Praca oryginalna *Original paper*

Identifying cows at risk of subclinical ketosis as part of the milk recording of dairy cattle in Poland in 2014-2022

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Summary

In 2013, the Polish Federation of Cattle Breeders and Dairy Farmers introduced a new service – identifying cows in a state of subclinical ketosis (SK). Based on the content of ketone bodies in milk, i.e. β-hydroxybutyrate and acetone determined in a milk sample taken on the day of the test day, cows that were probably in the SK state on the test day are identified using a logistic regression model. Such cows are indicated to breeders in the reports from milk recording. The aim of the study was to analyze the incidence of SK in the recorded population. During 10 years of SK monitoring, the incidence of SK in cows decreased with each subsequent year. SK occurred more often in cows with lower milk yield and in smaller herds. The results indicate a constant improvement in the health situation of recorded cows in Poland, in the context of the incidence of SK.

Keywords: ketosis, milk recording

Ketosis is a metabolic disorder of cows occurring mostly in the first two months after calving. It is associated with a negative energy balance (6). In ketotic animals, weight and body condition losses, and decrease of feed intake are observed. According to Oetzel (16) and Wu (21), type 1 ketosis is spontaneous ketosis occurring in undernourished cows and is also known as thin cow syndrome. It is typically manifested in cows 2 to 4 weeks after calving. On the other hand, type 2 ketosis, also known as fat cow syndrome, encompasses obese cows and those experiencing NEB and fat mobilization just before calving. The fundamental change in type 2 ketosis is fatty degeneration of the liver, clinically evident after calving (18). Ketosis is associated with reduced milk yield (1, 13) and worsening reproductive results (20). Moreover, ketosis often leads to other diseases, such as abomasum displacement (4) or mastitis and metritis (3). The occurrence of ketosis in the herd leads to the need for breeders to incur significant costs, not only related to the treatment itself, but also with an indirect impact on reduced profitability through reduced milk yield, poorer reproduction and premature culling. Canadian studies estimate that the cost of a single case of SK is \$203 (8). In turn, McArt et al. (15) calculated this cost at \$289 and showed that it is higher in primiparous cows than in multiparous cows.

Due to the serious consequences and costs of ketosis in the dairy cattle population, it was decided to develop a method for estimating the risk of SK, both at the level of individual cows and the entire herd. In 2013, the Polish Federation of Cattle Breeders and Dairy Farmers (PFCBDF) introduced a new service, which involved marking cows in the reports (RW) that could have been in the SK condition on the day of test day. Identifying cows which are suspected of having SK is based on a logistic regression model, in which the independent variables are the laboratory-determined content of acetone and β-hydroxybutyric acid in milk and the ratio of fat to protein in milk collected during the test day (12). It applies to cows only to the 1st and 2nd test day, i.e. it takes place between the 6th and 60th day of lactation. Based on the above-mentioned model, cows suspected of having SK are selected on the test day and the farmer is informed about such a suspicion by assigning the K! index to the cow. Cow selecting is based on analyzes of milk samples collected as part of the routine milk recording of dairy cattle conducted in Poland by PFCBDF.

Based on the K! index frequency in the herd, as well as the herd size, the probable frequency of SK (PFSK) in the herd is calculated. When it exceeds 10%, the breeder is informed in the report about the risk of SK in the herd. However, if this indicator exceeds 20%, the herd is considered to be at high risk of SK.

The aim of this study is to summarize the 10-year operation of the service.

Material and methods

The analysis was carried out using 2 datasets: set 1 containing data on cows and set 2 including data on herds. The data was downloaded from the Fedinfo database, belonging to PFCBDF, in which the results of test milkings carried out as part of milk recording are collected and processed. Set 1 contained data on samples taken from cows of various breeds under milk recording, mainly the Holstein-Friesian breed. The analyzes were conducted on the basis of data collected by PFCBDF in 2014-2022. The results obtained in 2013 were not taken into account because the service was introduced on April 1st, 2013.

Set 1 included an input of 10 959 098 records and these were processed data from test days, during which the qualified person collected milk samples, according to the methodology specified in the guidelines of the International Committee on Animal Recording (ICAR). Milk samples were preserved with 2-bromo-2-nitropropane-1, 3-diol (bronopol), and then their chemical composition was analyzed in one of the 4 accredited laboratories belonging to PFCBDF, using MilkoScan FT 6000 devices (Foss Analytical). These devices are regularly calibrated to determine the content of basic milk components, according to ICAR guidelines, and to determine the content of acetone and β-hydroxybutyric acid. The data in set 1 was processed data – based on the content of ketone bodies, protein and fat, each milk sample was assigned an appropriate health status, and thus the cow from which the sample came. The set excluded records in which the yield from the test day was 0 kg (there were 327 776 such records, which constituted 2.77% of the entire set.

Set 2 contained data on herds and included 1 790 633 records. Set 2 included data from 26 165 herds that were recorded in 2013-2022. The status assigned to herds was one of the following: "strongly at risk of ketosis", "at risk of ketosis", "no risk of ketosis", "unmarked". This is the PFSK (Predicted Frequency of Subclinical Ketosis) indicator – it tells about the degree of threat to the SK herd, it is not a direct contribution of cows marked as sick during a given test day. All records were taken into account for the calculations, except those with "unmarked" status.

Based on the data sets, the following was calculated (number and percentage of cows with the K! index depending on the calendar year):
- share of cows with the K! index in groups of primiparous cows, cows in the second lactation and third lactation and higher
- share of cows with the K! index depending on the number of the day after calving, for 2014 and 2022
- share of cows with the K! index depending on the calendar month
- share of cows with the K! index depending on the milk yield on test day
- share of herds "at risk of ketosis" and "strongly at risk of ketosis" in the total number of herds for which this indicator was estimated, depending on the calendar year
- share of herds "at risk of ketosis" and "strongly at risk of ketosis" in the total number of herds for which this indicator was estimated, depending on the calendar year and herd size
- share of herds "at risk of ketosis" and "strongly at risk of ketosis" in the total number of herds for which this indicator was estimated, depending on the calendar year and average daily milk yield on test day.

Data analysis and graphs were performed using the R language (https://www.r-project.org/) and the RStudio program. Basic descriptive statistics (Tab. 1) and percentages were used to describe the data set. In order to check the

Tab. 1. Descriptive statistics of set 1 (data on cow results from test days) and set 2 (data on herds in relation to the health status of the entire herd)

Variable	n	Average	Median	Minimum	Maximum	SD	CV
Number of samples							
all	10 631 322						
primiparous cows	3 554 722						
2nd lactation cows	2 761 429						
from cows in 3rd and further lactation	4 315 171						
Parity		2.54	2	1	22	1.7	65.9
Days in milk		31.70	32	5	60	16.3	51.6
Daily milk yield, kg		31.97	31.0	1	107	9.6	29.9
Number of records containing farm data	1 651 657						
Number of cows in herd		42.53	30	1	1546	56.6	133.1
Average milk yield on test day/per whole herd, kg		20.33	20.3	0.2	61.3	5.4	26.5
Average milk yield on test day/milked cows, kg		24.30	23.4	2.3	61.9	5.7	23.4

relationship between the health status and the size and average efficiency of the herd, the chi-square test and measures based on this test were used: the V-Cramer coefficient and the contingency coefficient.

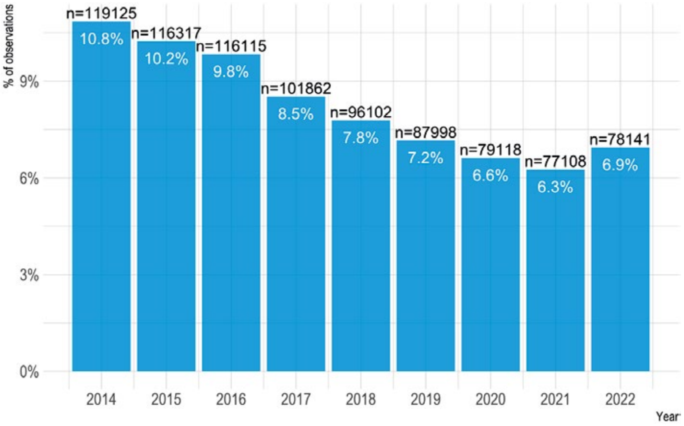

Fig. 1. Number and percentage of cows with K! in the years 2014-2022, in herds of recorded cows

Results and discussion

The share of primiparous cows in the data set (set 1) was 33%, cows in the second lactation 26%, and in the third and beyond 41%. The animals were on average in 31.7 days of lactation, with a daily milk yield of 31.97 kg (Tab. 1). The median for the parity was 2. The average number of animals per herd was 43 (from 1 to 1546), and the average milk yield of cows on test day was 24.3 kg.

Since the introduction of the service, the frequency of ketosis (the share of cows with the K! index) in the recorded population has been decreasing (Fig. 1). However, there is a slight increase in this frequency in 2022. In all parity groups, there was a continued tendency to reduce the share of cows with the K! index. In the group of cows in the third and further lactations, the share of cows with the K! index was higher than in primiparous cows and cows in the second lactation (Fig. 2).

Comparing the years 2014 and 2022, it can be seen that as the number of days since calving increases, the share of cows with the K! index decreases (Fig. 3). In 2022, the number of cows with the K! index between 5 and 7 days in milk decreased faster than the corresponding group in 2014. In 2014, on average, 19.6% of cows between 5 and 7 days in milk were suspected of being in the ketosis state, in 2022 it was 13.6% cows.

A smaller share of cows in the ketosis condition was observed in the period from September to December (Fig. 4).

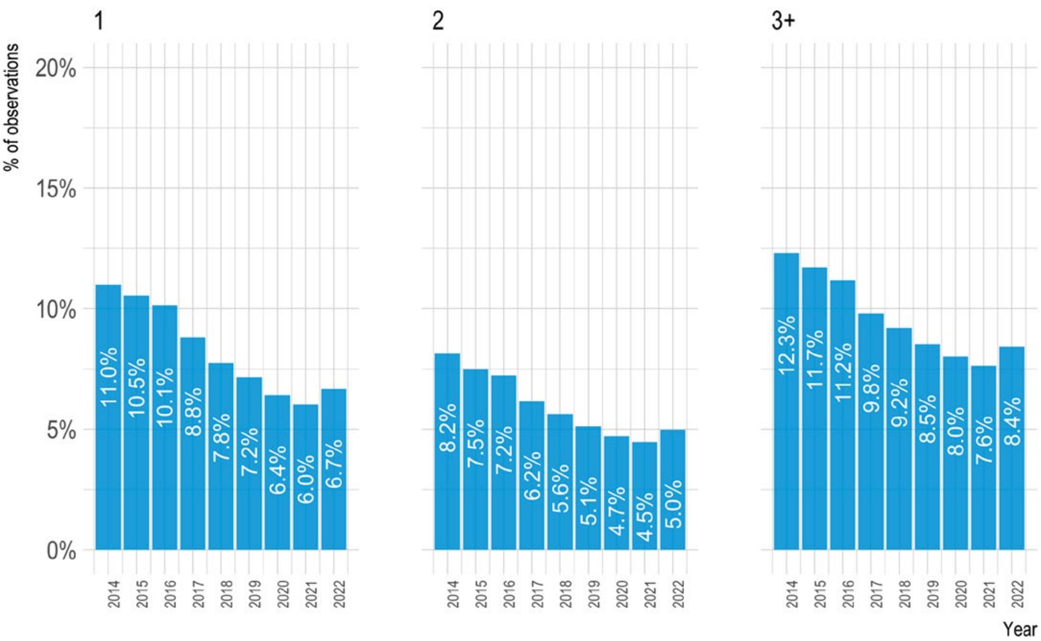

Fig. 2. Number and percentage of cows with K!, depending on lactation number (1, 2, 3+). Cows in their third and further lactation were included as one group

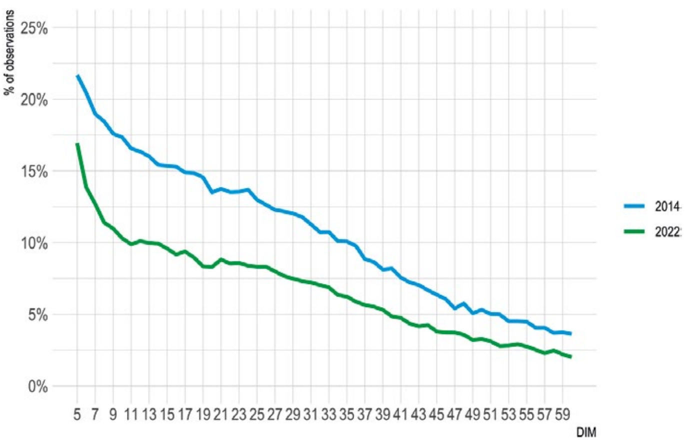

Fig. 3. Share of cows with K! depending on lactation days (days after calving) in 2014 and 2022

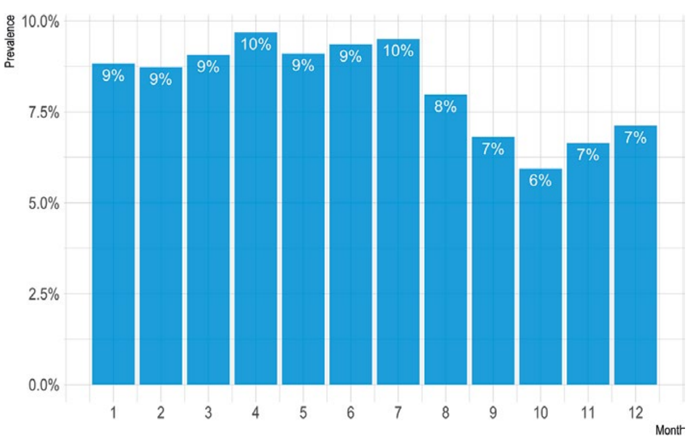

Fig. 4. Share of cows with K! in the following calendar months, in the years 2014-2022

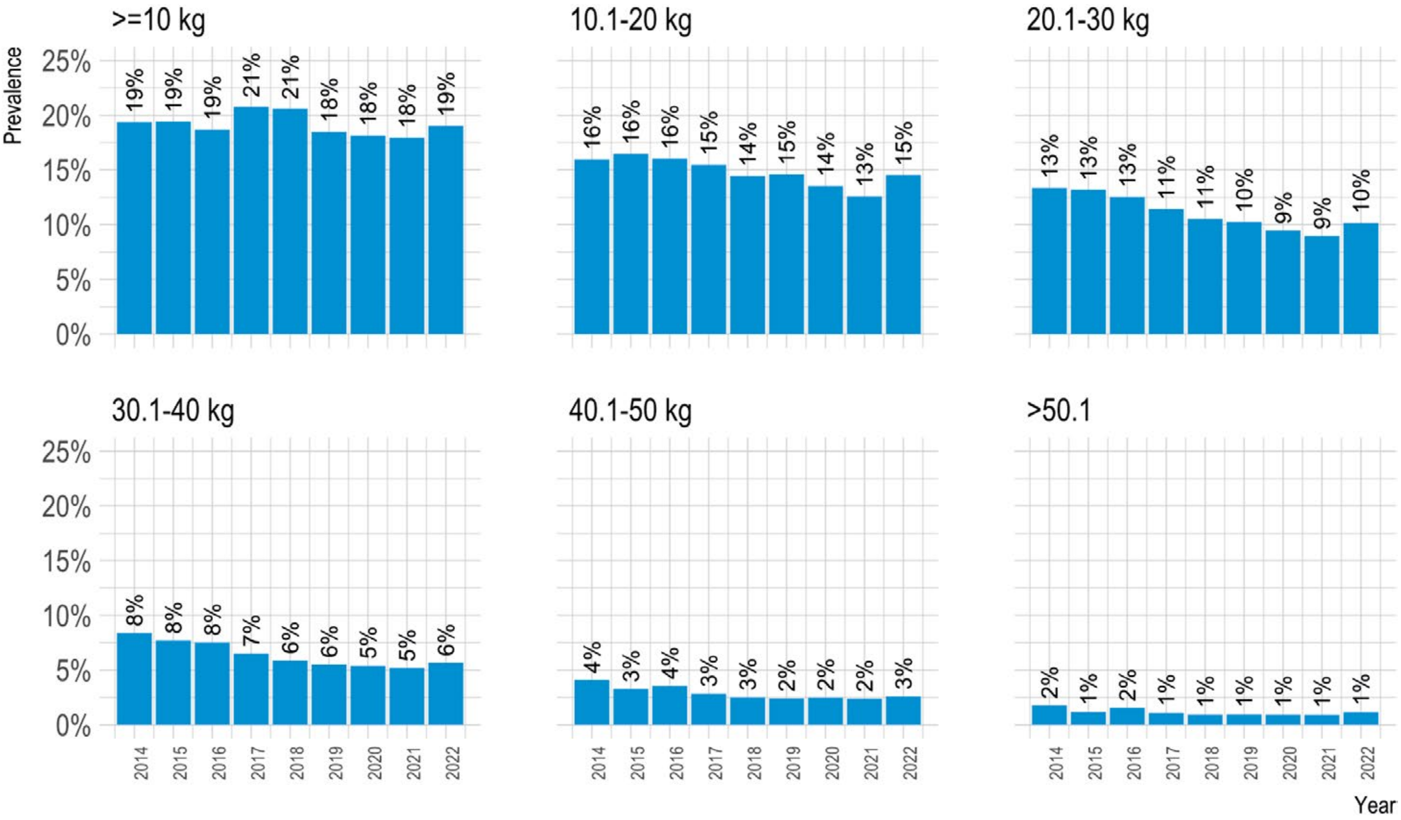

Fig. 5. Share of cows with K! depending on the average milk yield on the day of the test day

When the milk yield of a cow during test day was taken into account, the animals in which ketosis was most frequently observed were those producing the least milk, i.e. those in the group > = 10 kg (Fig. 5). As the daily milk yield increased, the incidence of ketosis decreased and the relationship was significant, although very weak (p-value = 0.0005, Cramer's V coefficient = 0.143, contingency coefficient = 0.142).

The share of herds at risk and at high risk of ketosis decreased from year to year (Fig. 6). Herds with 20 to 49 cows were most at risk of developing ketosis, and the relationship was significant, although very weak (p-value = 0.0004998, V-Cramer coefficient = 0.045, contingency coefficient = 0.078). SK occurred least frequently in herds numbering over 150 animals (Fig. 7).

After assigning the herds to the ranges of average milk yield of cows from the test day, it turned out that ketosis most often occurred in herds with an average daily milk yield of between 10.1 and 20 kg of milk. A similarly high risk occurred in herds with a productivity of 20.1-30 kg, while the most productive herds were characterized by a low share of cows suspected of being in the ketosis state (Fig. 8). The herd's ketosis status and belonging to a specific performance range were significantly, although very weakly, correlated (p-value = 0.0005, V-Cramer coefficient = 0.05, contingency coefficient = 0.088). Compared to the average frequency of SK studied in dairy cow populations in 10 countries in Europe, which according to Suthar et al. (17) was between 11.2%-36.6%, the Polish population was characterized by a lower incidence of ketosis. The increase in ketosis prevalence that occurred in 2022 can probably be associated with rising inflation and prices of products and services, which could translate into lower standards of veterinary care, the quality of cow nutrition or the use of consultancy. Lower prevalence in our case, than in the work of Suthar et al. (17), as well as in the works of Duffield et al. (5), McArt et al. (14) may result from a different diagnosis model. Our model is very conservative and

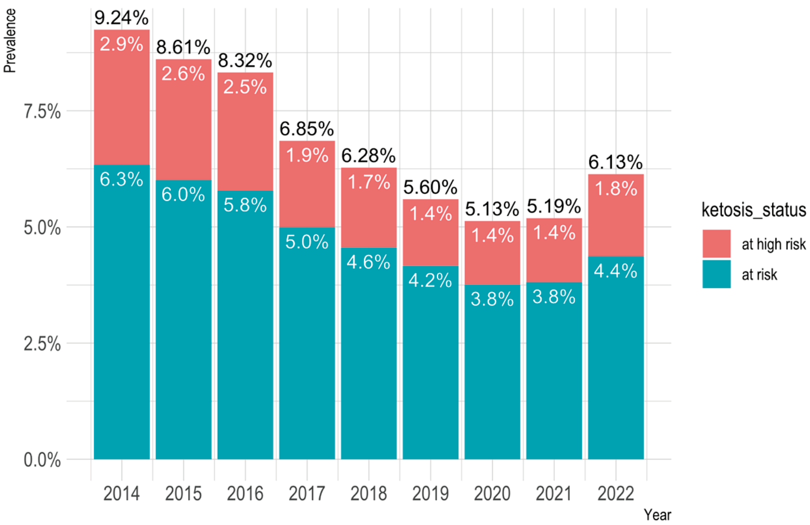

Fig. 6. Share of herds at risk and at high risk of subclinical ketosis

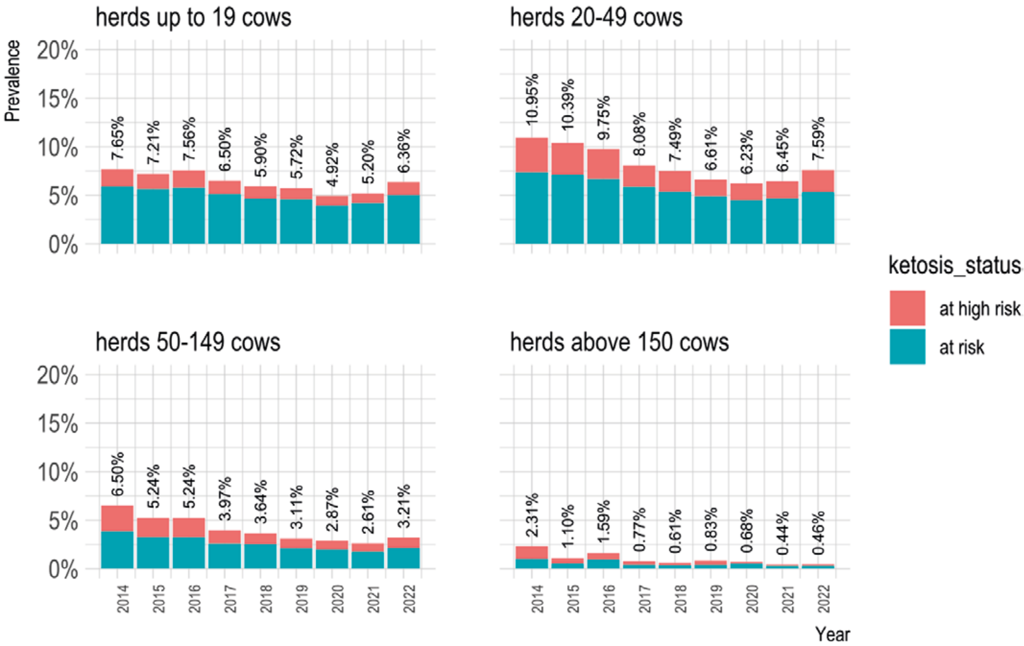

Fig. 7. Share of herds at risk and at high risk of subclinical ketosis, depending on herd size

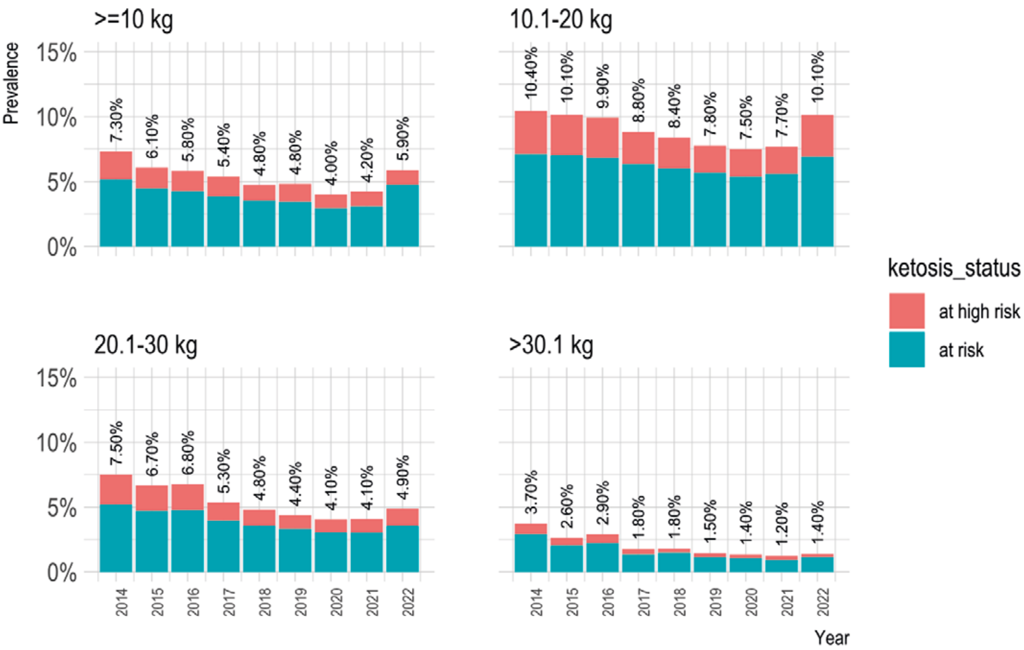

Fig. 8. Share of herds at risk and at high risk of subclinical ketosis, depending on the average daily milk yield in the herd

therefore selects significantly fewer cows in the ketosis condition than in other studies.

Ketosis most often occurred in the group of cows in the third and subsequent parities, which is consistent with the results of previous studies (9, 11).

Ketosis was least common in the months from August to December, while from January to July the share of cows in the ketotic state was higher, which is consistent with the research of Vanholder et al. (19), who indicate that the reason for such an increase could be poorer quality of feed in the first half of the year.

The fact that ketosis was much more common in herds with a daily milk yield of 10.1-20 kg and 20.1-30 kg of milk/day is surprising, since other studies have shown that the occurrence of ketosis increases with increasing milk yield (7, 10). The presented population data, based on a large amount of data, indicate that SK is not a metabolic disorder associated with high cow performance, but a disorder associated with poor cow welfare, including poor nutritional standards. The type of ketosis should also be considered here, because not all types of ketosis cause milk yield decrease. Usually, high-yield cows are believed to be more prone to ketosis (2, 4), but the study of Kowalski et. all (13) showed that only cows with elevated β-hydroxybutyrate alone (not acetone) levels being in 6-18 and 6-38 DIM for multiparous and primiparous respectively, were high producers. Cows which had the lowest average milk yields, fell into the group of acetone- β-hydroxybutyrate or acetone-alone ketosis type.

In the herds with the largest number of animals, ketosis occurred the least frequently, which could be related to the fact that large farms more often used the services of nutritional consultants, had the opportunity to divide animals into production groups, and, consequently, adjust feed rations to the needs of cows in particular stages of lactation.

The above results indicate a constant improvement in the health situation of recorded cows in Poland, in the context of the frequency of ketosis. This is due to breeders expanding their knowledge of nutrition, prevention and good practices related to the maintenance of dairy cows, as well as greater awareness of the negative effects of metabolic diseases. Introduction of this type of service contributed to the gradual reduction of the incidence of ketosis – the results in the reports received after the test day highlighted the scale of the problem, which many farmers may not have been aware of.

Further work is certainly recommended on improving the method of selecting animals suspected of subclinical ketosis, as well as constant monitoring of the results in the recorded population and education of breeders in the field of prevention.

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