubs that they had access to during the day and night. Presumably, their abortion rate has dropped because his management changes have led to a large decline in pine needle ingestion by his cows. Also, when Westphal offered his cows protein blocks that they consumed quickly, he had an unusually high number of cows abort their calves probably because they ate pine needles after consuming the protein blocks. One plausible explanation for Westphal's experiences and results from several experiments may be related to high protein ingestion, resulting in mild ammonia toxicity and subsequent feeding behavior alteration by cattle to prevent the negative consequences of mild ammonia toxicity.

The protein and other nitrogenous compounds in cattle feed is largely converted to ammonia by microbes in the rumen. Then, ammonia is used by many rumen microbial species as a nitrogen source for their protein synthesis (for maintenance and cell division). Optimal microbial protein yield results from different ruminal ammonia concentrations (e.g., 20 to 235 mg/l of rumen fluid) depending on the type of diet that is fermented (Orskov, 1992). However, Webb et al. (1972) found that cattle typically suffered severe ammonia toxicity when blood ammonia-N concentration exceeded 0.7 to 0.8 mg/100 ml. These concentrations were reached with rumen ammonia-N concentration between 80 to 100 mg/100 ml when ruminal pH was above 7, and between 160 and 277 mg/100 ml when ruminal pH was between 6.5 and 6.7. Lower pH is associated with slower ammonia absorption into the blood because at lower pH more ammonia is ionized to the ammonia ion CNH,) and much less of this is absorbed through the rumen wall than is the non-ionized form (Webb et al., 1972; Owens and Zinn, 1988). Moderate ammonia toxicity can also occur with reduced feed intake and diminished absorption of intermediary metabolites (because of damaged intestinal tissue) attributed to this level of ammonia intoxification (Visek, 1968; Kertz et al., 1980). Ruminal microbes can quickly convert urea to ammonia, and Kertz et al. (1980) observed depressed feed intakes and elevated ruminal ammonia concentration (ca. 26 and 107 mg ammonia/100 ml before and after feeding, respectively) for cows consuming diets containing 1 or 2.5% urea. They described the feeding behavior of a cow that they suspected was suffering from sublethal ammonia toxicity and that appeared to detect when a urea-containing diet was replaced with a diet lacking urea. In the first 20 minutes of the test, her intake of a 2.5% urea containing diet was 5.9 lb (.15 lb of urea). During the next 5 minutes, her intake of this diet was only .4 lb. Then, this diet was quickly replaced with one without urea and her intake for the final 5 minutes of the test increased to 4.3 lb.

We have new evidence that ruminants can learn to prefer foods or fluids that rectify digestive disorders like acidosis (Phy and Provenza, 1995). As stated earlier, Ponderosa pine needles contain high levels of condensed tannins and these tannins bind with plant protein and prevent ruminal microbes from converting it to ammonia. Thus, cattle that have ingested high levels of protein may at times ingest pine needles in order to reduce negative feedback they may receive from mild to moderate ammonia toxicity. We intend to test this hypothesis in the near future.

SUMMARY

Cattle probably consume Ponderosa pine needles for several reasons, and the reason(s) probably differ among ranches. Pine needle ingestion by late-term cows may possibly be reduced by avoiding the feeding of forages or concentrates that contain high levels of crude protein (e.g., good quality alfalfa hay and supplements with considerable amounts of ruminally degradable protein like soybean meal). However, ample availability of dormant pasture vegetation, straw, and grass hay for late-term cows seems desirable and may reduce their motivation to ingest pine needles. Providing cows with alternative sources of nutrients to ingest like the protein/molasses tubs that Westphal uses may help occupy their feeding time and satisfy their desire to consume a variety of nutrients thus reduce the time available and possibly their motivation for eating pine needles. Feeding in the afternoon also may be beneficial for reducing pine needle consumption.

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