Activity- based heat detection with the smaXtec intraruminal bolus system

Introduction of the smaXtec inside monitoring solution for progressive heat detection in dairy herds

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Introduction

Dairy farming has undergone significant transformation in the past few years. Against a background of increased global milk demand and aggravated cost pressure, farmers are encouraged to manage their dairy herd as efficiently as possible. They react with intensified production using high-producing animals in large-scale facilities, which often leads to shorter animal productive lifetimes due to reduced fertility and impaired health. The reproductive performance of a dairy herd is one of the major key drivers of a farm´s profitability. Regrettably, the overall fertility status of dairy cows is constantly decreasing, and it is, therefore, becoming increasingly difficult to ensure successful fertilization. Studies, for example, report drops of 1-2 % in the conception rate per year in high-performance dairy herds (Sheldon et al. 2006; Norman et al. 2009). In this connection, heat detection remains one of the most important components of a successful reproduction program. Due to changes in animal performance and management, estrus expression has changed dramatically over the past few decades. Estrus duration has decreased and is less pronounced, which complicates heat detection. While studies undertaken in the 1970´s report estrus times of around 17h, authors like Roelofs (2005) and Sveberg (2011) found estrus times of between only 7h to 11h with less mounting events. Another aspect is that cows often tend to show typical signs of being in heat like mounting and standing during the night at times when the herdsman is not observing the animals (Peralta et al. 2005). Farmers pursue a variety of approaches in heat detection like – the historically most common - method of visual observation, tail heat marking, timed breeding programs or automated animal activity monitoring and try to react to the new challenges of heat detection. While timed breeding programs dominate the US market, numerous European dairy herds are successfully monitored and managed with the help of activity monitoring systems. So far, most of the systems used work with collars and pedometers, which are associated with problems due to the device becoming displaced, causing injury or getting lost, while the latter could be more problematic in large-scale herds where individual observation is rare. Such systems take up a significant amount of working time as collars need to be replaced (after being lost) or regularly adapted to animals' weight. The use of pedometers is associated with the same type of problems and veterinarians also report injuries on the legs of heifers when farmers do not adjust the pedometers according to as the animals grow.

Solution: Activity-based heat detection with a bolus system located in the dairy cow's rumen

While heat detection based on activity levels is already accepted as a reliable method to detect cows in heat, there continue to be negative side-effects mostly due to the handling of the devices. The smaXtec inside monitoring solution has none of the reported disadvantages due to its use of another measurement location. The smaXtec solution (Figure 1) consists of a measuring device located in the rumen of the animal (bolus), meaning that additional devices such as pedometers, collars or ear tags are not required. The bolus is administered orally and stays in the rumen for the animal's lifetime without the risk of loss or shifting. It measures rumen temperature and activity (via accelerometer) continuously at 10 min intervals with activity measurement not affected by rumen motility. The recordings are read out by a simple plug& play infrastructure (Base Station and Repeater), which automatically transfers the data to the smaXtec cloud. This online approach means that data is accessible anywhere anytime and is permanently saved. The software (smaXtec Messenger) functions as an online platform for data and alert access, general organization and data sharing with veterinarians, consultants or farm staff. Notifications can be also received on smart devices such as tablets or smartphones (Android, iOS).

Typical increases in activity during heat are detected immediately and lead to the above-mentioned alert notifications being sent to the herdsman. Cow- individual activity levels are considered within the data processing. The heat events are presented to the farmer as graph (Figure 2) or list (Figure 3), where also the status of the event can be noted (e.g. insemination or pregnancy). Thus, the dairy cows' history of previously successfully conducted inseminations can be documented in the software to calculate the expected lactation.

Via the included temperature recording, the system also provides calving management support. About 15h before calving dairy cows show a drop in temperature, which enables onset of calving to be detected by the smaXtec system. Furthermore, continuous temperature measurement provides additional information about drinking behavior, which is relevant in addressing issues relating to health as well as to feeding. The combination of 24/7 activity and temperature measurement enables one-stop health monitoring and early disease detection. In addition, the smaXtec system also offers pH measurement (Premium bolus) enabling the monitoring of rumen conditions relating to health (acidosis detection) and feeding management quality (feed conversion efficiency).

Performance Testing

The performance of the smaXtec Heat Detection system has been verified based on data from flagship farms as well as research projects conducted in collaboration with external partners. The latest study, which will be presented in detail, was conducted in cooperation with the University of Goettingen.

The study was conducted on a commercial farm with a herd of 600 Holstein dairy cows in Germany. Data for this investigation originated from 100 cows (primiparous and multiparous) with an average milk yield of 11,200 kg/annum. All dairy cows were housed in a free-stall with cubicles and were milked three times a day. They received a TMR mainly based on maize silage. The cows were equipped and monitored with a smaXtec Basic bolus (temperature und activity measurement) 2 weeks prior to expected calving date. Heat detection started 30 days antepartum with daily visual observation, the smaXtec system, and blood progesterone, while the latter was used as gold standard. Visual checks were performed on all cows daily in the morning by trained staff independently of the smaXtec data. Blood samples from all cows, which were visually in heat as well as from all cows with a smaXtec alert, were taken to measure blood progesterone levels.

To test the performance of the smaXtec system, heats based on progesterone data were compared with heats detected by smaXtec. To provide quantitative information, the following metrics were used to evaluate all the collected data:

$$\text{Precision: } \frac{True\ Positives}{True\ Positives+False\ Positives}$$

$$\text{Sensitivity: } \frac{True\ Positives}{True\ Negatives+False\ Negatives}$$

The study confirmed the results of previous tests and demonstrated that the smaXtec system is an accurate tool for use in heat detection. With a precision of 93% and a sensitivity of 95% in the described trial, the system is proved to be reliable. With the inclusion of the results of previous tests, the overall precision is 89%, and sensitivity is 92%.

Conclusion

The detection of cows in heat has become more and more difficult over the past decades due to changes in animal behavior and management. Besides timed breeding programs, which are often costly due to poor conception rates, the use of activity monitoring systems developed into a reliable and accepted method in farms worldwide. While activity was previously only measured by collars, ear tags or pedometers, for the first time the smaXtec system delivers an activity-based heat detection system with data directly from the rumen. Performance tests confirmed the accuracy of the system. Together with its advantages in handling it is shown to be a reliable, innovative alternative for progressive heat detection and general herd monitoring.

References

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Figures

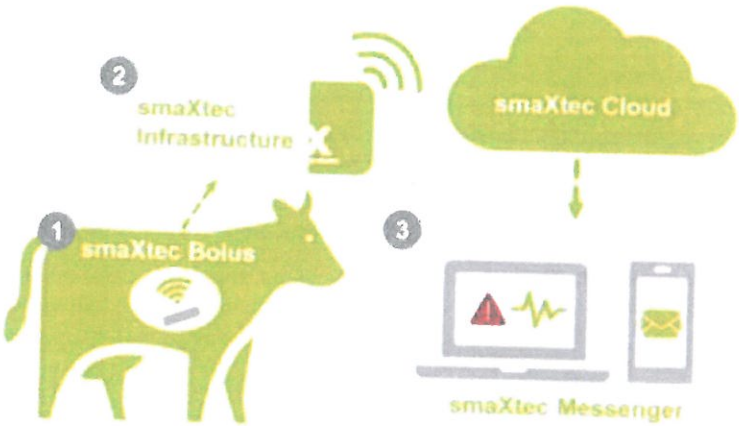

Figure 1: Components of the smaXtec inside monitoring system.

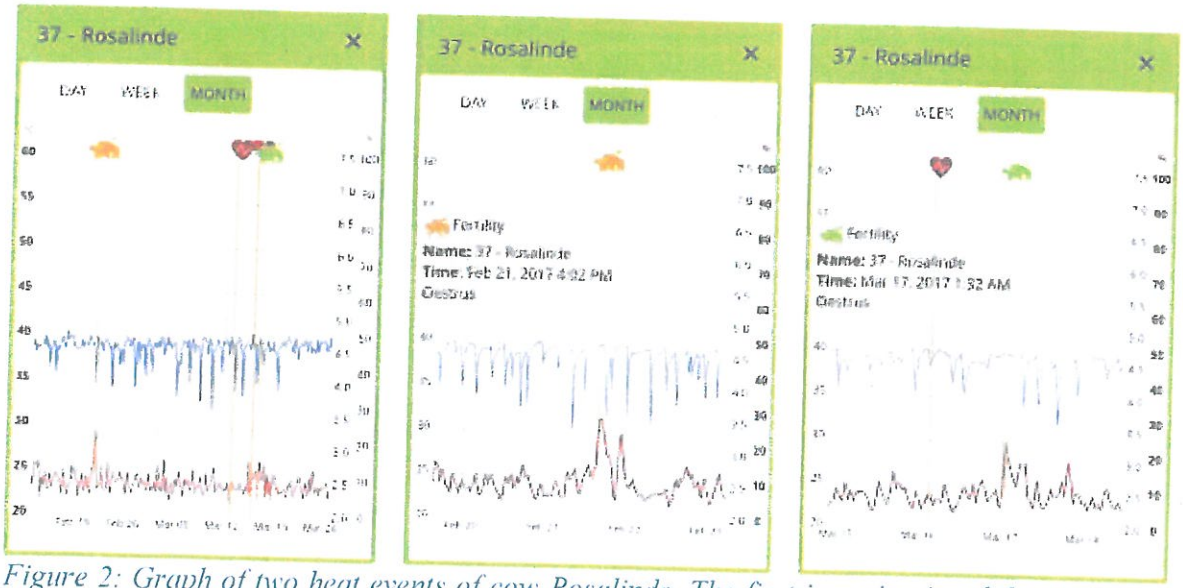

Figure 2: Graph of two heat events of cow Rosalinde. The first insemination did not lead to pregnancy, while the following was successful.

Figure 3: Heat events and health messages in cow Rosalinde's profile.