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Fertility parameters in German dairy herds: Associations with milk yield and herd size

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Abstract: Fertility in dairy cows has decreased over the last fifty years while milk production per cow has increased. Furthermore, dairy herds become larger resulting in fewer employees per cow, which might also influence reproductive performance. To elucidate the situation in Germany, selected parameters (conception rate, service rate, pregnancy rate, days to first insemination and days open) were studied using data on 148 herds. For statistical analysis the herds were categorized concerning milk yield: (1) < 30 kg, (2) 30−35 kg, and (3) > 35 kg/cow/day as well as concerning herd size: (1) < 200, (2) 200−400, (3) 400−1000 and (4) > 1000 milking cows. There was no difference in conception rate among herds. That means on dairy farms of larger size or with high milk yield the chance of an inseminated cow to become pregnant is the same as in small herds or in herds with low milk yield. Small herds (< 200 cows) had lower pregnancy rates than larger herds (200–400 cows). The pregnancy rate in herds with different milk yield was not statistically different. Though there was a trend that dairy farms with higher milk yield (> 30 kg) had higher pregnancy rates. The statistical differences and trends of pregnancy rates are due to higher service rate in larger herds as well as in herds with high milk yield. Therefore, service rate is the key factor for high reproductive performance on dairy farms. Poor fertility is not associated with high milk yield on herd basis or large herd size but may represent inappropriate farm management.

Keywords: conception rate; service rate; pregnancy rate

There has been much debate about possible antagonism between high milk yield and fertility. On the one hand, researchers point out that breeding for high milk production leads to impaired reproductive performance (Lucy 2001). On the other hand, researchers argue that in particular the improvements in management, e.g. nutrition, barn design, heat detection, resulted in higher milk yield and better fertility as measured in pregnancy rate (LeBlanc 2010). According to Washburn et al. (2002) conception rate in the USA has decreased in the last decades while milk yield has increased. For Germany there is one study in which fertility parameters in dairy herds in Brandenburg were examined between 1997 and 2006. In this study conception rate decreased from 52 to 45% (Zube and Franke 2007). However, in Germany there are no current data for the most important fertility parameters available, e.g. service and conception rate, which can be used by veterinarians and other consultants.

Due to economic reasons dairy herds get larger worldwide, also in Germany (Statistical Federal Agency 2018). As a consequence, there are fewer employees per cow on dairy farms and an increasing number of dairy farms depend on hired labour (Barkema et al. 2015). This could have effects on the fertility of herds. In several studies a lot of

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reasons for impaired reproductive performance at a herd level were found: heat stress (Wolfenson et al. 2000), negative energy balance (Roche et al. 2009), and postpartum infections of the uterus (Sheldon et al. 2009). However, if the herd size is negatively associated with fertility has not been answered so far.

Due to the missing knowledge of current fertility parameters in Germany the aim of the present study was to reveal data on reproductive performance in German dairy herds. Furthermore, it was determined if the size or milk yield of the herd are associated with those fertility parameters.

MATERIAL AND METHODS

Data. The fertility parameters conception, service and pregnancy rate as well as days to first insemination and days open were chosen for the study. For the calculation of these parameters a data set of the Alta Genetics Germany GmbH was provided. Every quarterly period Alta Genetics Germany performs a benchmark for costumer farms. The cows on the farms were mainly of Holstein-Friesian breed. However, the data for the breeds were not collected. For the calculation of the benchmark data backups of the herd management software (mostly DairyComp 305, Valley Ag Software or Herde, dsp Agrosoft) were used. These herd management software systems are used to store some data of the herds including insemination and milk yield pattern. In these programs the target values of fertility were calculated for every quarterly period. After readout the data were transferred to MS Excel. In total, 148 herds were analysed. The data for the quarters II–IV 2014 and I 2015 were used. That means for each herd four values of the parameters were used for statistical analyses.

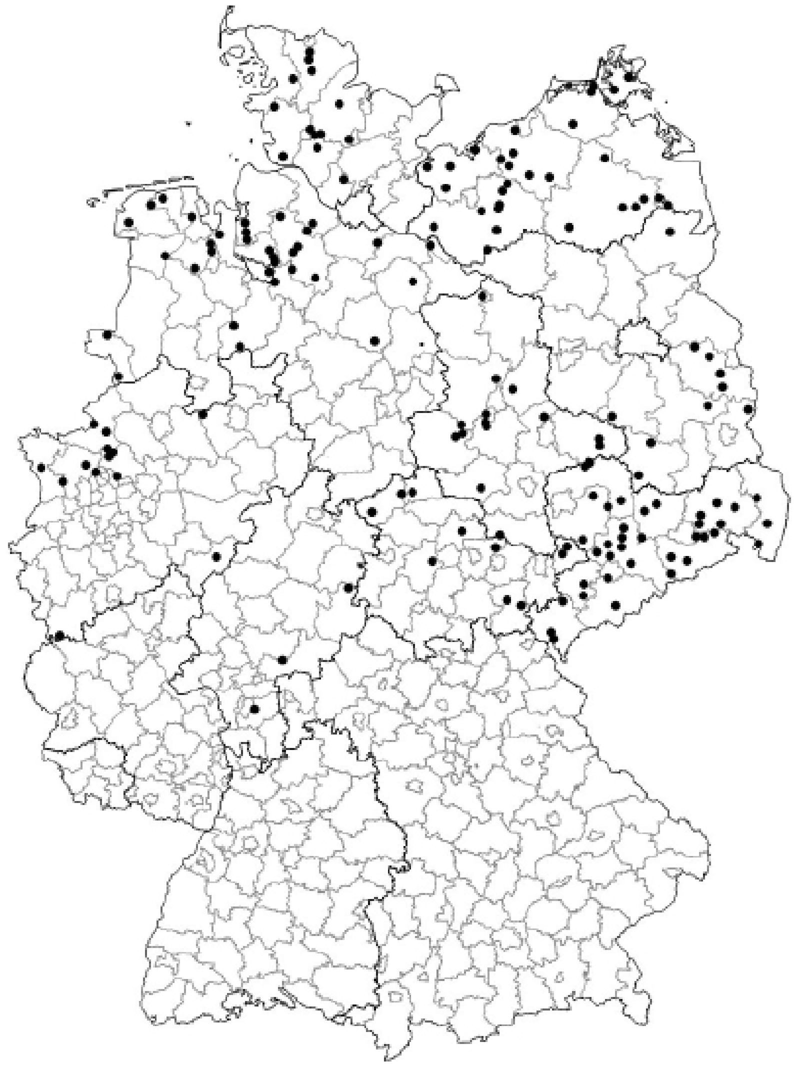

Figure 1. Map of Germany with the location of the farms that provided data for the study. Each symbol (●) represents one farm

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Definition of fertility parameters. Fertility parameters were calculated as defined by de Kruif et al. (2014):

Conception rate (%) = (Pregnant cows *n*/Inseminated cows *n* in a defined time period) × 100

Service rate (%) = (*n* of cows inseminated in a 21-day cycle/*n* of cows eligible for insemination after passing a voluntary waiting period) × 100

Pregnancy rate (%) = (Conception rate × Service rate)/100

Days to first insemination = number of days from calving to first insemination

Days open = number of days from calving to day of conception

Location of the farms. To illustrate the location of farms providing data for analysis a map was created using Kartenexplorer Version 2.04 (R6) (http://kartenexplorer.fli.de/) (Figure 1).

Statistical analysis. Statistical analysis was performed using the SPSS software (IBM). For all parameters mean and standard deviation as well as minimum and maximum were calculated. To reveal the effects of milk yield and herd size, the herds were classified according to milk yield (n = 143): (1) < 30 kg/cow/day (n = 57), (2) 30–35 kg/cow/day (n = 74), (3) > 35 kg/cow/day (n = 12), and herd size (n = 148): (1) < 200 cows (n = 8), (2) 200–400 cows (n = 52), (3) 400–1000 cows (n = 69), (4) > 1000 cows (n = 19). If some data of the herd were missing, e.g. milk yield, the data of the herd were excluded from the statistical analyses. Data were normally distributed and analysed using one-way ANOVA. For the parameters that offered statistically significant effects of herd size or milk yield, respectively, Tukey's test was computed to detect differences between the groups ($P < 0.01$).

RESULTS

Fertility parameters. The average herd size was 565 cows, i.e. the data on > 80.000 cows were used for the calculation of the parameters. Arithmetic mean and standard deviation as well as minimum and maximum of the calculated fertility parameters are shown in Table 1.

Associations with milk yield. According to milk yield, no statistical effects on days to first insemination and days open were found ($P > 0.01$) (Table

Table 1. Arithmetic mean, standard deviation (SD), maximum (Max) and minimum (Min) of conception, service and pregnancy rate as well as days to first insemination and days open (n = 148 herds, n = 82 065 ± 4933 cows)

Parameter	Mean ± SD	Max	Min
Conception rate (%)	34.4 ± 7.2	100	10
Service rate (%)	52.7 ± 9.3	74	16
Pregnancy rate (%)	18.0 ± 3.9	33	4
Days to 1st insemination	68 ± 10	116	45
Days open	121 ± 16	186	83

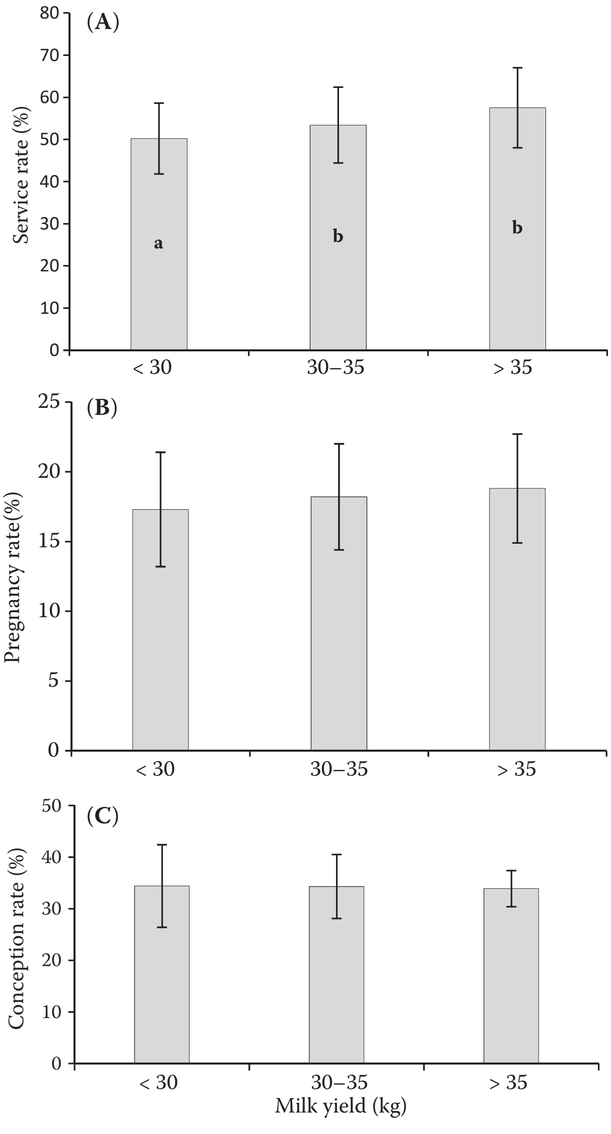

Figure 2. Service (**A**), pregnancy (**B**) and conception rate (**C**) in different categories of milk yield (< 30 kg, 30–35 kg and > 35 kg)

lowercase letters indicate statistically significant differences between the classes of milk yield: < 30, 30–35, and > 35 kg ($P < 0.01$)

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Table 2. Means ± standard deviation of days to first insemination and days open according to milk yield or herd size, respectively

Parameter	< 30 kg milk	30–35 kg milk	> 35 kg milk	< 200 cows	200–400 cows	400–1000 cows	> 1000 cows
Days to 1st insemination	69 ± 10	68 ± 9	67 ± 10	73 ± 11	68 ± 9	68 ± 11	67 ± 8
Days open	122 ± 18	121 ± 15	119 ± 14	125 ± 19	121 ± 18	121 ± 15	117 ± 13

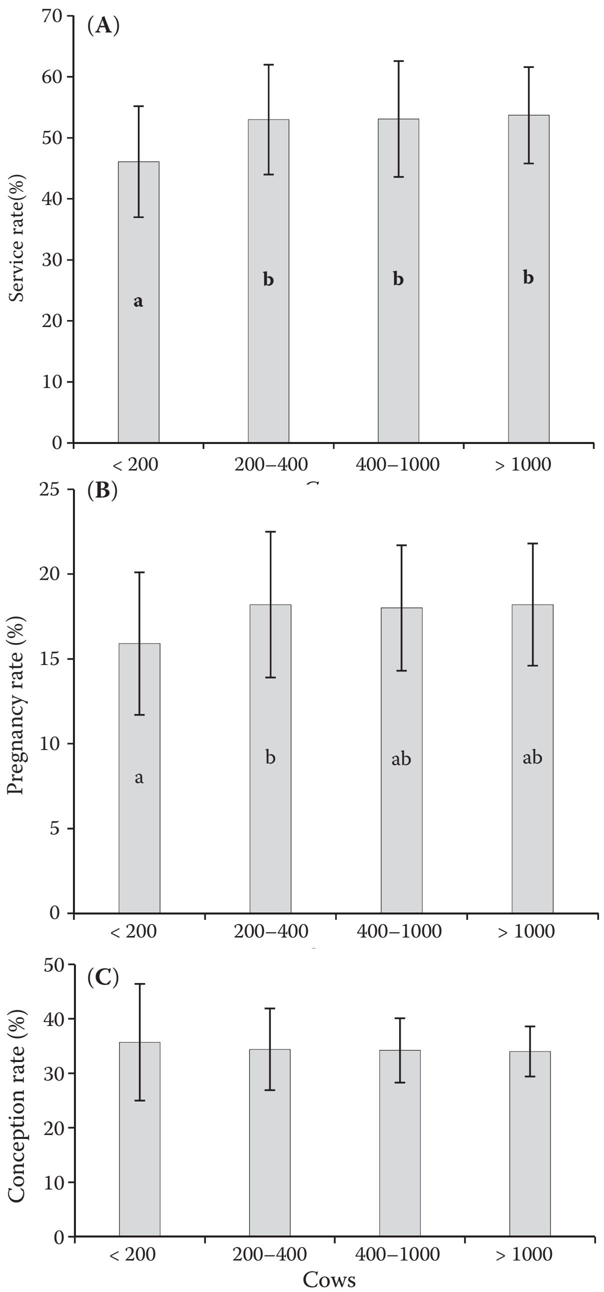

Figure 3. Service (**A**), pregnancy (**B**) and conception rate (**C**) in different categories of herd size (< 200, 200–400, 400–1000, and > 1000 cows)

lowercase letters indicate statistically significant differences between categories of different herd size: < 200, 200–400, 400–1000, and > 1000 cows ($P < 0.01$)

2). Also, conception rate and pregnancy rate did not present any statistical significance. However, there was a trend ($P = 0.09$) that the higher the milk yield, the higher the recorded pregnancy rate. Regarding service rate, there was a statistical effect – farms with > 30 kg of milk had higher service rates than farms with < 30 kg ($P < 0.01$) (Figure 2).

Associations with herd size. Concerning the herd size, there were no statistical effects on days to first insemination and days open. However, days to first insemination and days open trended to be lower the larger the herd ($P = 0.08$, $P = 0.12$, respectively) (Table 2). Furthermore, conception rate according to herd size revealed no statistical significance. In terms of service and pregnancy rate statistically significant differences were found. Smaller farms < 200 cows had lower service rates than larger herds. Moreover, smaller farms < 200 cows had lower pregnancy rates than herds of 200–400 cows ($P < 0.01$) (Figure 3).

DISCUSSION

The study presents an overview of selected fertility parameters. However, the data cannot be transferred to German herds in general as the average herd size of the study with 565 cows per herd was rather higher than the common herd size of 65 cows per herd in Germany (Statistical Federal Agency 2018). Though, the study provides data for larger herds (> 100 cows) in the north and east of Germany (Figure 1).

All values of the fertility parameters except for days to first insemination obviously miss the target values, which are given in the German literature for bovine herd health management (de Kruif et al. 2014) (Table 3). Regarding service and pregnancy rate also the maximum values of 74% and 33% are lower than the given target values of 80% and 35%, respectively. According to the present data new target values for conception, service and pregnancy rate are suggested in Table 3. For days to first insemination

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Table 3. Target values for conception, service and pregnancy rate as well as days to first insemination and days open given by De Kruif et al. (2014) and recommendation of new target values for conception, service and pregnancy rate suggested in the present study

Target values	Conception rate (%)	Service rate (%)	Pregnancy rate (%)	Days to 1st insemination	Days open
De Kruif et al. 2014	> 50	> 80	> 35	< 85	< 115
New values suggested	> 35	> 60	> 24	–	–

and days open no target values are given as these parameters are strongly dependent on voluntary waiting period, timed artificial insemination at first service and use of synchronization protocols in general. The circumstance that the information about voluntary waiting period, use of hormones or heat detection systems, and culling rates and reasons are not included into the data set is a lack of the study as this could provide more background information about the realization of the reproduction management on each farm.

The current data prove that conception rate is decreased compared to the values from 1996–2002 in Brandenburg, Germany (Zube and Franke 2007), and to the values of 2012 in the USA (Ferguson and Skidmore 2013). However, conception rate is lower, but service and therefore pregnancy rate are higher than in the USA in 2012 (Ferguson and Skidmore 2013). The data show that there are farms in Germany with exceptional values for pregnancy rate (33%). This is consistent with the study of Ferguson and Skidmore (2013), in which examples of farms with high fertility values were presented. In the present dataset there are also farms with really poor values of conception, service and pregnancy rate (Table 1).

According to milk yield or herd size conception rate revealed no statistical differences. That means irrespective of the level of milk yield or the size of the farm an inseminated cow has a chance of about 34% to get pregnant. Statistically significant differences were seen in service rate and hence also in pregnancy rate. Herds with higher milk yield and larger herds had higher service rates.

On the one hand, it could be assumed that herds with high milk yield have a more negative energy balance than less productive herds, which may result in impaired fertility (Roche et al. 2009). On the other hand, it seems logical that high milk yield on a herd level is achievable only by having high reproductive performance (LeBlanc 2010). On a cow level high milk production is negatively associated with fertility. However, the effects are small and particularly dependent on the herd level of milk production (Rearte et al. 2018). According to the present data, good reproductive performance can only be realized by having a high service rate as there are no statistical differences in conception rate between the herds with different milk yield. Furthermore, high milk production requires optimal barn and feeding conditions. Good farm management improves heat behaviour and thus leads to better heat detection (Diskin and Sreenan 2000).

In the present study the larger herd size is not associated with poor fertility. Moreover, larger farms (> 200 cows) realize better service rates than small herds (< 200 cows). However, only 8 herds with less than 200 cows were analysed in this data set. Typically, smaller farms are family-owned with no hired labour. That means only few persons are responsible for all farm issues. In larger herds it is more common that routines are captured in standard operating procedures to apply labour with greater consistency and to decrease errors (Barkema et al. 2015). This also warrants good heat detection.

CONCLUSION

Fertility parameters measured on larger dairy farms in the north and east of Germany differ significantly from target values given in the German literature of bovine health support. Service rate and therefore heat detection play a crucial role in fertility management as conception rate is less modifiable. Poor reproductive performance is not associated with high milk yield or herd size but may represent deficiencies in dairy farm management.

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