Detection of Low Frequency External Electronic Identification Devices Using Commercial Panel Readers

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ABSTRACT

The ability of a commercially available panel reader system to read International Standards Organization-compliant electronic identification devices under commercial dairy conditions was examined. Full duplex (FDX-B) and half-duplex (HDX) low frequency radio-frequency identification external ear tags were utilized. The study involved 498 Holstein cows in the final 6 wk of gestation. There were 516 total electronic identification devices ($n = 334$ HDX and $n = 182$ FDX-B). Eighteen FDX-B were replaced with HDX during the study due to repeated detection failure. There were 6,679 HDX and 3,401 FDX-B device detection attempts. There were 220 (2.2%) unsuccessful and 9,860 (97.8%) successful identification detection attempts. There were 9 unsuccessful detection attempts for HDX ($6,670/6,679 = 99.9\%$ successful detection attempts) and 211 unsuccessful detection attempts for FDX-B ($3,190/3,401 = 93.8\%$ successful detection attempts). These results demonstrate that this panel system can achieve high detection rates of HDX devices and meet the needs of the most demanding management applications. The FDX-B detection rate was not sufficient for the most demanding applications, requiring a high degree of detection by panel readers. The lower FDX-B rate may not be inherent in the device technology itself, but could be due to other factors, including the particular panel reader utilized or the tuning of the panel reader.

Key words: dairy cow, electronic identification, electronic identification device, panel reader

INTRODUCTION

Interest in electronic identification of cattle has increased due to the activities of the National Animal Identification System (NAIS). The Cattle Industry Working Group of the NAIS recommended the use of

low frequency electronic identification devices (EID) in the form of International Standards Organization (ISO) compliant (ISO, 1996a,b; NAIS, 2006) external ear tags within a future national animal identification system. Blasi et al. (2003) discussed additional background information.

These devices are currently available commercially using half-duplex (HDX) or full-duplex (FDX-B) technologies. These devices are relatively inexpensive, passive, and read-only. Because it is likely that both technologies may be present on commercial dairies, detection devices such as handheld wands or panel readers need to detect either technology.

The working group's recommendation, coupled with the availability of relatively inexpensive EID ear tags and wireless hand-held wand-readers, has increased interest in adapting EID for use in daily commercial dairy operations. Some current applications include guiding reproductive, treatment, and other management tasks using hand-wands; providing identification for sort systems using panel readers; and providing identification for parlor data systems using panel readers.

Basarab et al. (2006), under research station conditions, demonstrated detection rates of 99.87% for HDX, 98.08% FDX-B, and 97.47% for a 50:50 mix using a commercial antenna system (Allflex Large ISO RFID panel readers PNL 6020, Allflex USA, Dallas, TX). They reported, under research station conditions, a 77.74% HDX detection rate, a 96.03% FDX-B detection rate, and 88.07% detection rate of a 50:50 mixture using a different commercial antenna system (Destron product number AN4241C, Digital Angel Corporation, South St. Paul, MN) and ISO stationary reader (Destron product number LVCAT100C, Digital Angel Corporation). Under commercial auction conditions, the overall detection rate was 98.78% for the Allflex system, 98.66% for a redesigned Destron antenna system, and a combined 98.74% overall detection rate for both systems.

Depending on the application, detection rates for these devices must approach 100% to be useful for daily commercial application. This study examined the

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ability of a currently marketed panel reader for detection of low frequency EID under commercial dairy conditions. The FDX-B and HDX external ear tags meeting ISO standards were used.

MATERIALS AND METHODS

The study was conducted during November and December 2006 in a commercial free-stall barn in north-eastern Wisconsin. Animals used were 498 nonlactating Holsteins of all parities (154 nulliparous, 174 primiparous, 170 multiparous) in the final 6 wk of gestation.

All animals already possessed or were equipped with an external ISO-compliant EID in the left ear. The EID 15-digit number was recorded in the dairy management software to allow matching with the management identification of the animal. The presence of the EID and its assignment to the correct management identification was confirmed using an ISO-compliant handheld wand communicating to a handheld computer. There was a mixture of HDX (Allflex USA) and FDX-B (Digital Angel Corporation) EID. There were 334 HDX devices with 6,679 detection attempts and 182 FDX-B devices with 3,401 detection attempts. The HDX devices were present in 153 nulliparous, 153 primiparous, and 28 multiparous cows; FDX-B devices were present in 1 nulliparous, 23 primiparous, and 158 multiparous cows.

A single cow lane (84 cm width $\times$ 625 cm length) was placed into an animal traffic alley. The traffic alley containing the single cow lane was accessible by exiting a 12-stall parlor or directly from other traffic alleys. A 180-cm-long fiberglass gate was placed in front of the entrance of the single cow lane to facilitate animals forming a single file and to reduce the lane to 84-cm width. The first 285 cm of the single cow lane was constructed using a fiberglass gate on one side and the outside wall on the other. The next 340 cm had sides constructed from solid polyethylene sheets. The width in this area of the single cow lane was 84 cm.

Because the system was a walk-through alley with no restraint of the head, it was not possible to measure the head placement or the precise read distance from the tag to the panel for individual animals. Yet, assuming the animal walked down the center of the alley and the ear tag was 20 cm from the center of the head, the data collection range would have been approximately 20 to 24 cm for the panel on the same side as the tag and 62 to 66 cm for the panel on the opposite side. Data were not collected to differentiate the data collection success rate for the 2 sides.

Two ISO-compliant EID panel readers (Allflex Large Panel Reader-PNL60120, 60 cm width by 120 cm

height) were mounted directly on the polyethylene sheets. The first panel was installed on the right side of the entrance, with the center of the panel at 345 cm from the initial entrance and 112 cm above the floor. The second panel was installed on the left side of the entrance, centered at 465 cm from the initial entrance and 112 cm above the floor. The panel reader manufacturer (Allflex USA) tuned the panel readers to detect FDX-B and HDX technologies.

Cattle were routed through a single-12 parallel parlor and exited in groups of 12 animals before entering the single cow lane during a morning time or were routed directly to the traffic alley containing the single cow lane from other traffic alleys during an afternoon period. Data from the panel readers were collected in a central controller located near the panel readers and transmitted to a personal computer via an RS232 cable. A customized serial port data capture program on the personal computer was used to capture, time-stamp, and store the incoming data stream. The time-stamps for the EID data collection were to the nearest whole second.

Actual speed of movement by the animals was not measured. Nevertheless, the time-stamps of the EID observations were used to calculate the intervals between animals and could be used to indirectly infer speed of movement.

After completion of a test series, the captured data (including time and date) were read into the dairy management software. A paper report was generated for those animals whose EID was anticipated, but not reported as detected. This report was used to determine if physical absence from the pen (e.g., due to an unrecorded pen move, calving, or other events) was the reason for the EID not being detected. If the animal was physically present in the pen, the EID was visually confirmed present and read with a handheld wand to determine data entry errors and EID failure. Any EID that was not detected after 3 unsuccessful read observation attempts (**RA**) by the panel readers was replaced.

A master file of the captured raw data was created. Another file was created with a line per anticipated animal, including the management identification, EID, pen location, anticipated date, and the actual date and time if detected. Data were summarized using Excel (Microsoft, Redmond, WA). Detection percentages were calculated using a modified Wald approach as described by Sauro and Lewis (2005).

RESULTS

There were 6,679 HDX and 3,401 FDX-B device read attempts for 10,080 RA (HDX 66%, FDX-B 34%). Five

hundred sixteen unique EID were present, representing 498 animals (18 FDX-B replaced by HDX due to multiple unsuccessful detection attempts). Mean EID RA for individual EID was 20 ± 0.5 (range 1 to 39).

Due to the utilization of preexisting EID, the type of EID was not random by parity. The device type count by parity were nulliparous (153 HDX, 1 FDX-B), primiparous (153 HDX, 23 FDX-B), and multiparous (28 HDX, 158 FDX-B).

There were 39 separate group collection attempts with a mean of 258 ± 4 RA per group collection attempt (range 203 to 307). The mean percent successful detection for the 39 collection attempts was $97.9 \pm 0.5\%$ (range 87 to 100%). There were 3 attempts when all anticipated EID were detected.

During the 10,080 RA, there were 220 unsuccessful RA for an overall $97.8 \pm 0.3\%$ successful RA (9,860/10,080). There were 9 unsuccessful RA for HDX (6,670/6,679 = $99.9 \pm 0.1\%$ successful RA) and 211 unsuccessful RA for FDX-B (3,190/3,401 = $93.8 \pm 0.8\%$ successful RA). The 97.8% overall successful read attempt percentage agree with the 98.74% commercial auction results (Basarab et al., 2006).

The 9 HDX unsuccessful RA represented 9 different EID and the 211 FDX-B unsuccessful RA represented 122 different EID (61 EID with 1 miss, 38 EID with 2 misses, 16 EID with 3 misses, and 7 EID with ≥ 4 misses). There were 18 FDX-B replaced by HDX after multiple unsuccessful read attempts.

There were 5,930 read attempts with time intervals of less than 6 s between consecutive animals. There were 17 (0%) with identical times; 274 (5%) with a 1-s interval; 1,536 (26%) with a 2-s interval; 2,012 (34%) with a 3-s interval; 1,339 (23%) with a 4-s interval; and 752 with a 5-s interval. Mean interval was 3.12 ± 0.01 s.

DISCUSSION

Any potential differences in RA success rates for the 2 types could arise due to innate differences in detection distances between technology types, differences in detection ranges for individual EID, age of the individual EID, or suboptimal panel tuning (allowing more optimal detection of HDX technology vs. FDX-B technology). These factors require further investigation.

EID Detection Percentage Requirements in Commercial Dairy Applications

Electronic identification of cattle holds many exciting possibilities for various management applications on commercial dairies. Some current examples include

guiding reproductive, treatment, and other management tasks using hand-wands; providing identification for sort systems using panel readers; and providing identification for parlor data systems using panel readers.

All of these uses require a high level of device detection by an EID reader. Nevertheless, the level of detection required does differ depending on the application. The primary differences in detection needs are related to the requirement for knowledge of the precise detection order of the EID and whether an unsuccessful RA will cause data for subsequent animals to be improperly assigned. Each use has its own level for detection distance demands.

Tasks such as reproductive examinations, disease treatments, vaccinations, and group inventory usually involve a restrained animal and use of a handheld wand. In these cases, the reader can be placed in very close proximity to the EID; there are disadvantages to greater distances because it would not be desirable to have more than 1 EID in the detection zone at a time. These tasks usually involve identifying the animal and performing the task while still in the restrained animal's presence. In this case, there is no problem with sequencing mistakes if an EID RA is unsuccessful.

Additionally, because the task will be performed while the animal is physically present, any available alternative means of identification could be used to ensure the proper matching of task and animal. Therefore, the level of electronic device detection required is lower than other potential applications. Although this study did not examine the use of hand-wands, in the authors' experience the current technology for ISO-compliant ear tags and hand-wands is virtually 100% because the user manually scans the cow until the tag is read, even if it means repositioning the scanner or the orientation of the ear of the cow.

When using a sort system, in many cases the consequences of an unsuccessful detection involve only the specific animal. The results of this study indicate that under commercial circumstances HDX detection rates exceeding 99% can be achieved, a sufficiently high standard for routine sorting tasks. Although a clear minimum is difficult to establish, an identification rate of less than 97% will lead to substantial frustration for routine management sorting tasks.

Tasks such as parlor identification have more demanding standards than tasks involving individual animals or sort systems, especially if the data collected are used for selection of cattle for examination or treatment. Parlor identification systems usually identify animals at the entrance to the parlor side or at the individual stall (Eicker et al., 2001).

Individual parlor stall identification systems usually require the EID detection from a greater distance than hand-wand tasks, but cannot have a detection distance allowing detection of EID in adjacent stalls. The consequence of not detecting an EID will usually involve only the specific EID itself and is usually limited to that animal. Major drawbacks to individual parlor stall identification include additional costs of installation and the need to maintain multiple antennas in larger parlors (Eicker et al., 2001).

For parlors with entrance lane identification, the size of the parlor has an effect on the degree of inaccurate data. For example, a 1,000-cow herd being milked in a double-10 parlor would have 50 parlor sides per milking. A single unsuccessful detection could result in an average of 5 animals receiving incorrectly assigned data for that parlor side. Read observation attempt success would be 99.9% (999/1,000), but data accuracy would be 99.5% (including the undetected animal). The range would be 99.0 to 99.9%, depending on the parlor stall of the animal with the undetected EID. If 5 EID were not detected in the above example parlor for the entire milking, the EID RA success would be 99.5% (995/1,000), but data accuracy could be as low as 95.0% or as high as 99.5%.

If management is relying on these data to make decisions that have potentially negative impacts (e.g., antibiotic treatment or injection of prostaglandin), a potential 10% error rate is not acceptable. Data accuracy will become more critical and must be held to a much higher standard as newer testing sensors and technology become available. Examples may include determination of reproductive status or metabolic status and detection of diseases or pathogens.

Considerations for a Complete Identification System

Hardware manufacturers have made progress in developing systems to meet the needs for an electronic identification system with acceptable performance. Nonetheless, a fully robust identification system requires more than functional EID and panel readers. Because automated EID need to operate at very high levels of detection success without interfering with the normal pace of traffic flow of animals, a more complete approach to system design must be taken, including close attention to the physical layout of the lane containing the panel readers. To maintain high levels of detection, requirements for the lane layout include limiting the ability of multiple animals in the reader field at the same time, speed of travel through the lane (Basarab et al., 2006), prevention of partial entry and withdrawal, and shielding to eliminate identification

of animals on the outside of the panel lane. These factors require a carefully designed panel lane with animals walking through single-file in an orderly fashion. Some of these variables may vary in importance, depending on the class of animals using the system.

Some considerations for the layout include the entrance to the panel lane, the width of the panel lane, mounting and tuning of the readers, detection and elimination of environmental electrical noise, and robust wiring and communication systems. More research will be needed to determine the optimal approaches to these factors.

In this study, all EID tags were placed in the left ear, based on the recommendations of the NAIS and the manufacturers. Nonetheless, because there may be tags placed in right ears by mistake or other reasons (e.g., non-USA regulations) and because there may be bidirectional flow through some systems, the panel readers will need to be able to read a device in either ear.

CONCLUSIONS

Interest in electronic identification has increased due to the activities of the NAIS and the availability of inexpensive EID and wireless hand-held readers. The Cattle Industry Working Group of the NAIS recommended the use of low frequency electronic devices deployed as ISO-compliant external ear tags. The FDX-B and HDX ISO-compliant ear tags were used. The study demonstrated the potential for detection at relatively high rates (99.9% for HDX, 93.8% for FDX-B, 97.8% total). The HDX detection rate was high and would be sufficient for the most demanding applications. The FDX-B detection rate is not sufficient for the most demanding applications requiring a high degree of detection by panel readers. Caution is required prior to extrapolating these results to all FDX-B ear tags. For example, the FDX-B tags detection rates may differ from one manufacturer to another. Additional work will be required to examine different combinations of EID and panel readers.

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