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How to train a dog to detect cows in heat—Training and success

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ABSTRACT

Efficient and accurate estrus detection is a key management factor determining acceptable reproductive performance in dairy herds. Previous studies have shown that dogs can differentiate between vaginal mucus samples of cows in estrus and vaginal mucus samples of cows in diestrus with an accuracy between 40.3% and 97.0%. We set out (1) to develop a specific training protocol for training dogs to identify cows in estrus from the feed alley and (2) to determine sensitivity and specificity of trained dogs to detect cows in estrus. Six dogs were trained by means of positive reinforcement to detect cows in estrus from the feed alley following the training protocol. Four of those dogs participated in the final test after an average training time of 50 h per dog. Overall, they correctly identified positive cows as being positive in 23 out of 32 cases (i.e. sensitivity of 71.9%) and falsely classified positive cows as being negative in nine cases (28.1% type II errors). Out of 128 cases 119 were correctly classified as true negative cows (i.e. specificity of 93.0%) and in nine cases negative cows were falsely identified as positive cows (7.0% type I errors). Further research is warranted to develop an optimized training protocol that allows training estrus detection dogs for practical use within an appropriate time.

1. Introduction

For hundreds of years, dogs have been used for a variety of scent detection tasks. There are numerous scientific publications proofing scent detection abilities of dogs (Browne et al., 2006). Helton (2009) even designates scent detection dogs for a gold standard of detection technology. Dogs are used for multitudinous types of scent detection tasks, e.g. detection of explosives and land mines for police and military (Gazit and Terkel, 2003) or drugs (Nash, 2005). There are scent detection dogs used in wildlife conservation, e.g. by detecting desert tortoises in their natural habit (Cablk and Heaton, 2006), to indicate toxic contamination of the environment (Arner et al., 1986), or to support the elimination of rodents (Gsell et al., 2010). Recently, several applications in human medicine have been described and tested (Bijland et al., 2013). There are different types of tasks scent detection dogs can be trained to perform, i.e. a free search for a target in a defined area as in detection of explosives (Gazit and Terkel, 2003), a scent line-up, that is often used for cancer detection dogs (Moser and McCulloch, 2010) or matching the sample. In some countries, scent matching dogs are accepted to hold up as evidence in court of law (Tomaszewski and Girdwoyn, 2006). Target odours for scent detection dogs often are distinct and chemically known substances, such as explosives or drugs (Gazit and Terkel, 2003). In other cases the chemical composition of the target odour is unknown as in cancer detection (Willis et al., 2004; Johnen et al., 2013) or in identification of individual human scent (Schoon, 1996). In those examples dogs have to find a common denominator of all individual samples that are presented and have to generalize it as the target odour without recourse to the "pure" source of the odour (Willis et al., 2004).

Training dogs for scent detection usually comprises of three steps, i.e. adaptation to the training environment and the training methods, imprinting to the target odour, actual detection or discrimination training (Göth et al., 2003; Fischer-Tenhagen et al., 2011). During imprinting phase, dogs learn to associate a specific scent with reinforcement. In the actual discrimination training dogs are trained to identify this odour, to differentiate it from distracting odours (Fischer-Tenhagen et al., 2011), and to indicate the target odour by performing a trained indication behavior, often lying down or sitting at the target (Jezierski et al., 2008). Optimizing rewarding time and place has great influence on the training progress (Mackintosh, 1983).

Training methods differ a lot between different studies on canine scent detection. According to Walker et al. (2006), training methods based on positive reinforcement appear to have significant advantages compared to those based on aversive methods. In their study the authors trained dogs to detect n-amylacetate

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(nAA) by means of positive reinforcement. Their dogs were able to detect nAA up to a 20,000-fold lower threshold compared to a study that utilized electro shocks and water deprivation (Krestel et al., 1984). In a previous study, we showed that most studies concerning scent detection work with dogs did not provide sufficient information about training methods, which made it difficult to assess the evidence level of the studies and to compare the results (Johnen et al., 2013). This confirms Helton (2009), who criticized a lack of information regarding canine training provided in published research. We found that all dog trainers in the 14 studies on training scent detection dogs evaluated in our previous study worked with reward-based training (Johnen et al., 2013) such as play (Horvath et al., 2008; Sonoda et al., 2011), food (Gordon et al., 2008; Fischer-Tenhagen et al., 2011; Lin et al., 2011) or both (Brooks et al., 2003). A clicker was used as a conditioned positive reinforcement in six of the evaluated studies (Willis et al., 2004; McCulloch et al., 2006; Gordon et al., 2008; Richards et al., 2008; Cornu et al., 2011; Fischer-Tenhagen et al., 2011).

Although it is known that trained dogs are able to detect estrus in different types of samples from dairy cows (Kiddy et al., 1978), to our knowledge dogs are currently not used for estrus detection on farm. Efficient and accurate estrus detection is a key management factor determining acceptable reproductive performance in dairy herds (Heersche and Nebel, 1994; At-Taras and Spahr, 2001). Visual observation for behavioral changes such as standing to be mounted, mounting, and increase in activity or physical signs such as clear and viscous vaginal mucus is a common method. Average estrus detection rates on commercial dairy farms, however, are below 60% (Senger, 1994; Becker et al., 2005). Estrus related odours constitute a major source of mammalian chemical communication and are present in vaginal mucus, urine, saliva, faeces, and milk of cows in estrus (Sankar and Archunan, 2004). In several experiments, dogs were trained to distinguish between vaginal mucus samples of cows in estrus and samples of cows in diestrus with an accuracy between 40.3% and 97.0% (Kiddy et al., 1978; Hawk et al., 1984; Jezierski, 1992; Fischer-Tenhagen et al., 2011). Also the ability of trained dogs to detect estrus-associated odours in other materials (i.e. urine, milk, blood plasma and saliva) has been demonstrated (Hawk et al., 1984; Kiddy et al., 1984; Fischer-Tenhagen et al., 2011; Fischer-Tenhagen et al., 2013). Of seven studies on dog training for estrus detection in cows only one study described the dog training procedure including the time needed in detail (Fischer-Tenhagen et al., 2011). Kiddy et al. (1978) trained dogs to detect estrus by direct examination of real cows placed side by side in groups of three in adjacent stalls. Cows were defined as being in estrus when they would stand firm when mounted by another cow. Cows were judged as being in diestrus at days 6–12 after estrus was detected. Mean percentage of correct detections was 87.3%. However, sensitivity and specificity were not calculated. Such it could be proven that dogs actually could identify cows in estrus by smell with only 36 cows. In 12 sessions with 16–26 replicates per session, the dogs had to detect one out of three cows (i.e. one in estrus and two in diestrus). Individual cows were changed only between sessions. Dogs searched from a position behind the cows. A platform of 46 cm height was situated behind the cows to raise the dogs to a convenient working height.

The objective of this study was to find out if and how it would be able to train dogs that could be used for heat detection under practical conditions on a dairy farm from the feed alley and without laborious installations. For a practical application it would be necessary to utilize detection dogs for screening eligible cows and to indicate those in estrus. Fischer-Tenhagen et al. (2013) showed that trained dogs were able to detect estrus-specific odours in saliva samples. Dogs passing behind the cows would include risk of injuries, hygienic problems, and a more stressful experience for the cows. Therefore, identifying cows in estrus from the feed alley with the cows fixed in the head locks would be advantageous (Fischer-Tenhagen et al., 2013). Specifically we set out (1) to develop a specific training protocol for training dogs to identify cows in estrus from the feed alley and (2) to determine sensitivity and specificity of trained dogs to detect cows in estrus.

2. Materials and methods

2.1. Dogs

Six privately owned pet dogs were enrolled in this study (Table 1). Selection of dogs was by convenience. All dogs had basic obedience education. Four of the six dogs had previously participated in a study on estrus detection in cows by odour in the laboratory (Fischer-Tenhagen et al., 2015). In this study, 5 dogs were trained to differentiate natural vaginal fluid from cows in estrus and diestrus, and 5 different dogs were trained to differentiate spray with or without synthetic estrus molecules. Dogs trained on natural fluid and on spray could detect the estrus odour they had been trained on with an overall accuracy of 69.0% and 82.4%, respectively. To validate the synthetic molecules, dogs trained with synthetic molecules had to detect estrus odour in natural vaginal fluid without further training and reached an accuracy of 37.6%. Dogs trained on natural fluid detected the synthetic molecules with an accuracy of 50.0% without further training.

Only dog 6 was used to cows before the training procedure started as it was raised on a farm while the other dogs had no experiences with cows before the training started.

2.2. Cows

Cows were kept on a commercial dairy farm in Brandenburg, Germany, milking 200 Holstein-Frisians and housed in a free-stall barn on deep bedded straw. Cows were fed twice a day with totally mixed ratio (TMR). For the training and the testing procedure, ultrasound examination was chosen as a gold standard to classify the cows as positive, i.e. being in estrus, or negative, i.e. being in diestrus or pregnant. For training the dogs, a total of 324 cows were selected as positive when displaying signs of estrus such as standing firm when mounted by another cow and clear and viscous vaginal mucus. Transrectal manual and ultrasound examination (BCF easy scan, BCF Technologies Ltd., Livingstone, Great Britain) showed a highly turgid uterus and a prominent follicle of 1.2–2.5 cm but no corpus luteum. In 57 cows estrus was induced by injection of 0.5 mg Cloprostenol (PGF Veyx forte, Veyx-Pharma GmbH, Schwarzenborn, Germany). A total of 641 cows served as negative controls. In these cows a transrectal ultrasound examination revealed a pregnancy ($n = 416$) or a prominent corpus luteum $\geq$1.0 cm on at least one ovary but no prominent follicle ($n = 225$). During the examinations and the training and testing process, cows were fixed in head locks.

2.3. Dog training

According to European legislation no part of this study included any insult to any animal. The dog trainer in this study was an experienced animal trainer who had conducted practical training with many species for more than four years. The trainer had contributed to three other scent detection studies with dogs (Johnen et al., 2013; Fischer-Tenhagen et al., 2015; Schallschmidt et al., 2015). Training was conducted on the farm between April 2013 and June 2014 two times per week. Training location was the feed alley of the dairy barn. The feed alley was 3 m wide and bordered by the head locks on one side and a solid wall on the other side. As some of the dogs were distracted by the TMR the entire cow feed was removed from the feed alley before training. Equipment used in