## Nitrogen and P Excretion in Feedlot Cattle and its Fate

### How much is excreted?

The design of manure management systems often uses standardized values to estimate the amount of N and P that will be excreted during the course of a feeding period, often considered one year. The USDA Natural Resource Conservation Service has tabulated these values (Table 31-7, Lesson 31, Manure Utilization Plans), and estimates the amount of N and P excretion for a 1,000-pound steer. However, these values do not consider the large variation among feedlot cattle in level of feed intake, diets fed, feeding management programs, performance, and consequently, actual levels of N and P excretion.

Research conducted at the University of Nebraska (Bierman et al. 1999, Erickson et al. 2000, Erickson and Klopfenstein 2001a) studied the impact of dietary N and P concentrations on waste management in feedlot cattle. This research demonstrates the magnitude that diet formulation can have on N and P excretion in feedlot cattle. Tables 13-1 and -2 summarize the impact of total N and P intake on the excretion of these nutrients. Clearly, the amount of N and P excretion is highly correlated to the amount of N and P intake during the feeding period. For instance, increasing the amount of crude protein from approximately 12% to 13.5% increased the amount of N (crude protein) excretion by 13.5 pounds per steer in yearling steers and by 9 pounds per steer in calf-fed steers fed approximately 150 or 200 days, respectively (Table 13-3). Many feedlot producers and nutritionists formulate for excess crude protein (CP) to ensure that feedlot performance is not limited, providing an example of one formulation practice that deserves greater attention from an environmental standpoint. However, diet formulation strategies are not as simple as just removing protein from the diet. Protein requirements must be met for optimal performance. These requirements and new methods for determining requirements will be discussed further in subsequent sections.

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The total N and P intake and animal production dictate the amount of N and P that feedlot cattle excrete. Each individual feeding operation needs to calculate the total N and P fed and the total production (pounds of beef gain) to evaluate the status of N and P excretion. With the previously discussed variation that exists across the feeding industry, book values simply are insufficient. One tool that is available for estimating the N and P output of feedlots on an individual basis is a worksheet developed at the University of Nebraska (Koelsch 1999); it is available at the following website: <http://www.ianr.unl.edu/manure/Koelsch.html>. The worksheet allows users to input the number of animals, daily feed intake, dietary CP (N) and P concentrations, and animal performance. The spreadsheet also allows users to estimate the land requirements for manure application, and more importantly, evaluate the influence of a ration change on the amount of land required for manure application.

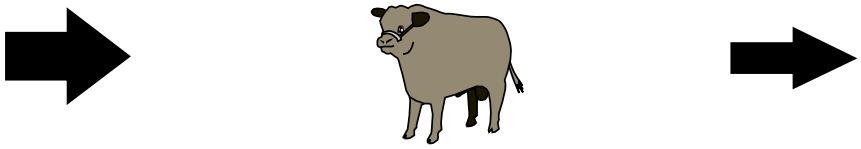
Table 13-2 provides a more simplistic approach for users to estimate the amount of N and P excretion based on feed intake, daily gain, and ration nutrient composition.

**Table 13-1. Effect of dietary P level on excretion.**

| | High P[a] | | Low P[a] | | Low P/All Con[a] | |
|---|---|---|---|---|---|---|
| Phosphorus[b] | Lbs[c] | %[d] | Lbs | % | Lbs | % |
| Input | 8.1 | 100 | 5.4 | 100 | 5.2 | 100 |
| Retention | 0.98 | 12.0 | 1.0 | 18.5 | 0.94 | 18.0 |
| Excreted | 7.1 | | 4.4 | | 4.2 | |

[a] High P = high P diet, 0.45% of diet dry matter; Low P = low P diet, 0.35% of diet dry matter; Low P/All Con = Low P diet (0.35%) all concentrate diet.
[b] Retention by the animal based on NRC equations.
[c] Pounds of P per head over the feeding period (87 days).
[d] Retention values expressed as percentage of N and P intake; the remaining values expressed as percentage of excreted N and P.
Source: Bierman et al. 1996.

**Table 13-2. Total manure nutrients excreted by a livestock operation based on feed rations.**



**Feed Nutrient Intake** — **Nutrients Retained by Animals or Animal Products Excretion** = **Nutrient**

**Feed Nutrient Intake**

| Animal Group | A. Daily Feed Intake (lbs) | B. Feed Nutrient Concentration | | | C. Total Nutrient in Feed (lbs) = A x B | |
|---|---|---|---|---|---|---|
| | | Protein | N[a] | P | N | P |
| *Example: 1,000 feedlot cattle* | *22,00 lbs DM/day (22 lbs/hd/d)* | *0.135* | *0.135 ÷ 6.25 = 0.0216* | *0.0035* | *22,000 x 0.0216 = 475 lbs/day* | *22,000 x 0.0035= 77 lbs/day* |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**Nutrients Retained by Beef Feeder**

| Animal Group | D. Number of Animals (maximum one-time capacity) | E. Average Daily Gain | F. Live Weight Nutrient Concentration | | G. Nutrients Retained by Animal (lbs) = D x E x F | |
|---|---|---|---|---|---|---|
| | | | N | P | N | P |
| *Example: Beef* | *1.000* | *(1,249-652)/147 d = 4.06 lbs/d* | *0.016* | *0.0070* | *1,000 x 4.06 x 0.016 = 65.0 lbs/d* | *1,000 x 4.06 0.0070 = 28.4 lbs/d* |
| | | | *0.016* | *0.0070* | | |
| | | | *0.016* | *0.0070* | | |
| | | | *0.016* | *0.0070* | | |

**Nutrients Excretion by Livestock**

| | | Annual Nutrient Excretion in Elemental Form = H x (C - G) or = H x (C-J) | | |
|---|---|---|---|---|
| Animal Group | H. Days Fed per Year | N | P | $P_2O_5$[b] |
| *Example: Beef finisher* | *350 days* | *350 x (475 - 65) = 143,5000 lbs/350 days* | *350 x (77 - 28.4)= 17,010 lbs/350 days* | *17,010 x 2.27 = 38,613 lbs $P_2O_5$/350 days* |
| | | | | |
| | | | | |
| | | | | |

[a] N in feed = Protein ÷ 6.25
[b] lbs $P_2O_5$ = lbs P × 2.29

## The fate of N and P following excretion

It is important to understand the fate of N and P that is excreted onto the pen surface. The data presented in Table 13-3 (Erickson and Klopfenstein 2001a) suggest that a large fraction of the N that is excreted onto the pen surface is lost during the course of the feeding period. This estimate of N loss was determined by measuring the amount of N in runoff manure that remained in the pen's soil surface after cleaning and by using estimates of the animal's N retention based on daily gain. The yearling steers were fed during the summer months, while the calf-fed steers were finished during the winter. These data suggest that up to 70% of the N excreted may be lost to volatilization, especially in cattle fed on open dirt lots during summer months. Microbial activity on the pen surface would be greater during summer compared with winter feeding conditions. The data in Table 13-3 also suggest that only small amounts of N exit the pen in runoff water. Properly designed pens and settling systems filter most of the N and P from the runoff water before it enters the holding pond. It appears that most of the excreted P remains in the manure (Erickson et al. 2000). Only small amounts of either N or P, less than 5%, have been measured in runoff from the pen surface (Bierman et al. 1999, Erickson et al. 2000, Erickson and Klopfenstein 2001a).

Because N volatilizes off the pen while P remains in manure, the nitrogen-to-phosphorus (N:P) ratio of manure can lead to challenges when utilizing manure for crops. This creates a unique problem with regard to the N:P ratio of most feedlot manure. Typical feedlot manure contains between 2 and 3 parts N to one part P at the time of removal. At the time of excretion, the N:P ratio of excrement (feces and urine) is approximately 6:1. Corn, for example, requires a N:P ratio of approximately 5 parts N to one part P. Thus, if the N:P ratio of manure could be improved, the need for supplemental N could be reduced when manure is applied on the basis of agronomic P needs, adding value to manure as a fertilizer source. If manure is applied according

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**Table 13-3. Performance and N balance of yearling and calf-fed steers fed a typical feedlot finishing diet (control) or a finishing diet adjusted to match the animal's protein requirement with time on feed (phase).**

| | Yearlings | | Calves | |
|---|---|---|---|---|
| **Feedlot Performance** | **Control** | **Experimental** | **Control** | **Experimental** |
| Daily gain, lbs | 3.98 | 4.07 | 3.45 | 3.40 |
| Feed efficiency | 6.33 | 6.02 | 5.88 | 6.10 |
| Nitrogen | | | | |
| Intake, lbs | 72.82 | 59.39 | 81.40 | 72.23 |
| Retention[a], lbs | 7.90 | 7.92 | 10.14 | 10.04 |
| Excretion[b], lbs | 64.92 | 51.47 | 71.26 | 62.18 |
| Manure, lbs | 12.91 | 19.61 | 43.51 | 41.53 |
| Soil[c], lbs | 3.85 | -0.89 | -3.66 | -6.46 |
| Runoff, lbs | 2.12 | 1.51 | 2.10 | 2.21 |
| Volatilized[d], lbs | 46.04 | 31.25 | 29.31 | 24.91 |
| % Volatilized | 70.9 | 60.7 | 41.1 | 40.10 |

[a] N retention based on daily gain, NRC (1996) equation for retained energy and retained protein.
[b] N excretion calculated as intake minus retention.
[c] Soil is core balance on pen surface before and after trial; negative values suggest removal of nutrient present before trial.
[d] Volatilized calculated as excretion minus manure soil minus runoff. Source: Erickson et al. 1999.

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to the N needs of crops, less P would be supplied, resulting in lower risk manure management strategies for feedlots. Certain options may increase the N:P ratio of manure to more closely meet the needs of row crops. Nutritionists would need to either increase N in manure or decrease P to produce manure with more environmentally favorable N:P ratios. Increasing the amount of organic matter on the pen surface through diet manipulation appears to trap more N in manure (Erickson and Klopfenstein 2001b). Other research projects suggest that lowering dietary P will also improve the N:P ratio by lowering the amount of P without influencing N content (Erickson et al. 2000; Bierman, unpublished data). Other management techniques, such as frequency of cleaning, deserve attention and are currently being explored.