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BOVINOSE: Pheromone-Based Sensor System for Detecting Estrus in Dairy Cows

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Abstract

The BOVINOSE project (www.bovinose.eu) aims to develop an electronic nose to detect estrus in a dairy cow, and thus to determine the optimal timing of artificial insemination. The physical principle is based on detection of sex pheromones that are secreted by the cow, exclusively during estrus. These pheromones are the natural olfactory signal for the bull that the cow is in heat. This technology aims to help the dairy farmers in the EU, the vast majority being micro-enterprises run as family businesses.

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1. Introduction

In order to control the calving interval, and therefore to optimize milk production and maximize offspring in dairy cattle, artificial insemination (AI) is widely used, having many advantages over the natural cover, such as hygiene control, farm safety (no bull need to be present anymore), injury prevention (cows/bulls dont need to be transported to bring them together), and disease prevention (from cow-to-cow, but even from farm-to-farm in the case of airborne diseases). Currently, the conception rate of AI varies from 30% to 70%, the most critical aspect of successful conception being the timing of the insemination. Highest conception rates are achieved when the insemination is done 8 to 12 hours after the start of estrus (also known as “standing heat”). The right timing of AI, therefore, is related to detection of estrus in a cow. Current methods are not always reliable, are labor-intensive, and require skill and experience. Failure to detect estrus or erroneous diagnosis of estrus has been estimated of over $300 million to the dairy industry in the USA [1]. Improving the success rate will significantly increase a dairy farmers profitability.

The BOVINOSE project (www.bovinose.eu) aims to develop an “electronic nose” to detect estrus in a dairy cow, and thus to determine the optimal timing of artificial insemination. The principle is based on detection of sex pheromones that are exclusively secreted by the cow during estrus to signal the bull that the cow in in heat. In the BOVINOSE project, the info-chemicals that make up the sex pheromones in cows were investigated, a set of sensors for detection

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of these sex pheromones (or mix thereof) is researched, and a functional prototype, consisting of a probe, an array of sensors and self-learning software for estrus prediction is being developed and tested in laboratory and field trials.

2. Estrust State and Pheromones

Recently, Sankar and Archunan isolated three specific chemical compounds in bovine estrus faeces that are not present in non-estrus feces, i.e. acetic acid (AA), propionic acid (PA) and 1-iodo undecane [2]. The estrus specific synthetic compounds were rubbed onto dummy cows, and bulls were observed for their sexual response. The results suggest that these compounds may be used as estrus indicator in bovine. In our gas chromatography (GC) studies, however, we identified only AA and PA as estrus related volatile compounds in feces.

3. Electronic Nose

An electronic nose (eNose) is in essence an array of different chemical sensors that is set up to analyze chemical compounds in gaseous phase electronically, and a pattern recognition model that takes the electronic signal as an input and provides an output signal that is interpretable by the user, e.g. the classification of the chemical compounds in the gas. In the case of BOVINOSE, this signal would typically be the indication whether or not the cow is in estrus.

The sensor array in the BOVINOSE system is designed to detect sex pheromones AA and PA that are assumed to be the inducers of the natural olfactory signal indicating for the bull that the cow is in heat. The sensors have been optimized in the sense that sensitivity to the pheromones has been enhanced and sensitivities to other gasses that are typically present in a cow shed (e.g. ethanol, ammonia, and water vapor, amongst other) have been reduced. The different sensors in the array have different sensitivities and selectivities. The sensitivity and selectivity of each element, however, is too low for reliable estrus detection. The idea is that combination of responses has characteristic patterns that are suffcient for detection of the relevant sex pheromones.

4. Pattern Recognition

To train the pattern recognition model, a training set of feature vectors (obtained by applying the eNose on samples from cow feces) and the target outputs related to these samples were compiled. Two types of target outputs were considered: (1) GC measured values of pheromones and (2) estrus states observed by human experts (farmers and veterinarians). For both types of data, models have been trained and tested. The results indicate for (1) a strong (0.5-0.9) correlation with GC gold standard. For (2), we found that in the majority of cows, the dates and times of estrus according to the model coincide with the date and times according to the human experts, or deviates about 0.5-1 day. In other cows (animal with untypical hidden estrus), results are worse. Furthermore, estrus data has been compared with the GC pheromone data, confirming the earlier findings in the literature that estrus and pheromones are correlated.

5. Conclusion

The first steps towards a practical eNose has been made. A device consisting of an array of sensors has been constructed. It has been demonstrated that this array is sensitive to sex pheromones in cow feces that correlate with estrus of dairy cows. Furthermore, the device is able to directly monitor the estrus state of cow with a certain precision. Further analysis is still to be carried out to confirm results. In addition, field tests with the device will be carried out in near future. If successful, further development steps are foreseen.

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