

Grassland acreage: a key factor for estimating dairy cattle's N-excretion

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Abstract

Animal nutrient excretion is a key factor in manure legislation and environmental monitoring. Because it can not be measured directly, total emissions are usually estimated using flat-rate coefficients. This is also the case for dairy cows, whose productivity has constantly increased over the past decade. It thus seems odd to use constant, flat-rate coefficients for estimating their N-excretion, as e.g. Flemish manure legislation has been doing (97 kg N/(cow x year)). N-excretion/cow is proportional to milk production/cow. For environmental monitoring, however, it is not easy to get milk production data at farm level. As milk production in turn is closely correlated to feed uptake, estimating nutrient excretion indirectly, by means of fodder acreage available, was explored. A significant relation was found between N-excretion per cow and the grassland and maize acreages per cow, in which the effect of grassland acreage is over 2,5 times larger than that of maize. Although average N-excretion has increased to 118 kg N/(cow x year) on specialised dairy farms, at the regional level, the cows' increasing productivity predominates, resulting in an increased eco-efficiency.

Keywords: N-excretion coefficients, dairy cattle, fodder acreage

Background and objectives

Social concerns about negative externalities from agricultural production exist for decades and become ever more important. Especially in regions with intensive animal husbandry, nitrates in surface and groundwater are a major element of concern. The European Nitrate Directive and local manure legislation in regions such as Flanders, the Netherlands or Brittany, that is becoming stricter with each consecutive version, both illustrate and respond to these concerns. Nutrient balances on farm or regional level have thus become important environmental monitoring and even policy instruments. A key factor in drawing up nutrient balances is animal nutrient excretion. This, however, can not be measured directly, so emissions are usually estimated through flat-rate coefficients per animal.

This is also the case for dairy cattle. However, over the past decade, dairy cattle's productivity has constantly increased. It thus seems odd to use constant, flat-rate coefficients, both over farms and over time, for estimating their N-excretion, as e.g. Flemish manure legislation has been doing over the past decade (97 kg N/(cow x year)).

From zootechnical trials it is known that there is a close relation between milk production and N-excretion. For drawing up farm gate N-balances, dairy cow's N-excretion can thus be linked to their productivity, as for instance the new Flemish Manure Decree is doing (Decree of 22/12/2006). When scaling up the individual farm level data to a regional level though, e.g. in environmental monitoring, the problem arises that it is not obvious to get sufficient data on milk production, especially when monitoring starts from Farm Structure Survey (FSS) data. Therefore an indicator for variable N-excretion was sought within the FSS-data.

Materials and methods

For the calculation of N-excretion data were used on highly specialised dairy farms from the Flemish Farm Accountancy Data Network (FADN). Farms with suckler or fattening activities, farms that imported other animals' manure and some other outliers were eliminated. This resulted in a sample of 135 dairy farms.

For these farms the "cattle N-balance" was calculated. This differs from the farm gate balance in so far that only animal husbandry is considered - separately from crop production- and the mineral flow from the farm's own fodder production is taken into account in the same way as purchased feeds (by estimating their production and N-content).

Excretion per livestock unit was thus calculated as

$$N_{excretion} = \frac{(\sum N_{inputs} - N_{milk} - N_{animals} - metabolism)}{LU}$$

In which the N-inputs into the dairy production system are purchased milk products; purchased animals; concentrates; purchased or farm grown roughage (maize silage, fodder beets, sugar beet pulp, beer draff), grass (grazed or mowed) and straw.

N-excretion estimations were made using the environmental module of the SEPALE-model (http://www.ilvo.vlaanderen.be/Social_sciences/Sepale_sector_model.htm), which allowed to include farmers' preferences. The model optimises at farm level, with opportunities to simulate exchange of intermediates, production factors and production rights.

Estimation of farm-specific excretion coefficients

Starting point is the relation between N-excretion and productivity. N-excretion by dairy cows could be estimated through the equation:

$$N_{excretion} = 60 + 0,008 (milk\ production) \quad [equation\ 1]$$

In which both the dependent and the explanatory variable are expressed in kg N / (LU*year) (figure 1). However, milk production is not available in the FSS data.

Therefore, for extrapolation and regional monitoring purposes, variables were sought that are available both in the FADN and in the FSS data, as explanatory variables for N-excretion. Keeping the close correlation between milk production and feed uptake in mind, the dependence was explored of N-excretion from grassland, maize, total fodder acreage (each expressed per livestock unit) and agricultural area (linked to soil type).

In a stepwise regression analysis the grass acreage available per livestock unit was found to be the key determining factor: 71 % of the variation in N-excretion/LU between the farms in the sample could be explained by grassland/LU. This relation can easily be explained: space-intensive dairy farms tend to keep their cows indoors for longer periods, which means that they have better control over the cows' daily ration and they probably manage their feeding better, by which they can limit manure excretion.

A similar positive, but less strong relationship was found with maize acreage/LU. Total fodder acreage and agricultural area were no significant explanatory variables. Thus N-excretion per livestock unit could be estimated by following equation:

$$N_{excretion} = 38,23 + 265,45(grass) + 101,19(maize) \quad [equation\ 2]$$

In which

N-excretion	=	kg N /LU
grass	=	ha grassland /LU
maize	=	ha silage maize /LU

Over the period 1995-2003 N-excretions per cow estimated from this equation were similar to N-excretions calculated from milk production according to the equation 1 (figure 1) and

average N-excretion was found to have increased to 118 kg N/(cow x year) on specialised dairy farms by 2001-2003.

Figure 1 also shows that in spite of the non-decreasing excretion coefficients calculated by either equation, the farm gate N-balance clearly decreases over time.

Sensitivity of excretion to grassland productivity

An important factor in estimating the “cattle N-balance” and the N-excretion from the fodder acreages is the productivity of the fodder crops. Silage maize productivities can be taken from the FADN data, for grassland productivity needs to be estimated, as part of it is grazed. The importance of a correct estimation can be seen from figure 1.

The evolution of 6,2 till 7 ton DM /ha, calculated by the Belgian FPS Economy’s Directorate-general Statistics (<http://statbel.fgov.be>), clearly underestimates Flemish grassland productivity, which results in N-excretions per livestock unit that are clearly not up to date.

For estimating equation 2 an average constant productivity of 11 ton DM /ha was assumed over the 1995-2003 period, according to Coomans *et al.* (2000). It was argued that a more judicious fertilisation countered the effect of stricter manuring regulations and decreasing fertilizer use. Currently though, as the vulnerable zones water, in which manuring is limited to 170 kg N/ha, are expanded and the acreage of grassland under management agreement is increasing an average productivity of 10,5 ton DM /ha seems more realistic. When estimating N-excretion through fodder acreage (equation 2) this would entail a decrease of about 4 kg per cow and per year.

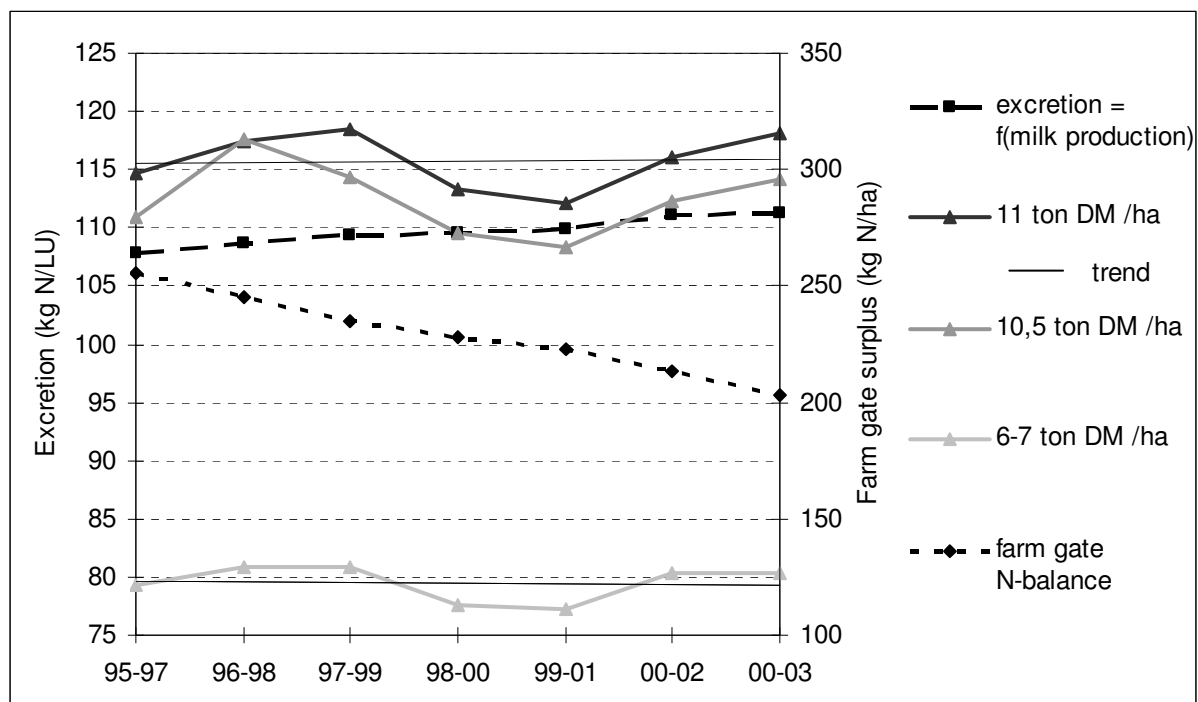


Figure 1: Farm gate N-balance on the sample farms (1996-2002) and evolution of N-excretion per livestock unit calculated from milk production or from fodder acreage, with different assumptions for grassland production (ton DM/ha).

Farm gate balance is exclusive NH₃-emission.

Implementation of variable N-excretion factors for dairy cattle

When extrapolating this relation to the entire population and over the past decade, it becomes clear that N-excretion/cow in Flanders has increased by almost 8 % between 1995 and 2004 (figure 2). However, at the regional level this increasing trend is shown to be less important than the cows' increasing productivity: over the same period milk production/cow increased by 21 %. Thus, an almost constant level of milk production was achieved with 31 % less cows, which adds up to a total N-excretion by dairy husbandry that is down by 11,4 %. This means that on the regional level there has been a decoupling between the 'driving factor', milk production, and the environmental 'pressure', N-excretion, and that eco-efficiency of dairy husbandry has clearly increased.

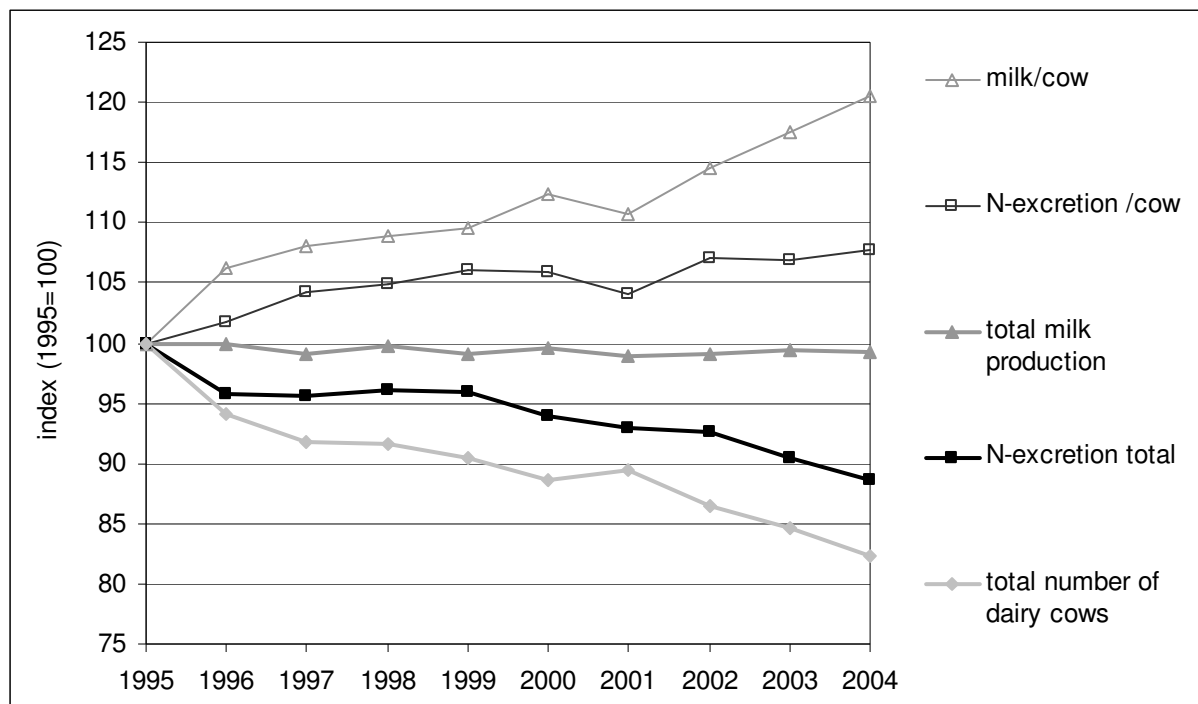


Figure 2: Eco-efficiency of milk production (Flanders, 1995-2004)

Milk production was calculated as deliveries to milk factories, which cover about 99 % of total production.

Conclusions

It was shown that variable N-excretion coefficients for dairy cattle that are consistent with the cows' productivity can also be estimated through fodder acreages. Both at farm and at regional level grassland acreage is the key factor in this estimation.

At the regional level, the cows' increasing productivity predominates their increasing N-excretion, resulting in an increased eco-efficiency of the sector.

References

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