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Application of RFID technology using passive HF transponders for the individual identification of weaned piglets at the feed trough

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ABSTRACT

The study examined simultaneous individual animal identification of newly weaned piglets based on radio frequency identification (RFID) using passive high frequency (HF) transponders focusing on identification rate and identification accuracy. The antenna for simultaneous individual animal identification was integrated into the round trough of the feeder and connected to a conventional high frequency long range reader. HF transponders were attached to the eartags of the piglets. An anti-collision system was used in order to facilitate simultaneous registration of animals which were within reading range of the antenna at the same time. Anti-collision systems allow multiple access handling and prevent the collision of transponder data within the reading range of a RFID reader, which would render data unreadable. In order to determine the identification rate of this innovative system, trough visits of selected focal animals registered by the simultaneous individual animal identification were verified using video observation. The anti-collision system of simultaneous individual animal identification was validated through group observations.

The identification rate of 97.3% in simultaneous individual animal identification was very high. 33.3% of the trough visits were thereby registered simultaneously. 64% of the trough visits were registered with a short time delay. Average time delay of simultaneous individual animal identification did not exceed 3.00 s. The simultaneous individual animal identification sensed the beginning of a trough visit 0.28 ± 6.08 s earlier than the observer. The simultaneous individual animal identification registered piglets leaving the trough on average 2.77 ± 7.11 s earlier than the observer. Frequenting the trough had a significant influence on the functionality of the simultaneous individual animal identification. The number of animals registered by the simultaneous individual animal identification differed on average by 0.19 ± 0.04 piglets from the result of the observer if one single piglet was within the range of the antenna. If more than five animals were within the range of the antenna, a deviation of 1.04 ± 0.19 animals was observed ($P < 0.0001$).

The demonstrated system in principle represents a good possibility to simultaneously identify piglets online at the round trough of a feeder.

1. Introduction

Radio frequency identification (RFID) is one of the several technologies in the field of automated identification methods which automatically identify objects or subjects by using specific markers (transponders) (Kern, 2006). Besides already existing identification methods, this transponder technology will play an increasingly important role, as it can be integrated relatively easily into a great number of subjects or objects due to the continuing miniaturization of the system components (Finkenzeller, 2006). The utilization of radio waves for the communication between transponder and reader (RFID reader) forms the basis of the RFID system. It serves identification purposes (auto ID) and uses data registered on the transponder. The non-contact transmission of data (without electrical contact) occurs only when data is being requested. The RFID reader performs all communication tasks with the transponder and in most cases it is positioned near the place intended for identification to take place. The transponder is attached to the object to be identified. The tag has an antenna for sending and receiving as well as a chip for processing signals. Encoded radio waves are exchanged between the reader and tag and decoded and processed in the respective electronic system (Finkenzeller, 2006).

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In the future, RFID technology will also become more important in the tagging of livestock as this technology can be used in industry-wide applications as well as for the optimisation of company internal process management (Intrakamhaeng et al., 2007). Up to now, conventional low frequency (LF) transponders with an operational frequency range of 134 kHz have generally been used for the tagging of livestock. Use of these transponders complies with international standards ISO 11784 and ISO 11785 (ISO, 1996a,b) and has been employed for a multitude of applications in animal production for more than 20 years (Finkenzeller, 2006; Jansen and Eradus, 1999). The disadvantage of conventional LF transponders is a relatively low reading speed only allowing to readout one transponder at a time in the reading range (Finkenzeller, 2006). Simultaneous identification of more than one transponder in a very short time as it would be required at the round trough of a feeder is therefore impossible.

In the present study, a RFID system has been developed facilitating the simultaneous registration of piglets at the round trough by using high frequency (HF) transponders (13.56 MHz), analogous to the ones which are already frequently employed in industrial and logistic applications. In case of simultaneous registration of piglets at the round trough, several transponders can be present in the range of the RFID reader at the same time.

If there are several transponders within the range of the RFID reader, then the RFID reader cannot differentiate, if one or more transponders are sending the signals. Consequently, signals have to be distinguishable (Kern, 2006). The technical realization of this kind of multi-access in RFID systems puts high demands on the transponder and RFID reader. It is necessary to reliably prevent transponder data collisions in the receiver of the reader as this would render data unreadable. The technical procedure (access protocol) used in the present study – in connection with RFID systems referred to as anti-collision system – provides interference-free multiple access. The simplest anti-collision system of all is the ALOHA procedure. In this procedure, the RFID reader requests a response of all transponders within reading range after a random time. The reader gives a time-frame for the response wherein the response times of the individual transponders differ slightly. In case of a collision, the procedure will be repeated until all transponders can be identified and readout (Kern, 2006). The actual time required to transmit information only takes up a fraction of the time interval which is defined until the repetition of the transmission. This way, transponders can transmit their information to the RFID reader at different times. The ALOHA procedure represents a transponder-based, stochastic TDMA procedure (time domain multiple access). Transponder-based procedures work asynchronously as data transmission is not controlled by the reader. The procedure is solely used for read-only transponders which normally need to transmit only few data bits (small serial number) to a RFID reader and send these to the reader periodically. TDMA procedures can only be used in HF systems. Furthermore, anti-collision systems can generally only be used in HF systems where the antenna has a high reading rate (Finkenzeller, 2006).

First of all the identification rate and identification accuracy in simultaneous individual animal identification have been scrutinised in this study, since simultaneous individual animal identification of pigs is an innovative technology. The validation of the anti-collision system was an essential part of the study because the distinction of all transponders and communication with individual transponders without false reports present the greatest challenges of this innovative technology. An application example should outline future application possibilities for simultaneous individual animal identification.

2. Animals, materials and methods

2.1. Experimental procedures

The monitoring period in the present study comprised the first three weeks in which weaned piglets (weaned at 21 days of age) were reared and included two rearing cycles.

The study was carried out in an automatically ventilated and heated nursery with two identical pens. Each pen measured 8.30 m^2 in size, wherein the area was divided into an activity area of 3.25 m^2 covered with slatted floor and a resting area of 5.05 m^2 with a concrete-lined surface. Each pen housed 20 piglets. Animals were taken to the research facility on the day of weaning. One of the pens was equipped with a sensor-controlled mash feeder (PreMixer, EFS - System GbR, Essen i. Oldb., Germany) dispensing doses of mashed feed over an auger into the trough. Except for the round trough, this sensor-controlled mash feeder is entirely made of stainless steel. A sensor extending into the trough monitored the feed depth in the trough. The distance between sensor and trough was 1 cm. As long as the sensor did not come into contact with the feeding mash, 23 g of pellet feed per minute was transported over an auger toward the trough and mixed with water at a ratio of 1:1.5 (water:feed) shortly before being dispensed. Mixing time and mixing cycle were 2 min each. The other pen was equipped with a conventional tube mash feeder (Lean Machine, Big Dutchman, Vechta, Germany). The storage tank of this feeder was made of plastic material. In contrast to the sensor-controlled feeder, piglets had to actively move two dosing brackets arranged horizontally above the plastic trough for the feed to be released. Subsequently the animals could blend the feed to mash with water from two spray nipples also arranged above the trough. Both feeders had six feeding places. Feed was available ad libitum in both feeders.

2.2. Set-up of simultaneous individual animal identification

2.2.1. RFID reader

In the present study self-constructed circular HF antennas with a diameter of 34 cm were integrated into the round troughs of the feeders (Fig. 1). Copper-wire with a diameter of 15 mm was used to make the HF antennas. Antennas were constructed using an antenna tuning board (Feig Electronics, ID ISC.MAT-A) and tuned for optimal identification. Especially for this study, troughs were made out of polyvinyl chloride (PVC) as plastic can be permeated more easily by the magnetic radiation of the antenna than metal (Dittmann, 2006). The integration of the antennas into the round troughs of the feeders provided protection against moisture (Fig. 2). They were connected to the RFID reader via a coaxial cable. The antenna used in the present study had a data transmission rate of up to 25 kbit/s and thus offered sufficient reading speed to simultaneously register several transponders using the anti-collision system (TDMA, ALOHA procedure, Fig. 3). The RFID reader used in this study was a high frequency long range reader (LR 200, Feig Electronics, Weilburg, Germany) with an operating frequency of 13.56 MHz and 2 W transmitter power. Maximum reading range was measured under laboratory conditions before the beginning of the study and amounted to 30 cm. One reading took 0.12 to 0.15 s. The long range reader and a low voltage transformer (24 V direct current voltage) were installed into a stainless steel box for protection against splash water and fixed to the feeder. The reader was connected to an external PC via a cable for data transmission.

2.2.2. Transponders used in the study

Transponders are the actual data carrier of the RFID system. They consist of a coupling element and an electronic microchip (Finkenzeller, 2006). In the present study every piglet was tagged