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# KETOSIS IN NORWEGIAN DAIRY HERDS — SOME EPIDEMIOLOGICAL ASSOCIATIONS*

By

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RIEMANN, H. P., R. BJERKE LARSSEN and E. SIMENSEN: *Ketosis in Norwegian dairy herds — some epidemiological associations.* Acta vet. scand. 1985, *26*, 482—492. — Ketosis data from the Health Card System, and interview data regarding feeding, housing, management and care were the basis for an epidemiological study in 306 Norwegian dairy herds.

Management and care were studied by means of an overall care index. The index was based on 20 questions which provided information about the general standard of management and care. Care was the factor having the most pronounced effect on the treatment rate of ketosis. Highest rates were seen in herds with a high standard of management and care, and lowest rates were seen in herds with a low standard.

Most ketosis was found in the mountain valley districts Nord-Østerdal/Gudbrandsdal and Valdres, and least in the lowland coastal district Rogaland. The treatment rate decreased with increasing herd size, and with increasing number of different feedstuffs used. Extra provision of feed concentrates between the morning and evening chores was associated with a lower treatment rate. Also associated with a lower treatment rate was the participation by the farmer's wife in the daily chores.

disease recording; feeding; management and care; dairy cattle.

Ketosis is one of the most prevailing diseases in Norwegian dairy production. According to data from the Health Card System for 1983 (*Anon.* 1984), 15 % of the cows were treated for ketosis, and 27 % of all veterinary treatments were concerned with ketosis. Differences between counties were seen.

Disease recording is an integrated part of the Norwegian Dairy Recording, which comprises 78 % of the Norwegian dairy

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cow population (1983). The Health Card System is based on the individual cow health cards which reside on the farms. On these cards disease treatments are recorded by the veterinarian. The data are reported to the central data base by the Dairy Recording personnel. The system has been in operation for the whole country since 1975 (*Solbu* 1983). At the present the health cards are considered to represent the best data base available for epidemiological studies of diseases in dairy cows in Norway. It is, however, not without errors. Among these are (*i*) incomplete recording and reporting because of negligence from the farmer, veterinarian or Dairy Recording personnel, (*ii*) differences in how severe the signs of disease are before the veterinarian is called on, and (*iii*) differences in diagnostic criteria. Also, reported cases contain an unknown number of "false" cases of ketosis (*Halse* 1984).

The purpose of the present paper was (*i*) to study associations between ketosis and factors related to feeding, housing and management by using available data from 306 Norwegian dairy herds, and (*ii*) to evaluate the fitness of the Health Card System for epidemiological studies of ketosis.

## MATERIALS AND METHODS

A survey of environment and management with reference to udder diseases was carried out in 320 Norwegian dairy herds in five districts of Norway (*Bakken* 1981). The herds were in principle selected by systematic random sampling from the list of herds attending the Dairy Recording. This was done by selecting every tenth name on the list. However, some deviations from this principle had to be made. If the local veterinarian or the Dairy Recording personnel assumed that the selected farmer was not willing to cooperate and keep som extra records, the name was omitted. Very few of the farmers who were asked refused to cooperate. The sample can be considered as representative for farms with intensive Norwegian dairy production.

Data from the same herds were used as basis for the present study, but because of incomplete data sets the number of herds was reduced to 306. Information about environmental conditions, including housing, feeding, management and care was obtained from a detailed questionnaire comprising a total of 218 questions. Two trained technical assistants collected the questionnaire data.

During the projetc period they several times worked together to ensure consistency and uniformity in data collection. Data regarding ketosis was obtained from the Health Card System for the years 1978, 1979 and 1980. As a measure of the occurrence of ketosis, the herd treatment rate, i.e. the 3-year average of the annual number of treatments per 100 cows per herd was used. In order to obtain a better fit to the normal distribution, $\log_{10}$ transformation of the herd treatment rate was used, and was called LOG KETOSIS.

Factors affecting the treatment rate were evaluated by means of a least squares technique (SAS program GLM procedure) (*Barr et al.* 1979). Factors included in the analysis are defined in Table 1. Information concerning milk yield, herd size and age

Table 1. Definition and coding of factors used in the analysis of covariance of factors affecting the treatment rate of ketosis in 306 Norwegian dairy herds.

| Definition/codes/comment | Variable |
|---|---|
| a = DISTRICT | Geographical district where the herd was located: 1 = Østlandet, 2 = Nord-Østerdal/Gudbrandsdal, 3 = Valdres, 4 = Rogaland, 5 = Nord-Trøndelag. |
| b = HERD SIZE | No. of cows in the herd (continuous variable). |
| c = MILK YIELD | 3-year-herd-average milk yield per cow in kg (continuous variable). |
| d = AGE | Herd average age of cows (lactation number · 10) (continuous variable). |
| f = SEASON | Season of year when the majority of the calvings took place: 1 = fall/winter, 2 = spring/summer, 3 = throughout the whole year, 4 = others. |
| g = CARE | Level of management and care as defined in Table 2 (continuous variable). |
| h =FEEDINGS | Extra feeding (concentrates) between morning and evening chores: 0 = no, 1 = yes. |
| i = FEEDSTUFFS | No. of different feedstuffs used during the indoor feeding period (continuous variable). |
| j = STALL | Stall type: 1 = long stall with stanchion gate (the cows had no access to the feeding table after the morning and evening chores), 2 = long stall without stanchion gate, or short stall (the cows had access to the feeding table all 24 hours of the day). |
| k = WIFE | Participation by farmer's wife in the daily chores: 0 = no, 1 = yes. |

Table 2. Definition and coding of 20 factors related to management and care which were used to define the variable CARE[1]) in 306 Norwegian dairy herds.

1. *Washing routines regarding calf boxes/pens/stalls:* 1 = before it is used by a new calf, 2 = several times per year, 3 = once per year, 4 = never.
2. *Dung removal from calf boxes/pens/stalls:* 1 = daily, 2 = when needed, 3 = before it is used by a new calf, 4 = seldom, 5 = never.
3. *Rinsing of feeding pails for calves:* 1 = after each feeding, 2 = once per day, 3 = one or several times per week, 4 = seldom or never.
4. *Washing of feeding pails for calves:* 1= after each feeding, 2 = once per day, 3 = once or several times per week, 4 = seldom or never.
5. *General washing of the cowbarn:* 1 = every year, 2 = not every year.
6. *Cleanliness of cowbarn (general standard, subjective evaluation):* 1 = very clean, 2 = clean, 3 = somewhat dirty, 4 = very dirty.
7. *Cleanliness of calf boxes/pens/stalls (subjective evaluation):* 1 = very clean, 2 = clean, 3 = somewhat dirtly, 4 = very dirty.
8. *Cleanliness of sucking calves (subjective evaluation):* 1 = very clean, 2 = clean, 3 = somewhat dirty, 4 = very dirty.
9. *Cleanliness of older calves (subjective evaluation):* 1 = very clean, 2 = clean, 3 = somewhat dirty, 4 = very dirty.
10. *Cleanliness of young stock (subjective evaluation):* 1 = very clean, 2 = clean, 3 = somewhat dirty, 4 = very dirty.
11. *Cleanliness of cows (subjective evaluation):* 1 very clean, 2 = clean, 3 = somewhat dirty, 4 = very dirty.
12. *Adjustment of the cow trainer (subjective evaluation):* 1 = satisfactory, 2 = not satisfactory.
13. *Thermometer in the cowbarn:* 1 = yes, 2 = no.
14. *Extra feeding between morning and evening chores:* 1 = yes, 2 = no.
15. *Over-night housing of the dairy cows during the summer season:* 1 = yes, 2 = no.
16. *Attendance at calving:* 1 = always present, 2 = present in most cases, 3 = present when time allows, 4 = not present at night.
17. *Brushing of cows:* 1 = daily, 2 = several times per week, 3 = once per week, 4 = now and then, 5 = seldom, 6 = never.
18. *Hair shearing of cows:* 1 = yes, 2 = no.
19. *Use of bedding in cow stalls:* —4 = yes, 0 = no.
20. *Manure removal from the cellar underneath while the cows are kept indoors:* —4 = no, 0 = yes.

[1]) CARE = 100 minus the sum of the factors 1—20.

of cows was obtained from the Dairy Recording. Information regarding the other factors were obtained from the questionnaire.

In an attempt to evaluate the human factor, i.e. management and care in relation to ketosis the variable CARE was defined according to Table 2 and included in the analysis. The factor was based on 20 questions which provided information about the general level of management and care in the herd. For each of the 20 questions the codes were ranged from what was considered to be "good" (low values) to "less good" (high values). CARE was defined as 100 minus the sum of the variables 1—20. Thus high values were supposed to represent a generally high standard of management and care and low values a low standard. Theoretically the value of CARE could vary from 37 to 90.

The data were analysed using the herd rather than the individual cow as the unit of concern and the following statistical model was used (see Table 1 for definition and coding of the various factors):

$$y = \mu + a + b + c + d + f + g + h + i + j + k + e$$

where

y = LOG KETOSIS
$\mu$ = least squares mean
a = effect of DISTRICT
b = effect of HERD SIZE
c = effect of MILK YIELD
d = effect of AGE
f = effect of SEASON
g = effect of CARE
h = effect of FEEDINGS
i = effect of FEEDSTUFFS
j = effect of STALL
k = effect of WIFE
e = error

All factors except e were considered fixed. Factors with no effect were successively removed from the model until the final model as shown in Table 3 only contained factors with significant effects. The reduction in $R^2$ was followed during this stepwise procedure.

Table 3. Analysis of covariance of factors affecting the treatment rate of ketosis ($log_{10}$ transformation) in 306 Norwegian dairy herds.

| Factor | Df | Mean squares |
|---|---|---|
| District | 4 | 0.86*** |
| Care | 1 | 3.33*** |
| Herd size | 1 | 1.22** |
| Feedings | 1 | 0.92* |
| Feedstuffs | 1 | 0.99* |
| Wife | 1 | 0.85* |
| Error | 296 | 0.16 |
| $R^2$, full model, % | | 30.2 |
| $R^2$, reduced model, % | | 27.7 |

## RESULTS

Table 3 shows the results from the analysis of factors affecting LOG KETOSIS. The following associations were found:

DISTRICT: Ketosis occurred most frequently in Nord/Østerdal/Gudbrandsdal and Valdres (mountain valley areas), and least frequently in Rogaland (lowland coastal area) (Fig. 1).

CARE: The treatment rate of ketosis was highest in herds with the highest standard of management and care, and lowest in herds with the lowest standard (Fig. 2 a and b). This relationship was most evident when corrections for significant effects of other factors according to Table 3 had been made (Fig. 2 b). Based on the uncorrected data, the value of CARE varied from 48 to 88 (mean 66.7, S.D. 6.6).

HERD SIZE: The treatment rate of ketosis decreased with increasing herd size.

FEEDING: Herds where extra feed concentrates were provided between the morning and evening chores had the lowest treatment rate (Fig. 1). However, reservations should be made regarding this effect, as only 22 herds practiced this way of feeding.

FEEDSTUFFS: A decreased treatment rate was seen with increasing number of different feedstuffs used.

WIFE: Less ketosis was seen in herds where the farmer's wife participated in the daily chores compared to herds where only the farmer cared for the cows (Fig. 1).

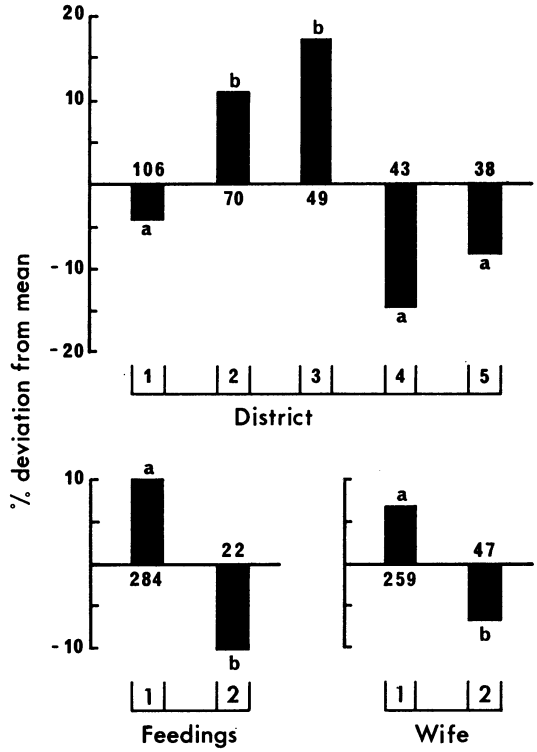


Figure 1. Effect of DISTRICT, FEEDINGS and WIFE on the treatment rate of ketosis ($\log_{10}$ transformation) in 306 Norwegian dairy herds. The DISTRICT codes are: 1 = Østlandet, 2 = Nord-Østerdal/Gudbrandsdal, 3 = Valdres, 4 = Rogaland and 5 = Nord-Trøndelag. The FEEDINGS (extra feeding with concentrates between the morning and evening chores) codes are: 1 = no, 2 = yes. The WIFE (participation by the farmer's wife in the daily chores) codes are: 1 = no, 2 = yes. The numbers at the base of the bars specify the number of herds in the corresponding groups. Means with different letters above/below bars are significantly different ($P < 0.05$).

The following factors showed on significant association with LOG KETOSIS: MILK YIELD, AGE, SEASON and STALL.

The factors included in the model explained about 30 % of the variation in the treatment rate of ketosis (28 % in the final model).

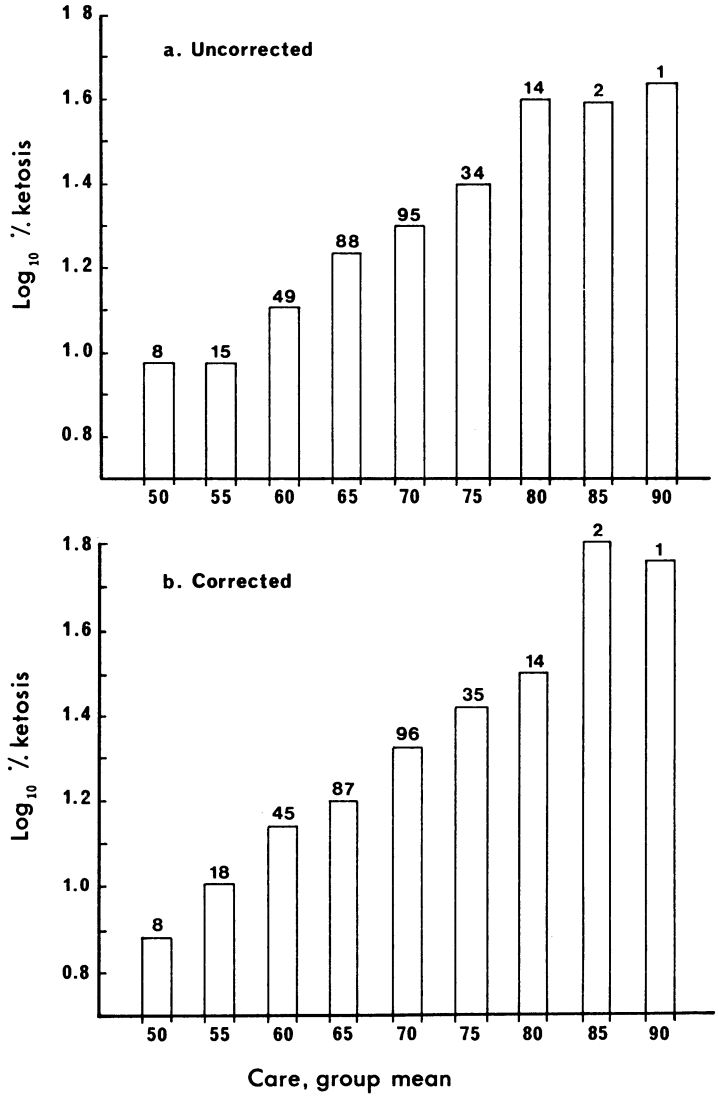


Figure 2. The relationship between CARE and the treatment rate of ketosis ($\log_{10}$ transformation) in 306 Norwegian dairy herds. a. Uncorrected value of CARE. b. The value of CARE is corrected for significant effect of factors as shown in Table 3. The variable CARE is defined in Table 2. Low values indicate a low standard of management and care, and high values indicate a high standard. The range of the groups are 47.5—52.5 (mean 50) etc. The numbers above the bars specify the number of herds in the corresponding groups.

## DISCUSSION

It was unexpected that most ketosis was seen in the herds with the highest standard of management and care. A possible explanation may be that the farmers in such herds are more skilled and aware of the health status of the animals and therefore more often call the veterinarian for treatment. They may also pay more attention to having the health cards filled in.

These results indicate that the method employed is a valid measurement of management and care. Conceptually improved management and care will have two opposite effects on number of recorded diseases. On one hand increased level of management and care will reduce risk for disease, on the other hand it will result in more efficient recognition of disease. In this study the latter clearly outweighs the former. The results demonstrate a need for taking into account management and care in epidemiological studies of factors affecting the risk of ketosis and presumably other diseases.

In addition to CARE, the effect of WIFE is also related to management and care. The same is probably also true for HERD SIZE, i.e. farmers in the larger herds are probobly more skilled and better able to provide an adequate feeding. However, more ketosis in the smaller herds may also be related to a better observation of individual cows. The recorded effect of herd size is in agreement with other data from the Health Card System (*Anon.* 1984).

DISTRICT had a highly significant effect on the treatment rate, but it is difficult to evaluate whether this effect is real or related to confounding factors such as differences in diagnosing and recording of the disease etc. However, the districts differ considerably with respect to climatic conditions, basis for fodder production etc. Nord-Østerdal/Gudbrandsdal and Valdres, with the highest treatment rates, are mountain valley districts with a long indoor feeding period, with grass silage and hay as the only components in the roughage diet, and with a calving season concentrated to the fall. Rogaland, with the lowets treatment rate, is a lowland coastal area in south-east Norway with a long grazing period and main calving season in the spring. The risk of ketosis in this season is less than in late fall and winter (*Øverby et al.* 1974).

The positive effect of FEEDING (i.e. feeding concentrates between the morning and evening chores) may be an indication

of more general use of concentrates and thereby larger energy intake in herds with this practice, or it may related to physiological conditions in connection with the digestion of the concentrates. The result may also indicate that farmers using this practice generally are more conscious with respect to the feeding of high-yielding cows.

The effect of FEEDSTUFFS (decreasing treatment rate with increasing number of different feedstuffs) may be related to a higher feed consumption when turnips, potatoes, alkali treated straw etc. is used in addition to grass silage and hay. Such feedstuffs may make the diet more tasty.

No significant association between MILK YIELD and the treatment rate of ketosis was found. This result is in agreement with data from the Dairy Recording (*Anon.* 1983), which also indicate that ketosis is not related to herd average annual milk yield. AGE and SEASON did not show any significant effects. However, in a study based on the herd rather than the cow as a unit, the variables used (herd average age of cows and main calving season) were probably too general to provide any conclusions. STALL did not either show any significant association with the treatment rate of ketosis. This indicates that whether the cows have access to the feeding table all 24 h of the day or not is of minor importance.

Feeding around calving and the first 4—6 weeks of lactation is considered to be important with respect to ketosis. (*Hove & Halse* 1983). In a previous epidemiological study in Norwegian dairy herds (*Dale et al.* 1978) underfeeding in early lactation was found to be an important etiologic factor. With the data used in the present study, only some general qualitative aspects of feeding could be evaluated.

This study show that the Health Card System is a valuable data base for epidemiological studies of some general aspects of ketosis. However, more work sould be done to study to what extent the veterinary treatments actually are recorded and reported. For more specific studies of ketosis there is a need for more precise diagnostic criteria. The keto-test on milk is often used by the veterinarian, but is not reported. There is also a need for collection of more specific data regarding type of feeding, feed quality, amounts given etc. in early lactation.

## REFERENCES

*Anon.:* Husdyrkontrollen i Norge 1983 (The Norwegian Dairy Recording 1983). Landsrådet for Husdyrkontrollen, Oslo, 1984. 99 pp.

*Bakken, G.:* A survey of environment and management in Norwegian dairy herds with reference to udder diseases. Acta agric. scand. 1981, *31*, 49—69.

*Barr, A. J., J. H. Goodnight, J. P. Sall, W. H. Blair & M. Chilko:* SAS Users Guide, 1979 ed. SAS Institute, Inc. Raleigh, North Carolina.

*Dale, H., L. Vik-Mo & K. Halse:* Ei feltgransking over ketose hjå mjølkekyr sett i høve til energidekninga i tidleg laktasjon. (Ketosis and energy balance in cows during early lactation. A field survey). Norsk Vet. Tidsskr. 1978, *90*, 3—10.

*Halse, K.:* Ketose og statistikk. (Ketosis and statistics). Norsk Vet. Tidsskr. 1984, *96*, 457—460.

*Hove, K. & K. Halse:* Energy metabolism in ruminants with special emphasis to ketosis and fertility. Proc. 5. Internat. Conf. Production Disease in Farm Animals, Uppsala, August 1983, pp. 115—123.

*Solbu, H.:* Disease recording in Norwegian dairy cattle. I. Disease incidence and non-genetic effects on mastitis, ketosis and milk fever. Z. Tierzucht. Zuchtungsbiol. 1983, *100*, 139—157.

*Øverby, I., M. Aas Hansen, K. Jonsgård & E. Søgnen:* Bovine ketosis. I. Occurrence and incidence in herds affected by ketosis in Eastern Norway 1967—1968. Nord. Vet.-Med. 1974, *26*, 353—361.

## SAMMENDRAG

*Ketose i norske storfebesetninger — noe epidemiologiske forhold.*

Ketosedata på grunnlag av helsekortstatistikken, sammen med intervjudata vedr. fóring, oppstallingsforhold og stell var grunnlaget for en epidemiologisk undersøkelse over faktorer med innvirkning på ketoseforekomsten i 306 besetninger.

Effekten av stellet ble studert ved hjelp av en faktor som ble kalt omsorg. Faktoren ble definert på grunnlag av 20 spørsmål som ga informasjon om kvaliteten av stellet. Omsorg var den enkeltfaktoren som hadde sterkest innvirkning på ketoseforekomsten. Den registrerte behandlingsraten var høyest i besetninger med godt stell, og lavest i besetninger med dårlig stell.

Det ble funnet mest ketose i fjellbygdene Nord-Østerdal/Gudbrandsdal og Valdres, og minst i Rogaland. Videre ble det funnet at behandlingsraten avtok med økende besetningsstørrelse, og med økende antall fórslag i forrasjonen. Det var mindre ketose i besetninger hvor det ble gitt ekstra kraftfór mellom morgen- og kveldsstellet. Det samme var tilfelle der hvor kona deltok i fjøsstellet.

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