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Reproductive Performance and Factors Affecting the Success Rate of Artificial Insemination of Cattle in Up-country Multiplier Farms of Sri Lanka

P.A.B.D. Alexander, H. Abeygunawardena, B.M.A.O. Perera[1] and I.S. Abeygunawardena[2]

Department of Veterinary Clinical Studies
Faculty of Veterinary Medicine and Animal Science
University of Peradeniya
Peradeniya, Sri Lanka

ABSTRACT. *A study was conducted to determine the reproductive performance, success rate and factors affecting conception rates following artificial insemination (AI) at Ambewela, Bopaththalawa, Dayagama and New Zealand farms of Sri Lanka. Information on farm characteristics, management, feeding and breeding was recorded. A total of 200 cows receiving AI were followed from a recorded service up to pregnancy. Detailed information on breed, age, parity, milk yield, body condition, body weight, intensity of oestrous signs, degree of cervical dilatation and uterine tone, site of semen deposition, time interval from oestrus onset to insemination, source of semen, and experience and skills of the technician were recorded at the time of insemination. Milk samples on the day of service (day 0), on day 10 and 21 post–service were obtained for milk progesterone estimation. Rectal examination was performed on 45–60 days post–insemination for pregnancy diagnosis on cows not returning to oestrus. The mean interval from calving to first service and conception were 111.2±74.2 days (n=133) and 156±92.7 days (n=170), respectively. The average first–service and all–service conception rates were 50.4% and 53.6%, respectively, while the average services per conception was 1.9. The results of this study indicate that the fertility status and overall success rate of AI at Ambewela, Bopaththalawa and Dayagama farms were in the lower range of the acceptable level while at New Zealand farm they were much lower than the desired levels. The study highlights the possible reasons for poor fertility as the factors related to management, heat detection, timing of AI, bull/semen and technician.*

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[1] IAEA/FAO Joint Division, Vienna, Austria.

[2] Department of Veterinary Pre–Clinical Studies, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, Sri Lanka.

INTRODUCTION

Since the beginning of 1950s, cattle and buffalo multiplier farms were established in several regions of the country with the primary objective of providing genetically superior progenies of exotic dairy type animals to smallholder farmers to upgrade the production potential of their animals. On this basis, livestock farms in the up-country wet zone region were established to maintain and multiply specific pure *Bos taurine* breeds such as Ayrshire (Ambewela farm), Friesian (New Zealand farm), Short Horn (Bopaththalawa farm) and Jersey (Dayagama farm). Natural mating with superior sires, both of imported and local origin was carried out in these farms until artificial insemination (AI) was introduced in early 1980s. Today AI is used as the primary breeding method in these farms (MRID, 1988).

Artificial insemination was first introduced to Sri Lanka on experimental basis in 1937 and the first AI was successfully performed at Meewatura farm at Peradeniya (Mahamooth, 1955). Thereafter, AI service was in operation in and around Peradeniya, but the acceptance by the smallholder farmers was low (Jeganathan, 1955). However, less attempt has been made to expand the AI service until independence. With the dawn of independence, development of agricultural sector was vigourously pursued, and the number of AIs per annum rose from 72 to approximately 100,000 in early 1990s (MADR, 1991/92). This increase parallelled the expansion of field veterinary service. Since mid 1970s with the receipt of international donor assistance, field level AI operation expanded significantly and today, it is operated island wide. However, the AI coverage in terms of the estimated number of breedable cattle in the country is still less than 15% and the calving rate due to AI has been estimated in the range of 20 to 30% (Soni *et al.*, 1991; Abeygunawardena and Amarasekera, 1995). The acceptability of AI by the small holder farmers, their heat detection efficiency, the success rate of AI and factors which affect the success rate of AI in the small holder farms have been studied previously (Abeygunawardena *et al.*, 1995a, 1995b; Alexander *et al.*, 1997). These studies revealed that while AI was accepted by almost all the small holders as a reliable breeding method, its success rate appeared to be less than the acceptable level (conception rate < 60%). Many factors emanating from the farm, cow, semen and AI technician have been attributed as causative factors for the low conception rates. Information with regard to the large animal multiplier farms is scarce. Thus, a study was carried out to estimate the fertility status, and determine the success rate and factors which limit the success rate of AI in four selected farms in the up-country wet zone region of Sri Lanka.

MATERIALS AND METHODS

The study was conducted from April 1997 to December 1997 at four up-country large farms, namely Ambewela, Bopaththalawa, Dayagama and New Zealand. A total of 200 cows receiving AI were followed and approximately 50 cows were studied from each farm. In liaison with the farm managers and the inseminators employed in the four farms, dairy cows receiving first insemination following a recorded calving were monitored until they were confirmed pregnant. Information on the farm, cow, semen, and AI technician was collected and recorded in the formatted record sheets.

Farm data

Information regarding total land extent of the farm, herd size, housing system, herd composition, type of management, feeding systems and breeding practices, including the voluntary waiting period from detection of oestrus to insemination, was collected.

Cow data

From cows presented to AI, information as regard to identification number, date of birth, parity, last calving date, last calving type, date of first postpartum heat, lactation state, body weight, average milk yield, code of semen, service number, dates of AI, interval between heat detection and AI, and time of the day at which AI was performed were recorded. Visual appraisal of heat sign, degree of vulval swelling and colour of mucus discharge was done and degree of uterine tone, site of semen deposition were assessed by rectal palpation. Further, the nutritional status of the animal was assessed by estimating body condition score (BCS) on a scale of 1 to 5 at AI.

Semen/bull data

Data with regard to the breed of semen donor, identification number, source (local/imported), volume, type of semen (chilled/frozen), quality (if available) and sperm dose were recorded for each AI performed.

AI technician data

Data was collected from AI technician included in the study with regard to the age, highest level of education, duration of formal training in AI, number of years of experience, average number of AIs done per month, type of employment, method of thawing of semen and other non–AI work performed by them.

Milk sampling

A milk sample (10 ml) was collected into a bottle containing a potassium dichromate tablet as a preservative at the time of insemination (Day 0). Second and third milk samples were collected on 10–12 days (Day 10) and 21–23 days (Day 21) after the insemination.

Dates of subsequent services, if any, were recorded for cows presented for repeat services. In all cases those not returning to service within 60–90 days after the last service were examined for pregnancy by rectal palpation.

Milk progesterone assay

Milk samples were placed in a refrigerator (4^{0}C) within 6 h of collection and transferred to the laboratory for processing within 7 days. At the laboratory, milk samples were centrifuged using a refrigerated centrifuge at 1000×g for 10 min and the fat–free fraction (skim milk) was drawn off and stored at -15^{0}C until assayed. Progesterone concentration was determined using a direct solid–phase radioimmunoassay (RIA) employing antibody–coated tubes, ^{125}I–progesterone as tracer and standards (0, 1.25, 2.5, 5, 10, 20, 40 nmol l^{-1}) prepared in skim milk (RIA kits were supplied by the joint FAO/IAEA Division, Vienna). The intra–assay and inter-assay coefficients of variation were 9% and 14.5%, respectively.

Data tabulation and analysis

The data were analysed using the Artificial Insemination Database Application (AIDA) developed under Microsoft Access and supplied by the joint FAO/IAEA Division, Vienna, Austria.

RESULTS

Farm information

Dairy was the primary purpose of cattle keeping in all four farms studied. Unproductive animals were sold for meat and a limited number of progenies were sold to the public for breeding purposes on *ad hoc* basis. Besides livestock, most farms cultivated crops to supplement income. The characteristic of four farms are given in Table 1.

Table 1. Characteristics of large multiplier farms.

Farm	Land extent (ha)	Pasture (ha)	Herd size	Breed	Managing system	At first service		
						BW (kg)	BCS	Average milk yield (l day^{-1})
Ambewela	242	62	450	Ayrshire	TSD	365±48	3±0·2	8·8±5·0
Bopaththalawa	210	108	367	Friesian	TSD	450±56	2·6±0·2	10·1±3·1
Dayagama	220	150	477	Jersy	TSD	285±28	2·6±0·4	9·5±2·2
New Zealand	325	43	365	Friesian	LBZ	500±42	3·1±0·3	14·0±4·3

TSD = Tie stall + day time grazing LBZ = Loose barn + zero grazing
BW = Body weight BCS = Body condition score

Management

Three farms (Ambewela, Bopaththalawa and Dayagama) used the tie stall systems while one farm used loose barn system. In all the farms late pregnant animals were kept under a tie–stall system. All farms had adequate light and ventilation but the floors were not properly constructed or maintained. In New Zealand farm lactating animals were not sent to pasture, but fed with cut grass, concentrate, urea–molasses mixture and brewers-waste occasionally. In other three farms, lactating animals along with other animals were sent to pasture after morning milking, and herded back to the tie-stall barns in the evenings. The principal forage source in most farms was an improved variety of *Pusa Giant Napier* (PGN) while one farm had *Kikiyu* grass. All the animals were given moderate amounts of concentrates (approximately 3 kg of compounded feed per animal) and minerals. Machine milking was done twice a day in three farms (Bopaththalawa, Ambewela and New Zealand) while at Dayagama hand milking was practised. Zero suckling was practised in all farms. Average age of calves at weaning was 3.2±1 months. All the farms had a good recording system with a certain degree of computerization. Only one farm (New Zealand) had other livestock such as rabbits and goats, and produced processed milk products. The excess production of this farm and the entire collection of other three farms were sold to a processor.

Breeding

All the farms used AI for breeding their cows, but natural service was used occasionally to impregnate repeat breeder animals (animals presented to more than 3 repeat services). Detection of heat was done visually by the herdsman in two farms (Ambewela and New Zealand). The other two farms (Dayagama and Bopaththalawa) used a teaser bull to aid in heat detection by the herdsmen. Artificial inseminations were carried out by farm employed inseminators. All the farms bred their cows at the oestrus occurring after 45 days postpartum. The breed of semen was determined by the genotype of the existing cow population in the farm. During the period of study, all four farms used only imported semen for AI.

Cow information

All the farms had *Bos taurus* genotypes but heterogeneity of the herd composition was observed. This has been due to random changes in breeding policy in the past at Bopaththalawa and Ambewela. The body condition score (BCS) of these animals ranged from 2 to 3.5 and the average body weight of cows presented to AI (400±93 kg) was lower than the expected body weight of the respective breeds.

Semen and technician information

Semen from five bulls was used for AI during the study period. Five technicians were included in the study (two technicians from Bopaththalawa and one technician per farm from Ambewela, New Zealand and Dayagama). The age of technicians ranged from 20–40 years and almost all of them had more than 2 years of experience. They also performed other duties besides performing AI.

Fertility indices following AI in cows

The overall mean interval from calving to first service was 111.2±74.2 days (Table 2), with the longest interval at New Zealand farm (128±96.5 days) and the shortest at Dayagama (91±33.5 days). Mean interval from calving to conception was 156±92.7 days, with the longest interval at New Zealand farm (175±96.1 days) and the shortest at Bopaththalawa (136.0±65.6 days). Mean first-service conception rate was 50.4% with the lowest recorded at New Zealand farm (31.3%) and the highest at Bopaththalawa (70.5%).

Table 2. Fertility indices of cattle subjected to AI.

Farm	Mean interval (days) from calving to		Conception rate (%) to		Services per conception
	First service	Conception	First service	All services	
Ambewela	102±63.2 (n=13)	159±103.6 (n=23)	53.8 (n=13)	65.7 (n=35)	1.5
Bopaththalawa	109±66.3 (n=34)	136±65.6 (n=42)	70.5 (n=34)	69.3 (n=62)	1.4
Dayagama	91±33.5 (n=35)	148±101.5 (n=45)	57.1 (n=35)	60.0 (n=75)	1.7
New Zealand	128±96.5 (n=51)	175±96.1 (n=60)	31.3 (n=51)	40.8 (n=147)	2.5
Overall	111.2±74.2 (n=133)	156±92.7 (n=170)	50.4 (n=133)	53.6 (n=319)	1.9

The all–service conception rate (CR) was 53.6% with the lowest at New Zealand farm (40.8%) and the highest at Bopaththalawa (69.3%). The average services per conception was 1.9, with the highest at New Zealand farm (2.5) and the lowest at Bopaththalawa (1.4).

Progesterone concentration

The interpretation of progesterone data, based on one sample (Day 0), two samples (Day 0 and 10–12) and three samples (Day 0,10–12 and 21–23) are given in Tables 3, 4 and 5, respectively.

Table 3. Diagnosis based on one sample.

Day 0 (AI)	Freq. (n)	%	Interpretation
Low	158	79.30	Progesterone concentration within negative range indicate that AI has been performed at a time other than the luteal phase
High	19	9.54	Progesterone concentration within the positive range are indicative of AI done during the luteal phase
Intermediate	22	11.10	Progesterone between these two ranges should be correlated with physiological status, and may indicate that AI was done too early or too late relative to oestrus.
Total occurrence	199		

Freq. : Frequency

Results from milk progesterone assay for day 0 samples (n = 199) revealed that 79.3% of the AIs were performed when progesterone concentration was below 1 nmol l^{-1} indicating that the cow could have been in heat. However, 9.54% of AIs were done when progesterone concentration was above 3 nmol l^{-1}, indicating that the cow could not have been in heat. The remainder of the samples 11.05% had values in the inconclusive range (1–3 nmol l^{-1}). Progesterone values of samples collected on day 0 and 10–2 showed that only 67.3% of the animals had normal ovulatory cycles, while 4.5% were either in anoestrus, anovulatory or had short luteal phases.

Table 4. Diagnosis based on two samples.

Day 0 (AI)	Day 10–12	Freq. (n)	%	Interpretation
Low	High	134	67.30	Progesterone concentration within negative range on day 10 indicates an Ovulatory Cycle
Low	High	9	4.50	Progesterone concentration within negative range on both days indicates Anoestrus, Anovulation or Short Luteal Phase, which may be more frequently found in animals which were anoestrus before AI
Low	High	11	5.52	Progesterone concentration within positive range on both days indicates AI on pregnant animal or Luteal Cyst
High	High	4	2.01	Progesterone concentration within positive range on day 0 and within negative range on day 10 indicates that AI was performed during Luteal Phase and next heat occurs after 7–14 days
*	*	41	20.60	* At least one of the samples showed an intermediate value(1 to 3 nmol l^{-1}). Other clinical data is required for proper interpretation.
Total occurrence		199		

Freq.: Frequency

The Progesterone values from all three samples (Days 0, 10–12 and 21–23) were available for 149 services. Progesterone data along with rectal palpation findings (45–60 days post–service) indicated that 54.3% had conceived, 6.7% had non–fertilization or early embryonic death or had gone into post–AI anoestrus, 4.2% had late embryonic death, luteal cyst or persistent corpus luteum (CL), and 1.3% of cases had been inseminated during pregnancy.

Table 5. Diagnosis based on three samples.

Day 0 (AI)	Day 10–12	Day 22–24	Preg. diag.	Freq. (n)	%	Interpretation
Low	High	High	Positive	81	54.3*	Pregnant
Low	High	Low	Negative	10	6.7	Non–fertilization, early embryonic mortality, post–AI anoestrus
Low	High	High	Negative	6	4.2	Late embryonic mortality, Luteal Cyst, persistent CL
High	High	High	Positive	2	1.3	AI on pregnant animal
*	*	*	Positive/ Negative	50	33.5	At least one of the samples showed an intermediate value(1 to 3 nmol l^{-1}). Other clinical data are required for proper interpretation.
Total occurrence				149		

* This value is based on 149 services which had all three milk samples. Note that it is different from first–service conception rate given in Table 2 as it was based on 133 first services.

Preg. Diag. : Pregnancy diagnosis, Freq: frequency

Contribution of different factors on the outcome of AI

Farm factors

The highest conception rate (CR) (69.4%) was observed at Bopaththalawa farm whereas the lowest (40.8%) was observed at New Zealand farm. Farms which coupled visual heat detection with teaser bull had higher CRs (64.5%) whereas farms which used only visual heat detection had low CRs (40.8%). Artificial inseminations were performed at time intervals ranging from 1 to 24 h after the first detection of heat. When grouped into 3 time intervals, 0–6, 6–12, and 12–24, the respective CRs were 60.0%, 49.2% and 51.4%. As regard to the time of the year, higher conception rates (>50%) were recorded during the month of June, July, August and September while the lower CRs (<40%) were recorded in March and April.

The first–service CR (50.4%) was lower than all–service CR (53.6%). Among the pure breeds kept in these farms Ayrshire breed had the highest CR (65.7%), Jersey breed had a medium CR (60.0%) while the lowest (49.3%) was observed among Friesians. Conception rate increased from parity 1 up to 6, and then declined to reach the lowest CR at parity of 10.

Higher CRs were achieved in animals with a BCS of 2.5 and above, and lower CRs with animals with a BCS of below 2.5. However, this was not reflected in the pooled data within or among farms. Cows at 'standing heat' at the time of insemination had the highest CR (64.2%, n=81) whereas the cows detected with heat signs such as 'mounting others' and 'mucus discharge' had CRs of 47.4%, and 42.5%, respectively.

Bull/semen factors

Imported deep frozen semen from five stud bulls (Ayrshire, Friesian and Jersey) were used on the cows included in the study. The CRs following the use of semen from 5 bulls ranged from 34.2–68.9%. Semen identification number Fr–390–1997 had the highest CR (68.9%, n=61) while Fr–387–1997 achieved the lowest CR (34.2%, n=114). Semen code numbers Jr–208–1997, Fr–388–1997 and Ay 85105 had CRs of 59.5% (n=74), 59.1% (n=22) and 63.6% (n=33), respectively.

Inseminator related factors

The conception rates achieved by the technicians is shown in Table 6. The highest CR was recorded by a technician serving the Bopaththalawa farm (72.3%); while the lowest was achieved by the technician serving the New Zealand farm (40.6%).

Table 6. Conception rates achieved by AI technicians.

AI technician	Farm	Number of services	Conception Rate (%)
A	Ambewela	34	64.7
B	Bopaththalawa	15	60.0
C	Bopaththalawa	47	72.3
D	Dayagama	113	53.1
E	New Zealand	106	40.6

DISCUSSION

Ambewela, Bopaththalawa, Dayagama and New Zealand farms are the principle farms that are responsible for multiplying Bos taurine cattle in Sri Lanka. Less than 75% of total potential land extent of these farms carry improved pasture and the stocking rate is much lower than the potential. In one farm, the purity of the principle breed has not been maintained and the reason for such deviation form the original breeding policy was obscure. The body weight of the animals were much lower than the expected body weights for the genotypes. This may be most likely due to sub optimal nutritional management practices and also the absence of regular selection and culling policy for desired breed characteristics and performance. The sub optimal feeding of animals was reflected in body condition score of the animals and most animals recorded a BCS of less than 2.5. Though there is plentiful supply of forage year around, the restriction on grazing time may have limited the intake and hence may be a reason for poor nutrition. At New Zealand farm, supplementation with urea–molasses mixtures is practised and the nutritional status of animals in this farm appeared to be better than those in other three farms. Further, the average milk yield (14.0±4.3 l per cow per day) of the Friesian herd at New Zealand was greater than the milk yield of the same breed at Bopaththalawa (10.1±3.1 l per cow per day). In general all four farms do not appear to practice a regular systematic culling programme on the basis of age, productivity and reproductive performances as reflected in the heterogeneity of the cattle population in terms of parity. The CRs showed a decline with increasing parity. This is a very likely outcome as older animals tend to be less fertile.

The average calving to first service interval at Ambewela, Bopaththalawa, Dayagama and New Zealand farms were 102, 109, 91 and 128 days, respectively, with overall average of 111 days. This delay of first service postpartum may well be due to long periods of postpartum anestrus. By judging at the body condition of these animals, the prolonged postpartum anoestrus is most likely due to poor nutrition of the stock, particularly during the early postpartum period. Although the New Zealand farm animals had relatively better body condition, yet their production levels were higher than the animals at other farms, most animals may have run into nutritional limitations particularly during immediate post-calving period due to a greater drain of nutrients from high producing animals. With an overall average of 2 services per conception, the overall calving to conception interval was 156 days, with the longest interval at New Zealand farm. At this level of efficiency of postpartum fertility, the average inter–calving interval was estimated to be 18 months, which is far less satisfactory for a multiplier farm.

The fertility indices of the four farms were different. Although the average milk production was superior at New Zealand farm, the indices of fertility in this farm, in terms of calving to conception, calving to first service and inter–calving intervals, were inferior to the other three farms. The fertility indices in other three farms in relative terms were better, however, their reproductive performances too were less satisfactory than the desired level. Many factors may have contributed to this situation in these farms. Firstly, as discussed earlier, it is a reflection of suboptimal nutritional management of the herd. Secondly, the overall fertility of a herd cannot be expected to be high when the herd carries more than the desired level of older animals. Thirdly, the long calving to first service interval may also be due to poor heat detection.

All four farms used AI as the primary tool to impregnate their animals. The first service conception rates at Ambewela, Bopaththalawa, Dayagama and New Zealand farms were 53.8%, 70.5%, 57.1% and 31.3%, respectively, with the overall value of 50.4%. The all–service conception rates at Ambewela, Bopaththalawa, Dayagama and New Zealand farms were 65.7%, 69.3%, 60.0% and 40.8% with an overall average conception rate of 53.6%. Only Bopaththalawa farm has achieved at least the lower range of standard level of conception rates, while other 3 farms recording much lower rates.

The knowledge and skills of farm personnel handling the dairy animals in all four farms appeared to be satisfactory. However, less attempt has been made in monitoring and evaluating the performance in a meaningful manner. As evidenced from progesterone concentration in milk samples, the accuracy of heat detection and the timing of insemination by the farms is less than the desired level. Based on day 0 sample (day of oestrus), 9.5% of the animals presented for AI had high progesterone levels, indicating they were not in true oestrus. Based on day 0 and 12 samples, even in those with low progesterone levels at the time of AI, only about 67.3% appeared to have had a normal ovulatory oestrus. Other 42.5% presented to AI were either having abnormal oestrus cycles or were not in oestrus. Based on day 0, 12 and 21 samples, 53.4% of the animals got pregnant. Had those been presented to AI were in true oestrus, by judging at this data one could expect higher conception rates. Thus, it is very conceivable that poor heat detection and improper timing of AI could have been the major reason for poor conception rates in these farms. This is supported by the finding that the farms which coupled visual heat detection with teaser bulls had higher CRs (64.5%) when compared to those farms which used only visual heat detection (40.8%).

The timing of insemination in relation to first detection of heat is known to be critical for achieving high CRs (Peters and Ball, 1995). Theoretically, higher conception rates can be achieved if animals are inseminated between 12–18 h after detection of heat. In the present study AIs were performed at time intervals ranging from 1 to 24 h. When graded into 3 time intervals (0–6, 6–12, and 12–24), the respective CRs were 60.0.%, 49.2% and 51.4%. This pattern of conception as regard to timing of insemination could have been most likely due to the herdsman inability to differentiate pro-oestrus and oestrus and to judge the time of onset of oestrus.

Factors related to the technique of performing AI such as transport, storage, handling during thawing and AI technique itself are also very important determinants of CR in AI programmes (Peters and Ball, 1995). The results of an on-going research indicate that there is a significant reduction in the quality of semen during storage and transport (Alexander *et al.* - unpublished data). It was found that there was a drop of motility of sperms from 55% to 50% upon dispatch from the point of production to point of use. At the point of production, there was again a significant reduction of motility with time of storage. As this aspect was not investigated in this study, conclusion cannot be made as regard to the possible contribution of semen quality on the conception rate. With regard to technique of insemination there appear to be differences among technicians, which may be related to skill, motivations and attitudes of and the facilities available to the technicians. The present study revealed a wide difference in CR achieved by individual technicians (*i.e.* from 53.1 to 72.3%). Four technicians achieved an acceptable level of CR (>60%) while two technicians had achieved lower conception rates. The lowest CR was reflected by the farm which was served by the technician with lowest achievement in CRs. Whether, this is a reflection of the technician's poor performances or the result of suboptimal management factors as related to heat detection, timing of insemination or semen factors cannot be determined for certainty at this stage. Of the 5 bulls from which semen has been used for at least 20 inseminations, one had very poor CR (34.2%, n=114), while the others recorded higher conception rates. It is clear that there is a possibility of contribution from the donor of semen to the observed variation in fertility. Therefore, further studies are needed to partition the effects of factors such as heat detection efficiency, timing of insemination, bull and semen type, and technician to evaluate the true effects of these factors on the fertility status of artificially bred cattle population.

CONCLUSIONS

The results of this study indicate that the overall success rate of AI in all multiplier farms studied was lower than the desired level. Many factors appeared to have contributed to this low level of efficiency. Of these poor heat detection and timing of AI stand out to be the most important contributory factors. Evidence was also emerged to suggest that lower level of technical efficiency in handling, storage of semen and the technique of AI could also contribute to this low success rate of AI.

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