Seasonal Changes in Nitrogen and Moisture Content of Cattle Manure in Cool-season Pastures

T.J. LYSYK, E.R. EASTON, AND P.D. EVENSON

Abstract

Fresh cattle manure was collected weekly from 3 cool-season riparian pastures in southeastern South Dakota during the summer of 1981 to determine the relationship of diet of livestock to manure quality. Five manure samples collected from each site were returned to the laboratory, mixed thoroughly, and subsampled to determine the percent moisture and percent total nitrogen of the feces. Moisture content of the manure was highest during the month of June but decreased later in the summer. Nitrogen content was highest in late spring and declined in July with a rise noted again in August. Nitrogen content appeared to follow reported changes in forage quality, particularly in vitro digestibility.

Manure breeding flies are considered major pests of livestock in feedlots and on rangeland in the northern tier states of the USA as well as throughout the southern Provinces of Canada. Throughout these areas the face fly, *Musca autumnalis* DeGeer, is distributed in wooded range and pastureland (Easton 1979) (Depner 1969) while the horn fly, *Haematobia irritans* (L.), is a permanent pest of cattle on both wooded and open areas wherever cattle may graze.

In view of the fact that the face fly carries the bacteria of pinkeye (caused by *Moraxella bovis*) that potentially can blind cattle, and control measures for this fly are currently inadequate, an investigation of the manure (larval food) was considered worthwhile since the quality of the manure may influence the development of the fly and account for why populations of the face fly vary from one region of the country to another or why variation has been noted between one pasture and another within the same geographical area.

Even though cattle manure represents the end product of the cow's digestive process, it contains a number of chemical, microbial, and biotic materials and manure is influenced both by the individual animal and by the nature of the consumed plant material (Treece 1966).

Moisture content of fresh cattle dung generally varies between 80 to 90% by weight (Valiela 1969). There have been few relationships established, however, between the diet of livestock and the moisture content of the manure (Treece 1966, Ruprah and Treece 1968, and Meyer 1978). Ruminants lose a large amount of water through the feces; however the amount lost depends upon the animals' total water intake over a period of time, the amount of dry matter the animal consumes, and the amount of fibrous material present in the forage (Church 1976).

Fecal nitrogen can be in the form of undigested plant material, microbial nitrogen, or combined with other nonprotein nitrogen sources. Moisture and total nitrogen content are parameters that have been examined by investigators that are concerned with these dung breeding flies. Kunz (1980) in experiments with horn flies *(H. irritans)*, and Greenham (1972) working with the bush fly *(M. vetustissima)*, have shown that fecal nitrogen is highest early in the growing season of the pasture, declines throughout the summer, but has an additional peak in activity as the summer progresses. This peak is believed to occur in response to forage growth patterns.

The purpose of this study was to examine the moisture and nitrogen content of freshly dropped cattle feces in several cool-season pastures in eastern South Dakota and to determine how changes in these 2 parameters occur over a season.

Study Sites and Methods

Description of Study Sites

Three pastures were selected for this study bordering the Big Sioux River on the Big Sioux Flood Plain where face fly *(M. autumnalis)* populations are considered the highest in the state (Easton 1985). A deciduous forest, primarily consisting of American elm (*Ulmus americana* L.), green ash (*Fraxinus pennsylvanicas* Marsh), and plains cottonwood (*Populus deltoides* Bartr.) (Choates and Spencer, Jr., 1969), is present along the river.

Ahern's pasture in South Dakota is located in northern Moody County near the Brookings-Moody County line and normally in this region beef cattle in cow-calf operations are maintained near farm buildings from November to May, when they are trucked or moved to summer pasture. Cattle in Ahern's pasture were moved there during the last week of May 1981. Soil types in this pasture were determined through examination of a county soil map (Watkins and Larson 1926) and were identified as Lamoure fine-silty mixed cumulic Haplaquolls and Sioux loam, a sandy skeletal udorthentic haploboroll. The predominate grass species in this pasture were identified as smooth brome (*Bromus inermis* Leyss), Western Wheatgrass (*Agropyron smithii* Rrdb.), Kentucky bluegrass (*Poa pratensis* L.), and Timothy (*Phleum praetense* L.). During the 1981 growing season salt blocks were present, but no other feed additives were added. The sole insecticide in use was 8% fenvalarate, Cyano (3-phenoxyphenyl) methyl 4-chloro-(1-methylethyl) benzeneacetate, pyrethroid insecticide impregnated ear tags that were applied 2/animal. This pasture had been grazed on a continuous basis yearly since at least 1977 (Easton 1979).

Wick's pasture is located in the extreme southern part of Brookings County in South Dakota. The cattle were also placed in this area during the last week of May. Insecticide treatments were not used on these animals at any time during 1981. Soil types were Cumulic and Vertic Haplaquolls, a high clay soil with poor drainage (Westin et al. 1959). The grass species present were similar to those reported above from Ahern's pasture, and grazing had been carried out continually each season since at least 1977. Salt was the only feed supplement provided in 1981, and it had been soaked in fuel oil for its possible larvicidal activity.

Wheeler's pasture is located in northern Moody County of South Dakota and the soil types were Cumulic Haploquolls and Udorthentic Haploborolls. The grass is predominately smooth brome which had not been grazed the year prior to 1981. Beef cattle were placed in this pasture during the first week of June.

Manure Collection

Fresh cow manure (voided within 30 minutes) was collected weekly from Ahern's and Wick's pasture during the period from 2

The authors are graduate assistant and associate professors, respectively, Department of Plant Science, South Dakota State University, Brookings 57007-1096.
This study was funded in part by the USDA Animal Health Special Grant No. 59-2461-0-2-058-0 and constitutes Technical Paper No. 1856 of the South Dakota State Univ. Agr. Exp. Sta.
The authors would like to thank Mary Ann Billet for technical assistance.
Manuscript accepted August 13, 1984.

June to 20 October and from Wheeler's pasture from 9 June to 6 October. Cattle were placed on Wheeler's pasture later in the spring and removed earlier in the fall than at the other sites. Collections were made by placing the fresh manure pats into airtight plastic containers with the aid of 2 plasterer trowels. Five pats were collected from each site through 8 September; from 15 September to the end of the study, 2 groups of 3 pats each were collected from each pasture so that the variation that would occur within a pasture could be statistically tested.

Manure samples were returned to the laboratory, mixed thoroughly and subsampled before determining the percent moisture and percent total nitrogen of the feces. Five samples were taken from each collection through 8 September; from 15 September on, 3 subsamples were taken from each of 2 groups collected within a pasture, giving a total of 6 subsamples for each pasture.

The moisture content of the manure was determined by weighing fresh subsamples and drying them for a 24-hour period in an oven at 60°C. Subsamples were allowed to cool and were then reweighed. The percent moisture was calculated on the wet weight basis.

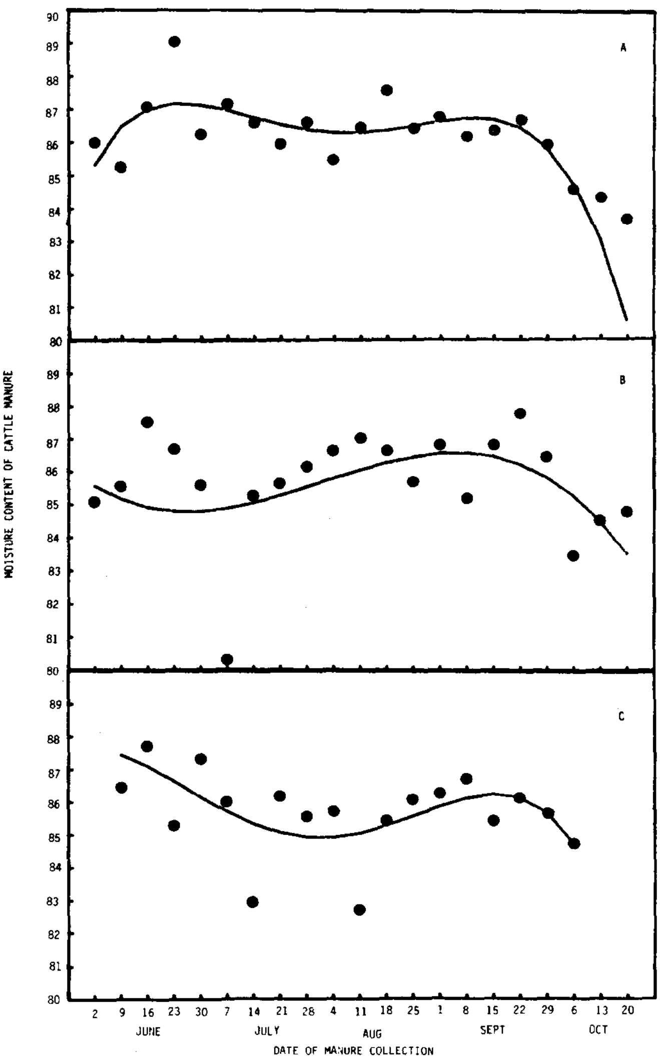

Fig. 1. *Relationship between % moisture content of manure and number of weeks cattle had been on 3 riparian pastures in Southeastern South Dakota before manure collection (D)*

A. *Ahern's pasture*
$Y = 84.68 + 1.2029\,D - 0.23573\,D^2 + .01642\,D^3 - .00038\,D^4,\ r^2 = .594$

B. *Wick's pasture*
$Y = 86.44 - .55824\,D + .07566\,D^2 - .00261\,D^3,\ r^2 = .136$

C. *Wheeler's pasture*
$Y = 86.57 + .47951\,D - .23326\,D^2 + .02427\,D^3 - .00073\,D^4,\ r^2 = .254$

The subsamples were later analyzed for their nitrogen content using a standard macro-Kjeldahl technique for plant tissue (Jackson 1958).

Analysis of variance techniques were conducted separately for the portions of the data that were sampled and subsampled to determine if significant differences in manure moisture and nitrogen exist between pastures and dates. The 2 data sets were then pooled and regression analyses were conducted to determine if temporal patterns in these 2 parameters exist.

Results

Moisture Content of Manure

The average moisture content of the manure from each of the 3 pastures over time was 86.1, 85.6, and 84.8%, respectively, for Ahern's, Wick's, and Wheeler's pastures.

Significant differences in moisture content of the manure exist between pastures and between dates in the analysis of variance of subsampled data. There was also a significant pasture-date interaction, indicating that manure moisture on a given date of collection was strongly influenced by the site it was collected from. No significant differences were found in moisture content between pastures when the replicated data from later in the season were analyzed. There were significant differences between dates and no significant interaction was found. Replications were significant, indicating that there is variation in fecal moisture within a pasture. The coefficient of variation is lower for the sampled portion of the data than for the subsampled data, 0.222% vs. 0.397%.

To get an idea of the trends in moisture content of manure over time, percent moisture of the cattle manure was regressed against the date of manure collection expressed as the time in weeks after the cattle had been placed on the pasture. Since there was a pasture by date interaction, separate regression analyses were conducted for each pasture.

The moisture content of cattle manure collected from Ahern's pasture is plotted in Figure 1A. Percent moisture was highest at the end of June, then declined slightly until 22 September. After this, the decline was greater.

Moisture content of manure collected from Wick's pasture is illustrated in Figure 1B. Moisture content of the feces was highest in early June and midsummer, and lowest in late June-early July. There was also a tendency to decrease in the fall.

The changes in moisture content over the season for Wheeler's pasture is plotted in Figure 1C. The observed values fluctuate more than observed for the former pasture. As with Wick's pasture, moisture content is highest in early June and tended to peak again later in August. The trends also indicate that moisture decreases in July and again in late September and early October.

Nitrogen Content of Manure

Feces collected from each of Ahern's, Wick's, and Wheeler's pastures had average nitrogen values over time of 1.97%, 1.81%, and 1.94%, respectively. As with moisture, significant differences existed between pastures and dates and a significant pasture-date interaction existed in the subsampled portion of the data. Similar results were found when replications were included except that replications were not significant, indicating that the variation in fecal nitrogen within a pasture was not an important source. The coefficient of variation was higher in the subsampled data, 0.984% vs. 1.810% for the sampled data.

Results of the regression analyses of manure nitrogen are presented in Figures 2 A, B, and C. These analyses were performed separately for each pasture due to the significant pasture by date interaction. The seasonal values of manure nitrogen for Ahern's pasture are in Figure 2A. Nitrogen was highest in late spring and declined until 21 July. It rose until 4 August and was of a medium range until the beginning of October and then declined.

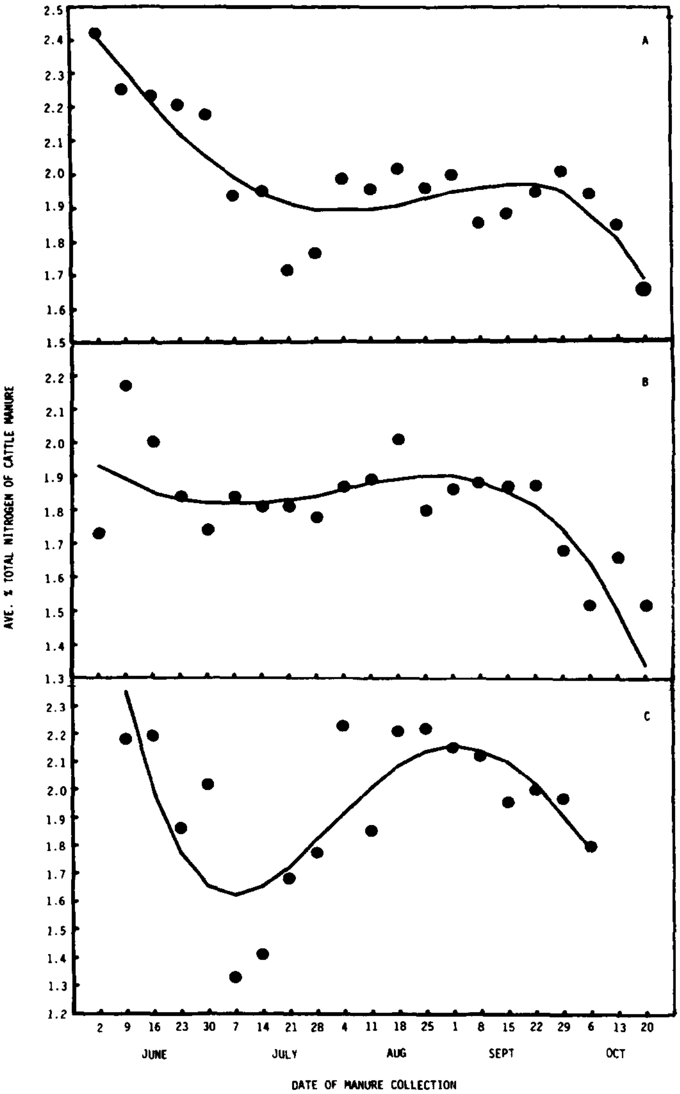

Fig. 2. *Relationship between % total nitrogen content of manure and the number of weeks cattle had been on 3 riparian pastures before manure collection (D).*

A. Ahern's pasture
$Y = 2.54 + .11289\ D - .00067\ D^2 + .00083\ D^3 - .00003\ D^4,\ r^2 = .747$

B. Wick's pasture
$Y = 1.98 - .04018\ D + .00288\ D^2 - .00008\ D^3 - .00001\ D^4,\ r^2 = .487$

C. Wheeler's pasture
$Y = 3.56 + .80298\ D - .11144\ D^2 + .00572\ D^3 - .00010\ D^4,\ r^2 = .545$

The trends in manure nitrogen from Wick's pasture are in Figure 2B. Again, nitrogen was highest in the spring, declined until early July, and somewhat rose through August. After September 22, it declined again.

The changes in manure nitrogen were more pronounced in Wheeler's pasture (Fig. 2C). Again, nitrogen started off at a high level in the late spring, was lowest on 7 July, and again rose until 4 August, but to a higher level than in the other pastures. After 25 August, nitrogen declined slowly.

Discussion

The percent moisture of feces in the 3 South Dakota pastures studied ranged from 80–89%, and was generally higher than the 80% ± 3 reported by Kunz (1980) for the horn fly in Texas, the 85% reported by Greenham (1972) for the bush fly in Australia, or the 75–80% listed in Church (1976).

In general, time of collection can be thought of as a measure of the seasonal age of the pasture. It accounts for more of the variation in nitrogen than in moisture content as evidenced by the higher R-squares associated with nitrogen. Moisture content of cattle feces is largely a function of water intake but can be modified by such things as dry matter intake or environmental temperatures (Church 1976). The dry matter content of forage grasses is high in the fall and this may account for some of the decline in fecal moisture content (Paquay et al. 1970), and thermal stress may be responsible for the small declines seen in mid-summer. It should be noted that there is much unexplained variation in fecal moisture, indicating that factors other than the seasonal age of the pasture affect fecal moisture content. Also, it should be noted that since variability in fecal moisture exists within a pasture, the animals can influence fecal moisture, perhaps more than forage quality.

Nitrogen content of cattle manure from animals maintained on pastures varies considerably over time and differs between pastures. The trends in nitrogen content of manure found here resemble closely those reported in Texas (Kunz 1980) and Australia (Greenham 1972). One major difference is that the early and late summer peaks in nitrogen in South Dakota are not as widely separated in time as they are in the warmer climates. In Texas, Kunz (1980) reported that peaks in manure nitrogen occur in early May and late September; while in Australia (Greenham 1972), the peaks in nitrogen were separated by about 3 months.

Manure nitrogen does correlate well with the seasonal age of the pasture. In ruminant feces, nitrogen can come from undigested portions of the diet such as grass residues, bacteria, cellular debris, and water soluble nitrogen (Mason 1969). Changes in nitrogen content of the feces can be caused by changes in diet or changes in the bacterial forms or a combination of both.

It has been shown that diet can infuence fecal nitrogen in sheep (Orskov et al. 1970). Although it is not entirely clear what exactly influences fecal nitrogen in cattle, reported trends in crude protein and in vitro digestible dry matter of pasture grasses over a growing season resemble the patterns shown here for fecal nitrogen (Campbell and A.D. Dotzenko 1975, Newell and Moline 1978 and Church 1976). It seems reasonable to infer that forage quality may influence manure quality.

We believe that the nitrogen content of manure affects the fecundity of the face fly over a season and constitutes one of the reasons why differences in face fly numbers occur between pastures and why a large body size is probably necessary for this fly to successfully overwinter. It is known that the size of flies has been shown to be correlated with their reproductive potential and various nutrient levels can determine the size of fly larvae which ultimately determines the number of ovarioles in the adult fly. This study indicates that processes that alter the quality of manure could be developed and used as an advantage in the development of a more effective control method for the face fly.

Literature Cited

Campbell, I.S., and A.D. Dotzenko. 1975. Evaluating forage quality of pastures. J. Range Management. 28:149-151.

Choates, G.A., and J.S. Spencer, Jr. 1969. Forests in South Dakota. USDA Forest Serv., Intermountain Forest Exp. Sta. Forest Serv. Resource Bull. Int.-8.

Church, D.C. 1976. Digestive Physiology of Ruminants. 2nd. ed. Oxford Press, Portland Ore. Vol. 1-3.

Depner, K.R. 1969. Distribution of the face fly, *Musca autumnalis* in Western Canada and the relation between its environment and population density. Can. Entomol. 101:97-100.

Easton, E.R. 1979. The value of the pyramid sticky trap for sampling face flies, *Musca autumnalis,* under field conditions in South Dakota. Environ. Entomol. 8:1161-1164.

Easton, E.R. 1985. Progress toward establishing a pest management program for the face fly, *Musca autumnalis* DeGeer, in South Dakota. Tech. Bull. No. 81, South Dakota State Univ. Agr. Exp. Sta.

Greenham, P.M. 1972. The effects of variability of cattle dung in the multiplication of the bush fly *(Musca vetustissima).* J. Anim. Ecol. 41:153-165.

Jackson, M.L. 1958. Soil Chemical Analysis. Prentice-Hall, Inc. Englewood Cliffs, N. J.

Kunz, S.E. 1980. Horn fly production as influenced by seasonal changes in rangeland forage conditions. Southwest. Entomol. 5:80-83.

Mason, V.C. 1969. Some observations on the distribution and origin of nitrogen in sheep feces. J. Agr. Sci. 73:99-111.

Meyer, J.A., C.M. Christensen, and F.W. Knapp. 1978. The influence of various levels of ground ear corn and alfalfa hay in the bovine diet on the development of the face fly. Environ. Entomol. 7:829-830.

Newell, L.C., and W.J. Moline. 1978. Forage quality evaluations of twelve grasses in relation to season for grazing. Univ. Nebraska-Lincoln, Inst. of Agr. and Natur. Resources. Res. Bull. 283.

Orskov, E.C., C. Fraser, V.C. Mason, and S.O. Mann. 1970. Influence of starch digestion of sheep on caecal fermentation, caecal microflora and nitrogen excretion. British J. Nutr. 24:671-682.

Paquay, R., R. de Baere, and A. Lousse. 1970. Statistical research on the fate of water in the adult cow. J. Agr. Sci. 74:423-432.

Ruprah, N.S., and R.E. Treece. 1968. Further studies on the effect of bovine diet on face fly development. J. Econ. Entomol. 61:1147-1150.

Sands, P., and R.D. Hughes. 1976. A simulation model of changes in the value of cattle dung as a food resource for an insect. Agr. Meteor. 17:161-183.

Treece, R.E. 1966. Effect of bovine diet on face fly development: A preliminary report. J. Econ. Entomol. 59:153-156.

Valiela, I. 1969. An experimental study of the mortality factors of larval *Musca autumnalis* De Geer. Ecol. Monogr. 39:199-225.

Watkins, W.E., and G.A. Larson. 1926. Soil survey of Moody County South Dakota. USDA Bureau of Chemistry and Soil. Pub. No. 2.

Westin, F.C., G.T. Buntley, F.E. Shubeck, L.F. Ruch, and N.E. Burstresser. 1959. Soil Survey Brookings Co., S.D. USDA Soil Conserv. Serv. Publ. Ser. 1955 No. 3.