Adoption of digital technologies for the management of repeat breeder cows in the dairy herds of Bangladesh

Abstract

A crucial component of contemporary livestock dairy production is digitalization. In order to monitor and manage repeat breeder (RB), we describe the use of dairy herd records, closed-circuit (CC) cameras, and ultrasonography findings. A cow must get through a number of physiological hurdles after calving in order to become pregnant. Herd fertility is achieved through timely artificial insemination (AI). Using CC cameras and ultrasonography, we surveyed 25 local farms and 25 commercial farms for this study. Within the dairy farms under survey, we discovered 10 RB. Following six months of observation, we minimized and 70% of RB cows were pregnant. AI is the term for the widespread use of reproductive tools in Bangladesh. The success of AI depends on the exact timing of estrus and ovulation. The CC camera plays a role in determining these two AI variables. All farms used AI during our analysis, but ultrasonography was only used sporadically. But there aren't many commercial farms that use CC cameras only for security. We were unable to locate any farm that used CC cameras for breeding. While recent advancements in ultrasonography can help diagnose reproductive tract pathology, further studies are required to decide whether or not these methods can be applied clinically in veterinary medicine. New tools, such on-farm CC camera surveillance, need to be created in order to take advantage of the research findings and apply them to improve on-farm performance and increase awareness among dairy herd owners.

Key Words: Dairy cows, Repeat breeder, Digital technologies, Adoption, Management.

Introduction

The dairy cow industry has much more digital technologies available than other livestock industries (Stachowicz and Umstätter, 2020). Digital tools for reproduction are not widely used in Bangladesh. However, poor conception rates and extended periods between calvings are the results of reproductive diseases and disorders in Bangladesh (Shamsuddin et al., 2001, 2006; Sheldon et al., 2009). With the ability to monitor the complete reproductive system non-invasively, closed-circuit (CC) cameras and ultrasonography have emerged as critical diagnostic tools in the field of bovine medicine for assessing the female reproductive system and dairy herd (Carriere et al., 2005). Early in the 1980s, veterinary professionals and animal scientists became interested in ultrasonography as a result of research demonstrating the technology's value in analyzing cow reproductive organs (Taylor et al., 2004; Pierson et al., 1988). According to Kumar and Purohit (2009), ultrasonography is an efficient tool for tracking therapy responses and diagnosing reproductive issues. Treatment for reproductive diseases aims to improve ovarian and uterine defense and repair while reversing inflammatory changes that reduce fertility.

Repeat breeding (RB) is a major problem in cow breeding that results in large financial losses for dairy producers because of more inseminations, longer calving intervals, and greater culling rates (Bartlett et al., 1986, Lafi et al., 1992).RB is defined as the inability to conceive following three or more regularly spaced services without clearly visible anomalies (Zemjanis, 1980).Failure to fertilize or embryonic mortality are two potential reasons why RB is required—a return to oestrus after mating or artificial insemination (AI). Several studies have found that in female cattle with normal fertility, 10% of the cases of fertilization failure are due to early embryonic death within 3 weeks of fertilization. 30%, which in the first 21 days after AI led to an early pregnancy loss of around 40% (Roche, 1981). This suggests that 40% of females will, on average, return to oestrus after each AI or mating[28-30]. Numerous external factors, such as diet and climate, in addition to intrinsic animal traits, have been linked to this early embryonic loss in cattle (Ayalon, 1984; Pope, 1988). Furthermore, early embryonic loss—which comes from the early eradication of unsuitable genotypes—has been proposed as "normal" (Bishop, 1964). The following non-infectious causes are listed by El-Khadrawy et al. (2011): infertile bulls, poor nutrition, heat stress, chromosomal aberrations, hormonal imbalances, anatomical defects of the reproductive tract, improper timing of insemination, inadequate detection of estrus, improper handling of semen, and poor management. In this work, we monitored the RB cows on dairy farms using CC cameras, with a focus on precisely identifying estrus.

Moreover, ultrasonography's non-invasive characteristics render it an ideal clinical and scientific instrument for examining bovine reproduction (Mwaanga et al., 2004; McDougall, 2001). Ultrasound technology is the most accurate method of determining if an RB cow is pregnant. We also assessed the corpus luteum, ovarian follicles, and ovarian cyclicity in Bangladeshi zebu cows to improve reproductive efficiency. We were able to examine uterine and cervical alterations thanks to this approach. (Hoque and others, 2009). Therefore, the ultra-sonograph and CC camera are useful instruments for improving herd fertility, especially for RB cows. The higher production rate and lower management and treatment costs of RB cows benefit farmers monetarily as well.

Methods and Materials

Data collection

To analyze the existing level of mechanization and automation in our animal dairy production for labor-economic evaluations, a thorough prescribed questionnaire survey of farmers was used for this work. To achieve this, the normal machinery utilization and operating practices prevailing in each firm were devised for 25 local and 25 commercial dairy farms. Different quantities of questions and response choices that are pertinent to our animal dairy production will be included in the surveys. The fieldwork was conducted in local and commercial dairy farms in some selected areas of Bangladesh utilizing ultrasonography and CC cameras.

Closed-circuit (CC) camera

CC camera systems was installed in the selected and identified RB cows dairy farm for monitoring (Figure 1).

a) **Heat Detection:** CC cameras were installed in areas where cows congregate or exhibit signs of heat.
b) **Calving Surveillance:** CC cameras placed in calving pens or maternity areas allow farmers to remotely monitor cows during the calving process.
c) **Fertility Monitoring:** CC camera systems were used to monitor reproductive health and fertility parameters in dairy cows. This includes observing estrusbehavior, assessing body condition score, monitoring uterine discharge, and detecting signs of reproductive disorders such as metritis or cystic ovaries.

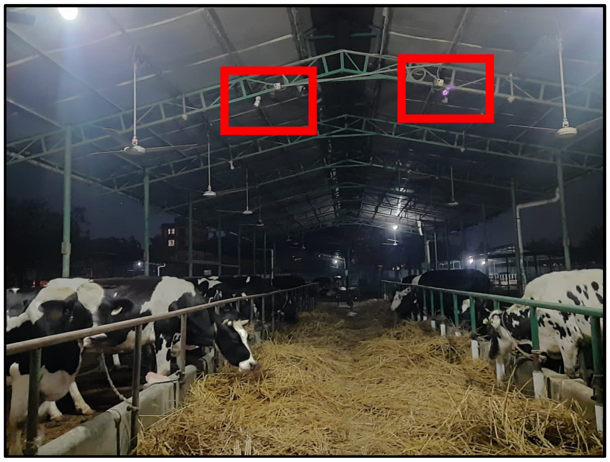

Fig. 1. Closed-circuit (CC) cameras in the dairy farm (Red squares).

Ultrasonography

As early as 28 days following AI, the dairy cows' reproductive tracts were scanned using transrectal ultrasound to detect the existence of a growing fetus. A portable ultrasound device equipped with a linear array dual frequency probe (3.5 MHz) was used to do the ultrasound scan. Ultrasonic gel and a real-time B-mode ultrasound scanner (EsaoatePiemedical, Tringa Linear) operating at 3.5 MHz (frequency converted from 3.5-7.0 MHz) were utilized (Figure 2a, b).

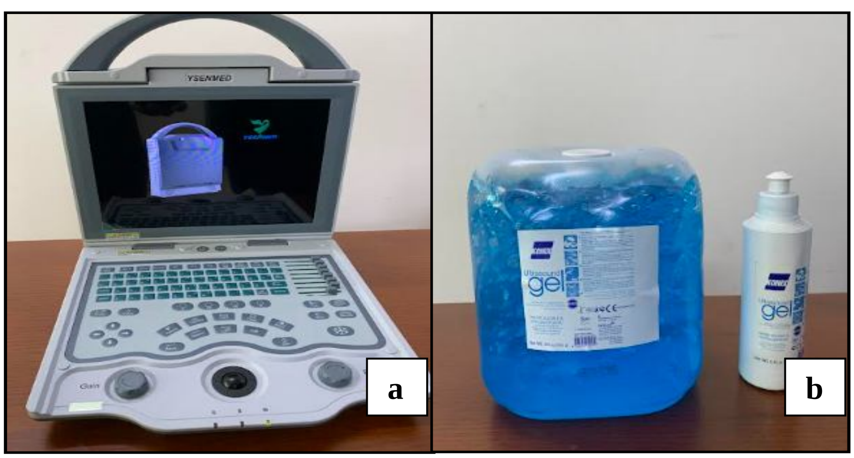

Fig. 2. a) Ultrasound Scanner, and b) Ultrasonic gel

Statistical analysis

A Microsoft Excel spreadsheet was used to hold the recorded numerical data, from which descriptive statistics (percentages) were calculated. Nonparametric techniques were employed to analyze the data, which were presented as mean ± standard error (SE).

Results and Discussion

In Bangladesh, AI is the nationwide use of reproductive tools. We observed 25 commercial and 25 local farms in different locations in Bangladesh. The results are presented in Table 1 and 2. We found most of the farms using AI for the breeding purpose. On the other hand, a fewcommercial farms (7) use ultrasonography and rarely (3) using in the local farms. Moreover, very few commercial farms (3) use CC cameras only for security purposes other than reproductive purposes. Local farms did not use CC camera.

Table1: Reproductive and monitoring tools used in the commercial livestock dairy farms

Dairy herd	Number	Artificial insemination	Ultrasonography	CC camera
Commercial	1	+	-	+
	2	+	+	-
	3	+	-	-
	4	+	-	+
	5	+	-	-
	6	+	-	-
	7	+	+	-
	8	+	-	+
	9	+	+	-
	10	+	-	-
	11	+	-	+
	12	+	+	-
	13	+	-	-
	14	+	-	+
	15	+	-	-
	16	+	-	-
	17	+	+	-
	18	+	-	+
	19	+	-	-
	20	+	-	-
	21	+	+	-
	22	+	-	-
	23	+	-	+
	24	+	-	-
	25	+	+	-
	"+" Using the specified tools and "–" not used			

Table 2: Reproductive and monitoring tools using in the local livestock dairy farms

Dairy herd	Number	Artificial insemination	Ultrasonography	CC camera
Local	1	+	-	-
	2	+	-	-
	3	+	+	-
	4	+	-	-
	5	+	-	-
	6	+	-	-
	7	+	-	-
	8	-	-	-
	9	+	-	-
	10	+	-	-
	11	+	+	-
	12	+	-	-
	13	+	+	-
	14	+	-	-
	15	+	-	-
	16	+	-	-
	17	+	-	-
	18	+	+	-
	19	-	-	-
	20	+	-	-
	21	+	-	-
	22	+	-	-
	23	+	-	-
	24	+	-	-
	25	+	-	-
	"+" Using the specified tools and "–" not used			

Repeat breeder cows, closed-circuit cameras and ultrasonography

Ten RB cows were identified from selective commercial and local dairy farms were under close observation and records. The RB cows underwent timely artificial insemination, accurate estrus detection, and close monitoring. Seven RB cows out of ten were found to be pregnant through ultrasonography. The remaining RB cows were not expecting. We hypothesized that the failure to detect estrus was the reason behind 70% of RB cows. It was recommended to cull the non-pregnant RB cows because of the unidentified cause shown in Table 3.

Table 3: Management of repeat breeder cows

Repeat breeder Cows	CC camera monitoring Estrus time	Natural/AI Time	Pregnant/Non-Pregnant (Estrus /Ultrasonography
1	11.45 PM	8.00 AM	Pregnant
2	4.45 PM	9.00 PM	Pregnant
3	2.00 AM	8.00 AM	Pregnant
4	9.23 PM	8.00 PM	Non-pregnant
5	7.43 AM	2.00 PM	Pregnant
6	3.00 AM	9.00 AM	Non-pregnant
7	2.00 AM	8.00 AM	Pregnant
8	9.23 AM	8.00 PM	Non-pregnant
9	7.43 AM	2.00 PM	Pregnant
10	3.00 AM	9.00 AM	Pregnant
Success rate-70%			

Several prominent people in the smart farming industry in America and Europe introduced smart dairy farming (SDF) techniques into small- or large-scale farms in order to improve agricultural management and increase revenues. Researchers developed "afimilk," "Fullwood," and "ConnectedCow" to detect estrus and monitor the health of the herd (DeLaval, 2020). Nevertheless, there aren't many farms employing SDF techniques in the Asia-Pacific area. As of right now, Bangladesh does not have any startups or companies offering high-tech products and services. This suggests that Bangladesh is lagging behind other countries in the globe in its dairy cattle business. On the other hand, CC cameras' benefits have made them a necessary part of dairy farms' everyday operations. Monitoring herds, dairy operations, and even biosecurity are among the benefits of using CC cameras for safety and security. Our observations indicate that the CC cameras on the dairy herds were purely security-related. This research proposes an internet of things (IoT) integrated non-invasive, non-contact estrus detection method to increase the detection efficiency of standing-heat behaviors in cows.

The clinical diagnosis of pathological disorders and the assessment of the reproductive tract's physiological state have gained additional depth with the application of ultrasonography. In addition, the use of surveillance closed-circuit television cameras is essential for animal reproduction and other purposes, particularly the precise timing of estrous cycles. For a dairy herd's artificial intelligence to be successful, estrous timing is crucial. Therefore, the percentage of animals displaying normal postpartum uterine involution and return to cyclicity as determined by ultrasonography (Crowe, 2008; Sheldon et al., 2009) can be used as a gauge for how well periparturient care is working. The frequency of reproductive examinations, the operator's skill level, and the farmer's willingness to invest time and money in the operation can all have an impact on how much knowledge from research is used in clinical practice. With the introduction of Doppler and high resolution ultrasound equipment, more thorough examinations are now feasible; nevertheless, a cost/benefit analysis has not been done.Although ovarian structures can be more accurately differentiated with ultrasonography than by palpation (Ribadu et al., 1994), distinguishing follicles from blood arteries and the lymphatic system requires some expertise and caution.Blood vessels may be mistaken for a fresh wave of developing tiny follicles as they reach the ovary at the ovarian pedicle. Carefully seen from the point of development, the corpus luteum (CL) is 76% visible on the day of ovulation (Ginther, 1998). But this is much simpler to do if you know where the ovulatory follicle was before; otherwise, you would need to check and document the structures frequently. Although a thorough examination of the ovaries is necessary to diagnose anestrus, the presence of a tiny amount of luteal tissue does not imply normal cyclicity. Progesterone concentrations in milk and plasma are often lower in the first CL postpartum than in the normal period. Progesterone concentration and CL diameter are often significantly associated (Ginther, 1998); however, progesterone concentration decreases two to three days before to the reduction in CL size at the conclusion of the cycle (Ribadu et al., 1994). During the luteal phase, the echogenicity of luteal tissue is constant, declining on Day 2 after reaching its peak during development. It declines once more one or two days prior to the decline in progesterone concentration. Following luteolysis, the echogenicity rises once more as the CL diameter shrinks. In terms of structure, the CL is often visible until the day of ovulation, although its diameter is only about 20 mm. Although CL echogenicity changes have been identified using computer image processing, a consistent setup of the ultrasound apparatus and monitor would be necessary if CL echogenicity changes were to be employed as a therapeutically useful predictor of CL age by sight. It has been determined that echotexture, or heterogeneity (variation) of the structure's echogenicity as determined by the standard deviation of the mean pixel value, may be a more valuable indicator than echogencity alone (Siqueira et al., 2009). Prostaglandin (PG) pulses during spontaneous luteolysis seem to be linked to brief rises in CL blood flow, which subsequently decreases in tandem with progesterone concentration. Therefore, according to Bollwein et al. (2012), CL diameter by itself may provide more therapeutically relevant information than Doppler ultrasonography. In the center of CLs, there is frequently a fluid-filled hollow called a lacuna that varies in size and duration. Regardless of whether luteolysis takes place or the pregnancy keeps the CL intact, the majority achieve their maximum diameter 6 to 10 days after the CL forms and fill in by Day 18. Typically, the luteal tissue wall's thickness does not exceed the cavity's radius. However, during typical cycles, enormous thinwalled CLs can emerge (Ginther, 1998). It has been largely confirmed by ultrasonography that waves of follicular development take place in vivo. Each estrus cycle, cows have two or three waves that emerge (diameter more than 4 mm) on roughly Days 0, 9, and 16 of the cycle (see diagrams in Crowe, 2008). Generally speaking, a CL has acquired PG receptors to be completely sensitive to exogenous PG if its diameter is more than 20 mm. The smallest follicle with a diameter more than 5 mm (i.e., emerged) has an inverse relationship with the time to estrus following luteolysis. The timing of estrus following PG injection can be predicted using this information (Siquiera et al., 2009). Throughout its existence, the follicular lumen contents (antrum) exhibit a steady level of echogenicity. According to certain theories, the buildup of cell debris during atresia causes it to become increasingly diverse (Ginther, 1998). In an on-farm setting, this is delicate and challenging to ascertain. Once anovulatory follicles reach their maximal size, their follicle walls become less echogenic. When the follicle begins to shrink during atresia, it grows once more. Before ovulation, the echogenicity of the walls of ovulatory follicles decreases more and then rises (Ginther, 1998). It has also been demonstrated that, when ovaries are harvested after slaughter and placed in an in vitro maturation system, the ovarian tissue that produced low-quality embryos is less echogenic than the tissue that produced high-quality embryos. It has not been investigated if these visual distinctions can be used to forecast outcomes in clinical settings. The follicle that will become dominant and the others before deviation have the same blood flow. Following this, the dominant follicle receives more blood flow, while the other follicles receive less (Acosta et al., 2005). The blood flow increases much more during ovulation as a result of the surge in LH. It is unknown whether variations in blood flow between follicles that do or do not ovulate after luteolysiscould predict fertility. Before ovulation, the amount of folding in the uterine wall decreases while its thickness, contractility, echogenicity, and luminal fluid content all rise (Ginther, 1998). When a small, less defined CL is present, it can be helpful to differentiate between the stages of the estrus cycle, as it may be undergoing luteolysis (Day 19–20 of cycle) or recently created (Day 3–4). However, fluid in the uterine lumen before ovulation, but not after, is useful.Even while vaginal fluid may contain blood after ovulation, it is still a better indicator than what is seen at both times. In our experience, a lot of veterinary surgeons do not value the information above when doing B-mode ultrasound examinations on cattle. One can predict the point within the estrus cycle and the time to spontaneous or PG-induced luteolysis and ovulation in two to three days if all of the previously mentioned information is taken into consideration and a two-wave cycle in lactating cows is considered. According to recent research, the frequency of follicular waves and duration of the estrus cycle are influenced by the CL's ovarian position in relation to a follicle (Ginther et al., 2013). Tools for ultrasonography and CC cameras are very helpful in managing dairy herds' recurrent breeder cows.

Conclusions

In cows, RB is a complex issue that involves issues related to each cow as well as management and environmental concerns. In dairy farms, the prevalence of RB was higher. This was probably caused by an intensive management system, a lack of herd health practices, and a poor estrus detection and timing of AI. The adoption of digital technologies in Bangladesh livestock dairy production varies strongly between different agricultural enterprises. Ultrasonography and CC camera need to be developed not only to minimize the RB cows but also to allow farmers and veterinarians to monitor the dairy herds, so that the dairy herds are cost effective and benefited to the farmers.

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Details of the AI usage are given below:

1.

2.

3.

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