Adoption of scientifically recommended artificial insemination practices by paravets: a depiction of current scenario of four states in India

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Abstract
The present investigation was done to assess the different practices followed by the AI technicians (paravets) while performing artificial insemination (AI). A total of 160 paravets were selected for the study having equal representation from 4 different states of India (Gujarat, Rajasthan, Telangana, and Odisha). Questionnaire and telephonic survey were used for collecting data. Several practices followed by paravets were assessed under three sub-groups, viz., practices followed prior to, during, and post-artificial insemination. In as many as seven practices, viz., gathering pre-AI information, storage of semen straw, time of performing AI, thawing container, wiping of semen straw, cutting of semen straw, and record keeping, the adoption gap was found to be nil. Maximum adoption gap (30.60%) was seen in “adopting basic sanitary measures,” whereas about 13% of adoption gap was found in the case of “monitoring of heat post calving” followed by “checking of heat prior to AI” (8.00%). Hence, along with provision of necessary measures for water bath, apron, and gumboots by State Department of Animal Husbandry (SDAH), the paravets should be made aware about the importance of basic sanitary measures. Crystoscope availability should also be ensured as it is easy to use by paravets and farmers for heat detection.

Keywords Paravets · Artificial insemination · Adoption gap · Crystoscope · Sanitary measures

Introduction
Livestock being an integral and irreplaceable part of the agriculture production system plays a crucial role in the development of India’s economy. Though the sector contributes 4.1% to total GDP and around 1/3rd, i.e., 27.4%, to agricultural GDP, the major limiting factor faced by it is due to low productivity (BAHS, 2019, DAHD, GoI). In India, artificial insemination (AI) is generally performed by AI technicians (paravets). As per the reports of Farmers’ Manual, DAHD&F, GoI, there are several factors which hinder in success rate of AI and also restrain in quality service delivery such as wrong AI technique may lead to conception failure and hence requires well-trained inseminators for successful AI. Repeat breeding, poor conception, improper heat detection, incorrect handling of semen, and unavailability of trained technicians are some of the most important constraints in the breeding sector (Hamdani, 2013; Eklundh and Camilla, 2013; Ibrahim et al., 2014; Lawrence et al., 2015). This indicated how knowledge gaps and improper practices threaten the outcome of AI and thereby also affect the extent of the adoption of AI. Capacity of AI technician (paravets)
and insemination technique are also the major role players for poor fertility (Shamsuddin et al., 1997). A number of practices such as rectal palpation, checking of soft cervix, thawing temperature, straw cutting method, and semen deposition too have a significant impact on the success of AI (Ybañez et al., 2017). It is also reported that paravets delivering livestock services had medium to low knowledge level in breeding aspects and there is a need to fulfil the knowledge gap to have an impact on overall quality of service (Hamdani, 2013). An artificial insemination (AI) service following standard operating procedures (SOPs) and being delivered at the doorstep of animal owners is crucial to effective animal breeding activities. According to 20th Livestock Census, Govt. of India, total adult female bovine population in India is 133.3 million. But only 20% of the breed-able bovine population is under AI coverage and the rest of the 80% of the breed-able bovines are covered through natural service (Annual Report, 2019–2020, DAHD&F, Government of India). This is leading to deterioration in the performance and productivity of cattle. So the Government of India is giving utmost importance to strengthen the animal breeding prospects through effective AI services. Hence, a revolutionary step has been taken by the Government of India to increase the AI coverage through the Nationwide Artificial Insemination Program (NAIP). Keeping these facts under consideration, there was an urgent need to study the practices/steps followed by paravets/AI technicians while performing artificial insemination.

Materials and method

The study was conducted in four states of India, viz., Rajasthan, Gujarat, Telangana, and Odisha. From each state, three districts were purposively selected as per the accessibility of the researcher. The selected districts from Rajasthan were Jaipur, Sikkar, and Jhunjhunu; districts selected from Odisha were Nabarangapur, Balasore, and Dhenkanal; from Telangana the districts selected were Mahbubnagar, Warangal, and Khamam whereas from Gujarat, Kutch, Banaskanta, and Anand were selected. Samples for the study were paravets/AI technicians of the respective areas actively involved in artificial insemination under state animal husbandry departments. Questionnaire and telephonic survey methods were used to collect data.

A total of 400 questionnaires, viz., 100 to each state, were mailed to the respondents residing in the study areas keeping in view the response rate of questionnaire (30–40%). There were 180 filled questionnaires returned back from which 40 were incomplete. A telephonic survey was used for gathering the complete data from those which returned incomplete/partially filled. Forty paravets were randomly selected from each state making a total sample of 160 paravets.

Keeping in view the SOPs for artificial insemination, a total of fourteen practices were enlisted under 3 sub-heads, viz., practices followed “prior to artificial insemination,” “during the actual execution of artificial insemination,” and “post artificial insemination.” The respondents were given score (1) for each adopted practice and score (0) for practice not adopted. Adoption level for each practices was calculated as percentage score using the following formula. Similarly adoption gap was estimated

\[
\text{Adoption Score} = \sum_{i=1}^{n} \frac{X_{ij}}{Y_{ij}} \times 100
\]

where \(n\) = total number of respondents, \(X_{ij}\) = obtained score of \(i\)th practice by \(j\)th respondent, \(Y_{ij}\) = maximum obtainable score of \(i\)th practice by \(j\)th respondent.

Data analysis was done by use of statistical software SPSS to calculate the frequency, percentage, mean, and standard error. Comparison among groups was done by one-way ANOVA.

Results

Socio-personal and socio-economic profile of paravets

The results given in Table 1 give the information about socio-personal and socio-economic profile of the respondents which includes age, gender, educational qualification, family background, job experience, number of trainings undergone, and average annual income.

Age

From the results, it is evident that a large proportion (65.0%) of the total number of respondents was from the young age group of 21 to 32 years followed by the middle age group, viz., 21.9%. Significant difference \((p < 0.05)\) was found among the four states with regard to age of paravets. Respondents of the Telangana state had a significantly higher average age as compared to other states with an average age of 35.05 years. The average age of the total sample was 32.06 years.

Gender

Of the total sample, 95% were male and only 5% of them were female. Among the respondents of the four states, Rajasthan was having the highest number of female, i.e., 10% as compared to the other 3 states followed by Gujarat with 7.50% female who were working as paravets.
Educational qualification

Among the total sample, 76.25% paravets had educational qualification up to intermediate and 23.75% were graduate and above. Proportion of respondents having qualification of Graduate and above was more (35.00%) in the case of Rajasthan.

Family background

Results from the pooled sample reveal that most of the paravets (70.0%) were from a rural background followed by a semi-urban (15.0%) and urban (14.4%) background.

Job experience

Among the total number of respondents, majority (81.30%) were having low experience in AI ranging from 1 to 10 years. No significant difference was found among the states. The average experience of the respondents was 6.97 years.

Number of training undergone

The respondents were asked about the number of trainings undergone on AI in their work period. Results indicated that maximum number of respondents (43.75%) had undergone one training followed by 36.25% who had undergone two training on AI. Among the number of respondents who had undergone two trainings, the respondents of Rajasthan were more, i.e., 42.50%.

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**Table 1** Socio-personal and socio-economic profile of AI technicians (paravets)

| Socio-personal and socio-economic profile | Gujarat (n = 40) | Rajasthan (n = 40) | Odisha (n = 40) | Telangana (n = 40) | Pooled (N = 160) |
|------------------------------------------|-----------------|-------------------|----------------|------------------|-----------------|
| Age (in years)                           |                 |                   |                |                  |                  |
| Young (21–32)                            | 67.50%          | 75.00%            | 57.50%         | 60.00%           | 65.00%          |
| Middle (33–44)                           | 20.00%          | 12.50%            | 30.00%         | 25.00%           | 21.90%          |
| Old (45–55)                              | 12.50%          | 12.50%            | 12.50%         | 15.00%           | 13.10%          |
| Mean ± SE                                | 30.5 ± 1.4      | 29.28 ± 1.4       | 33.07b ± 1.3   | 35.05b ± 1.2     | 32.06 ± 0.68    |
| F value                                  | 3.56*           |                   |                |                  |                  |
| Gender                                   |                 |                   |                |                  |                  |
| Male                                     | 92.50%          | 90.00%            | 97.50%         | 100.00%          | 95.00%          |
| Female                                   | 7.50%           | 10.00%            | 2.50%          | 0.00%            | 5.00%           |
| Educational qualification                |                 |                   |                |                  |                  |
| Intermediate                             | 82.50%          | 65.00%            | 90.00%         | 67.50%           | 76.25%          |
| Graduate and above                       | 17.50%          | 35.00%            | 10.00%         | 32.50%           | 23.75%          |
| Family background                        |                 |                   |                |                  |                  |
| Rural                                    | 75.00%          | 67.50%            | 82.50%         | 57.50%           | 70.60%          |
| Semi-urban                               | 2.50%           | 15.00%            | 10.00%         | 32.50%           | 15.00%          |
| Urban                                    | 22.50%          | 17.50%            | 7.50%          | 10.00%           | 14.40%          |
| Job experience                           |                 |                   |                |                  |                  |
| Low (1–10)                               | 82.50%          | 90.00%            | 77.50%         | 75.00%           | 81.30%          |
| Medium (11–20)                           | 7.50%           | 0.00%             | 17.50%         | 22.50%           | 11.90%          |
| High (21–30)                             | 10.00%          | 10.00%            | 5.00%          | 2.50%            | 6.90%           |
| Mean ± SE                                | 6.60 ± 1.22     | 5.58 ± 1.26       | 7.25 ± 1.18    | 8.45 ± 0.84      | 6.97 ± 0.57     |
| Number of training undergone             |                 |                   |                |                  |                  |
| One                                      | 45.00%          | 45.00%            | 50.00%         | 35.00%           | 43.75%          |
| Two                                      | 35.00%          | 42.50%            | 35.00%         | 35.00%           | 36.25%          |
| Three                                    | 15.00%          | 12.50%            | 10.00%         | 25.00%           | 15.62%          |
| Four                                     | 5.00%           | 2.50%             | 5.00%          | 5.00%            | 4.37%           |
Annual income

Respondents were asked about their annual income per year. Results reveal that the average annual income of the sample was 2.87 lakhs with a comparatively higher average annual income in Telangana state.

Practices followed by paravets while performing AI

Practices followed prior to artificial insemination

Prior to the actual conduction of AI, it is a standard recommended practice to check if the animal was in heat or not and gather various information about AI. Further, proper storage and handling of semen straw for the preservation of semen so that the sperms remain viable and do not lose their motility is also an important practice before actual execution of AI. Results of the study presented in Table 2 revealed that for checking heat prior to AI, majority of paravets (81.2%) followed both external signs and per rectal examination followed by observing only external signs (16.25%). A wholesome proportion of respondents (65.0%) asked about time of heat as pre-AI information. In the case of storage of semen straw, cent percent of the paravets stored the semen straw in Cryocan.

Table 2 Distribution of respondents according to practices followed prior to artificial insemination

| Practices followed prior to AI | Gujarat (n = 40) | Rajasthan (n = 40) | Odisha (n = 40) | Telangana (n = 40) | Pooled (N = 160) |
|------------------------------|-----------------|-------------------|----------------|-------------------|------------------|
| Checking of heat prior to AI |                 |                   |                |                   |                  |
| By external signs             | 17.50%          | 10.00%            | 20.00%         | 17.50%            | 16.25%           |
| Both external signs and per rectal | 82.50%      | 90.00%            | 80.00%         | 82.50%            | 81.20%           |
| Gathering pre-AI information |                 |                   |                |                   |                  |
| By Crystoscope                | 7.50%           | 0.00%             | 0.00%          | 0.00%             | 1.87%            |
| Time of heat                  | 60.00%          | 52.50%            | 75.00%         | 72.50%            | 65.00%           |
| Time of heat and characteristics of discharge | 40.00%      | 47.50%            | 25.00%         | 27.50%            | 35.00%           |

Storage of semen straw

| Practice                  | Gujarat (n = 40) | Rajasthan (n = 40) | Odisha (n = 40) | Telangana (n = 40) | Pooled (n = 160) |
|---------------------------|-----------------|-------------------|----------------|-------------------|------------------|
| Cryocan                   | 100.0%          | 100.0%            | 100.0%         | 100.0%            | 100.0%           |

Practices followed during actual execution of artificial insemination

Table 3 presents the practices followed by paravets during artificial insemination. Results of the table clearly indicate that cent percent of the respondents performed AI

| Practices followed during AI | Gujarat (n = 40) | Rajasthan (n = 40) | Odisha (n = 40) | Telangana (n = 40) | Pooled (n = 160) |
|------------------------------|-----------------|-------------------|----------------|-------------------|------------------|
| Time of AI                   | 12–18 h after estrus | 100.0%            | 100.0%         | 100.0%            | 100.0%           |
| Thawing done in              | Pot containing hot water | 47.50%          | 90.00%         | 100.0%            | 95.00%           |
|                             | Both pot and water bath | 52.50%          | 10.00%         | 0.00%             | 5.00%            |
| Checking of thawing temperature | Thermometer   | 100.0%           | 95.00%         | 87.50%            | 92.50%           |
|                             | Manually       | 0.00%            | 5.00%          | 0.00%             | 5.00%            |
| Temperature and time of thawing | 30–45 s (37 °C) | 95.00%          | 97.50%         | 92.50%            | 97.50%           |
|                             | 10 s (37 °C)   | 5.00%            | 2.50%          | 0.00%             | 0.00%            |
|                             | Others         | 0.00%            | 0.00%          | 7.50%             | 2.50%            |
| Wiping of semen straw        | Tissue paper   | 22.50%           | 45.00%         | 42.50%            | 80.00%           |
|                             | Cloth          | 77.50%           | 55.00%         | 57.50%            | 20.00%           |
| Cutting of semen straw       | Straight        | 100.0%           | 100.0%         | 100.0%            | 100.0%           |
| Basic sanitary measures      | Gloves         | 100.0%           | 100.0%         | 100.0%            | 100.0%           |
|                             | Gumboots       | 100.0%           | 2.50%          | 0.00%             | 7.50%            |
|                             | Apron          | 100.0%           | 75.00%         | 75.00%            | 40.00%           |
| Deposition of semen in       | Uterine body   | 95.00%           | 77.50%         | 95.00%            | 97.50%           |
|                             | Horn           | 0.00%            | 22.50%         | 0.00%             | 0.00%            |
|                             | Cervix         | 5.00%            | 0.00%          | 5.00%             | 2.50%            |

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12–18 h after estrus. Majority (83.12%) of paravets did thawing in a pot containing hot water followed by some (16.87%) who used both a pot and water bath depending on the situation. Majority (95.62%) of respondents were thawing the semen straw for 30–45 s at 37 °C followed by 1.90% thawing only for 10 s which is a wrong practice and leads to decrease in the probability of conception. Most of the paravets (52.5%) used a clean cloth for wiping of semen straw followed by 47.5% who used tissue paper. Cent percent of respondents were cutting the semen straw at a 90° angle. All of the respondents used gloves while performing AI whereas gumboots and apron were used by only 27.50% and 80% of the paravets respectively. Maximum of paravets (91.20%) deposited the semen in uterine body followed by horn (5.62%) and cervix region (3.12%).

Post-AI practices followed by the paravets

Table 4 presents the practices followed by paravets after actual artificial insemination. Results of the table indicate that after the completion of AI, follow-up was done by 93.12% of the paravets while 6.88% of the respondents did not perform the follow-up. Monitoring for heat post calving was done by 86.87% of the paravets and record keeping for the AI was done manually by majority (89.37%) of respondents followed by both manually and computerized (10.63%).

### Adoption gap in scientific recommended practices for artificial insemination among paravets

Tables 5 and 6, respectively, present the adoption score and gap in scientific recommended practices pertaining to artificial insemination among paravets. Results of the tables highlight that in as many as seven practices, viz., gathering pre-AI information, storage of semen straw, time of performing AI, thawing container, wiping of semen straw, cutting of semen straw, and record keeping, the adoption score was cent percent; thus, a gap was found to be nil. Almost all the fourteen practices mentioned in Table 4 had a high adoption score among paravets. From the data given in Table 6 and

#### Table 4 Distribution of respondents according to the practices followed after artificial insemination

| Practices followed after AI | Gujarat (n=40) | Rajasthan (n=40) | Odisha (n=40) | Telangana (n=40) | Pooled (n=160) |
|----------------------------|----------------|-----------------|--------------|-----------------|---------------|
| Follow-up of heat after AI |                |                 |              |                 |               |
| Done                      | 92.50%         | 95.00%          | 92.50%       | 92.50%          | 93.12%        |
| Not done                  | 7.50%          | 5.00%           | 7.50%        | 7.50%           | 6.88%         |
| Monitoring of heat post calving |            |                 |              |                 |               |
| Done                      | 95.00%         | 97.50%          | 75.0%        | 80.00%          | 86.87%        |
| Not done                  | 5.00%          | 2.50%           | 25.00%       | 20.00%          | 13.13%        |
| Record keeping            |                |                 |              |                 |               |
| Manually                  | 100.0%         | 57.50%          | 100.0%       | 100.0%          | 89.37%        |
| Both manually and computerized | 0.00%         | 42.50%          | 0.00%        | 0.00%           | 10.63%        |

#### Table 5 Adoption of scientific recommended practices for artificial insemination among paravets

| Adoption score of scientific recommended practices for AI (average percent score) | Gujarat (n=40) | Rajasthan (n=40) | Odisha (n=40) | Telangana (n=40) | Pooled (N=160) |
|---------------------------------------------------------------------------------|----------------|-----------------|--------------|-----------------|---------------|
| Checking of heat prior to AI                                                   | 91.2           | 95              | 90.01        | 91.18           | 92            |
| Gathering pre-AI information                                                   | 100            | 100             | 100          | 100             | 100           |
| Storage of semen straw                                                         | 100            | 100             | 100          | 100             | 100           |
| Time of performing AI                                                          | 100            | 100             | 100          | 100             | 100           |
| Thawing container                                                              | 100            | 100             | 100          | 100             | 100           |
| Checking thawing temperature                                                   | 100            | 95              | 87           | 92              | 94            |
| Temperature and time of thawing                                                | 95             | 97              | 92           | 97              | 96            |
| Wiping of semen straw                                                          | 100            | 100             | 100          | 100             | 100           |
| Cutting of semen straw                                                         | 100            | 100             | 100          | 100             | 100           |
| Basic sanitary measures                                                        | 100            | 58.6            | 57.8         | 61.1            | 69.4          |
| Deposition of semen                                                            | 95             | 100             | 95           | 97              | 97            |
| Follow-up of heat after AI                                                     | 92             | 95              | 92           | 92              | 93            |
| Monitoring of heat post calving                                                | 95             | 97              | 75           | 80              | 87            |
| Record keeping                                                                 | 100            | 100             | 100          | 100             | 100           |
| Overall adoption score                                                         | 97.7           | 95.54           | 92.05        | 93.57           | 94.91         |
Fig. 1, it is evident that maximum adoption gap (30.6%) was seen in basic sanitary measures as the paravets were not maintaining basic sanitary practices, viz., wearing of protective clothing during performing AI; a significant difference ($p < 0.01$) was found among the four states in adopting basic sanitary measures which reveals that paravets of Gujarat showed nil adoption gap as compared to the other three states that showed a significantly higher gap in the abovementioned practice. About 13% of adoption gap was found in the case of monitoring of heat post calving which further showed a visible significant difference among the states which depicts that the respondents of Gujarat and Rajasthan had comparatively lower adoption gap than the respondents of Odisha and Telangana. There was also an adoption gap found in the case of checking of heat prior to AI (8.00%) followed by checking thawing temperature (6.00%), follow-up of heat after AI (7.00%), appropriate temperature and time of thawing (4.00%), and site of deposition of semen (3.00%), though no significant differences were found among the states.

![Adoption gap of various practices related to AI among paravets](image-url)
Current conception rate of AI

For estimating the current conception rate in terms of number of AI done/conception in the selected four states, a cross-sectional assessment was done again during August 2021 from the already surveyed respondents through telephonic interviews. A total of 86 technicians responded from which 24.41% were from Gujarat, 19.76% from Rajasthan, 30.23% from Telangana, and 25.58% from Odisha. The results revealed that the average number of AI/conception was 2.52 which shows that the overall conception rate as reported by the technicians is 39.68%. The state Gujarat showed a quite higher conception rate as compared to the other three states (Table 7).

For triangulation of the results regarding average conception rate, already available reports from Government sources and previous research findings have been compiled and documented (Table 8). As per the reports of Department of Animal Husbandry, Dairying and Fisheries, Government of India, the overall conception rate from AI is 35%. The Telangana State Livestock Development Agency reported that 16.49 Lakhs inseminations were done during 2019–2020 and 5.4 Lakhs calves were born. This makes the average calving rate around 32.8% from AI. Similarly, the Annual Activity Report of Fisheries and Animal Resources Development Department, Odisha reported 12.24 Lakhs AI in 2020–2021 and 4.13 Lakhs calving which makes the calving rate from AI around 33.74%. As per the Annual Report (2019–2020) of the Bharatiya Agro Industries Foundation (BAIF), 42% conception rate was achieved by using sex-sorted semen. This organization is working on improvement of livestock through providing doorstep AI services to 43.83 Lakhs farm families. Various researches conducted in different parts of India have also reported the conception rate from AI. Thirunavukkarasu and Kathiravan (2009) reported 34.53% conception rate from AI in Tamil Nadu whereas Bansal et al. (2019) reported average conception rate of 52.16% in Bihar. Pushpa and Chandel conducted a study in Gujarat and stated that dairy cooperatives reported a higher conception rate of AI ranging from 39.15 to 65.77% whereas the conception rates as reported by district animal husbandry departments ranged from 36.66 to 56.46% (Table 8).

Discussion

In the current study, it is evident that there was a gap of 8.1% in the case of heat detection prior to AI. Several studies on estrus behavior indicated about the silent heat without external signs in the case of buffaloes (Roy and Prakash, 2009; Chohan et al., 1992) causing the major

| States     | Average number of AI/conception | Conception rate |
|------------|---------------------------------|---------------|
| Gujarat (n = 21) | 2.14                           | 46.72%        |
| Rajasthan (n = 17) | 2.59                           | 38.61%        |
| Telangana (n = 26) | 2.70                           | 37.03%        |
| Odisha (n = 22) | 2.65                           | 37.73%        |
| Pooled (N=86) | 2.52                           | 39.68%        |

| Particulars     | Sl. no | Sources                                      | Mentioned conception rate | Area          |
|-----------------|--------|----------------------------------------------|---------------------------|---------------|
| Government reports | 1      | Annual Report (2020–2021), Department of Animal Husbandry, Dairying & Fisheries, Govt. of India | 35% | Overall India |
|                  | 2      | Policy paper 96, NAAS, Government of India, 2020 | 35% | Overall India |
|                  | 3      | vahd.telangana.gov.in (2019–2020)              | 32.8% (calving rate=total number of calves born/total number of insemination) | Telangana |
|                  | 4      | Annual activity report (2020–2021), FARD, Odisha | • 12.24 lakh insemination • 4.13 lakh calves born • 33.74% calving rate from AI | Odisha |
| Research reports | 5      | Annual Report, 2019–2020, BAIF (baif.org.in)   | 42% (using sex-sorted semen) | 12 states of India |
|                  | 1      | Thirunavukkarasu and Kathiravan (2009)         | 34.53%                    | Tamil Nadu |
|                  | 2      | Bansal et al. (2019)                           | 52.16%                    | Bihar |
|                  | 3      | Pushpa and Chandel (2014)                      |                           | Gujarat |
| (i) Dairy cooperatives |     | Amul Dairy Kheda                              | 65.77%                    |               |
|                   |       | SUMUL Dairy Surat                             | 52%                       |               |
|                   |       | Sabar Dairy                                   | 39.15%                    |               |
| (ii) District Animal Husbandry Department |       | Surat                                         | 36.66%                    |               |
|                   |       | Kheda                                         | 42.69%                    |               |
|                   |       | Sabarkantha                                   | 42.72%                    |               |
|                   |       | Junagadh                                      | 56.46%                    |               |
limitation in detecting heat leading to conception failure and thus, non-adoption of AI (Rajendra and Prabhakaran, 1992). It is also reported that conception failure may occur due to untrained technicians and incorrect time of insemination (Gizaw and Dima, 2016). Hence, perfect AI execution and knowledge about heat detection tools like IVRI-Cryostoscope are very important for increasing the conception rate and reducing the unwanted time gap between parturition and next pregnancy.

Similarly, the study also reported that majority were following proper thawing procedure whereas, few respondents (6.0% and 4.0%) were handling the straw improperly as they used to check the temperature manually, and the temperature and time of thawing according to them was wrong. Saacke (1974) suggested that the temperature and time should be 35 °C and 30–60 s. As per previous researches, the critical factors for reproductive performance encompass both herd-level and cow-level management factors and the herd-level factors include cow management, methods of feeding, heat detection, and semen handling (Lucy, 2001; Hudson et al., 2012). These deviations from SOPs may lead to reduced reproductive performance.

As per the current study, a visible gap (30.6%) was found in adoption of basic sanitary measures among paravets while performing AI. This is in concordance with the results of (Hope et al., 2013) who reported that around 1/3rd of inseminators did not take adequate protective measures to ensure proper hygiene while performing AI. Previous research says that in the case of cows, bacterial contamination during the execution of AI can suppress the pregnancy rates (Morrell, 2006). Furthermore, unhygienic practices during AI could also facilitate microbial colonization in the reproductive tract adversely affecting the fertility of cows (Givens and Marley, 2008; Dubuc et al., 2010) and can lead to ovarian malfunction, and reduced oocyte viability in dairy cows (Sheldon et al., 2014). These risks emphasize the need of maintaining proper hygiene during performing AI in cows. In a study, the usefulness of using protective sheaths (PS) over the AI gun on pregnancies per AI was evaluated in dairy cows (Bas et al., 2009), which showed an increase in pregnancies per AI in cows inseminated using the AI gun with sheath (43.8 ± 2.9%) compared to those inseminated without the sheath (32.3 ± 2.6%). An appropriate and hygienic AI practice is essential to improve reproductive performance in dairy cows. But, the critical steps like proper hygiene and appropriate semen handling are usually overlooked. Hence, basic sanitary measures such as washing of hands, wearing of gloves, protective clothing, and gumboots are prerequisite for safe conduction of AI and will also prevent from invasion of microbes in reproductive tract of cattle, thus leading to sustainable improvement in reproductive performance.

From the results, it is visible that the paravets were accurate with the standard time of insemination which is around mid-heat to late heat (12–18 h after onset of heat) as it provides optimal condition for fertilization and improving embryo quality as well. This is contrary to the results of Garcia et al. (2001) who reported AI in cows at inappropriate times denoting serious heat detection errors. In a study conducted by Dalton et al. (2001), using HeatWatch technology observed the association between time of insemination, fertility percentage, and embryo quality in dairy cattle. In the study, cows were inseminated at 2.0 h, 12.1 h, and 24.2 h after onset of heat and concluded that insemination at 12 h after onset of oestrus provided a better condition in terms of maximizing conception and simultaneously protecting the embryo qualities and this would agree with the report of Dransfield et al. (1998) who suggested 4 to 16 h after onset of heat as the prime time for insemination. The quality of embryo may get impaired following late/delayed insemination as the ovum gets aged (Dalton et al., 2001).

The results revealed that majority of the paravets (91.7%) were depositing semen in uterine body with few exception who used to deposit in uterine horn (5.62%) and mid-cervix (3.12%). The results go in line with several studies (Stewart and Melrose, 1952; Olds, 1953; Diskin et al., 2005) which showed minute differences in conception due to semen deposition in varied places, viz., uterine horns, uterine body, and mid-cervix, which resulted in the acceptance of uterine body as site of depositing semen during AI in cattle. It is observed that there was a high significant effect ($p < 0.01$) of site of semen deposition on conception rate as uterine deposition of semen resulted in higher Conception (3.12%). The results go in line with several studies (Stewart and Melrose, 1952; Olds, 1953; Diskin et al., 2005) which showed minute differences in conception due to semen deposition in varied places, viz., uterine horns, uterine body, and mid-cervix, which resulted in the acceptance of uterine body as site of depositing semen during AI in cattle. It is observed that there was a high significant effect ($p < 0.01$) of site of semen deposition on conception rate as uterine deposition of semen resulted in higher Conception (3.12%).

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From the results, it is evident that adoption gap of 13% and 7% was seen in the case of monitoring of heat post calving and monitoring of heat post AI. According to previous research, non-performance of post-AI heat detection leading to non-reporting of embryonic death and unobserved failed conception affects the insemination adversely (Garcia et al., 2001). Moreover, the major hindrances in profitable dairy husbandry are due to low conception to first services, more number of services per conception, delayed calving to 1st service interval, and improper and poor heat detection after AI (Alam and Ghosh, 1988; Shamsuddin et al., 2001). From the results of existing conception rate from AI, it is evident that the respondents reported overall conception rate of 39.68%. The Annual Report (2020–2021), Department of Animal Husbandry, Dairying and Fisheries, Govt. of India, also reported that overall conception rate of dairy animals has improved from 20 to 35% which is a steady improvement. Thirunavukkarasu and Kathiravan (2009) in their study also reported the conception rate of 34.53% in dairy cows. The Government of India is putting utmost emphasis on improving conception rate through effective AI. As per the reports of Basic Animal Husbandry Statistics (2018–2019), Government of India, total number of inseminations has been increased from 73.36 million in 2017–2018 to 75.8 million in 2018–2019 which shows a steady improvement in terms of both AI coverage and overall cattle development. The total milk production of the country is 187.75 million tonnes which showed a potential increase of 6.5% over the previous year. Additionally, cattle population has increased from 190.90 million to 192.52 million in the years 2018–2019. In connection to this, Nationwide AI program has been initiated on a mission mode in 2019 in two phases (phase-I and phase-II). It is targeted to increase the AI coverage up to 50% for which rigorous trainings are being conducted on AI and all the information is being recorded on INAPH portal and app on real-time basis (Press Information Bureau, 2019, Government of India).

The results of current study revealed that overall adoption of scientific recommended practices for AI was followed by majority of the respondents with a lower gap in certain practices like checking of heat prior to AI, monitoring of heat post AI, monitoring of heat post calving, checking of thawing temperature, and time duration of thawing, whereas a bit higher gap was seen in following basic sanitary measures while preforming AI. As discussed above, cattle fertility is associated with many underlying factors from which proper technique of AI plays a crucial role in successful conception. To improve the conception rate up to the required level, various aspects of infertility should be considered along with proper AI technique as the infertility problem is multifaceted. Several predisposing factors such as age, milk production status, nutritional status, reproductive disorder, parity, and seasonal variations have significant impact on consequent conception rate. Thirunavukkarasu and Kathiravan (2009) in a study reported that age and milk production status had a significantly negative impact on conception which revealed that as age and milk production increased, conception rate decreased subsequently. Similar results were also reported by Harichandan et al. (2018) who stated that high yielder showed comparatively low conception rate than that of low yielders which might be due to the fact that high producing cows are more prone to metabolic and endocrine disturbances resulting into subsequent low conception rates. Hence, proper fulfilment of energy requirements in high yielders is essential. Seasonal variation has a significant effect on conception. As reported by several researchers, the lowest conception rate was recorded during summer season than winter and rainy seasons (Khair et al., 2013; Harichandan et al., 2018; Bansal et al., 2019). Nutritional deficiency also plays a major role as reported by Haque et al. (2015) which showed that the conception rate in cows fed with combination of green fodder, concentrate, and straw was significantly higher than cows fed only straw. Deficiencies of several trace minerals and vitamins play a major role in poor fertility due to delayed puberty, anestrus, etc. resulting in higher economic loss (nddb.coop). Thakur et al. (2006) reported that causes of infertility in cows in India are usually either hereditary, acquired, functional (anestrus, cystic ovary, ovulation defects, etc.), nutritional imbalance, or infectious causes. Hence, in addition to proper AI procedure, a multidimensional approach is needed to improve the overall reproductive performance of dairy animals considering all the associated and latent factors related to infertility.

Conclusion
Adoption gap of scientific recommended practices for AI reveals nil gap in as many as seven practices with a small gap of less than 10% in five practices. The practices which showed adoption gap, though low, should be highlighted, and necessary measures can be taken by state animal husbandry department to strengthen the capacity of paravets. A bit higher gap of 30.6% was found in basic sanitary measures for AI and a 13% gap in monitoring of heat post calving. The state animal husbandry department needs to improve the input availability for paravets for improving the efficiency of the AI services. Further, Crystoscope availability should be ensured as it is easy to use by paravets and farmers for heat detection. The paravets should be made aware about the importance of basic sanitary measures as wholesome proportion of paravets were not adopting basic sanitary measures despite the availability of inputs. The paravets should be trained and made aware regarding the post-AI heat detection so that the reproductive performance
of cows can be monitored and necessary measures can be taken to combat any complications. The results showed an average of 39.68% conception rate from AI. Along with provision of refresher training to the respondents, various factors related to infertility in dairy animals should be taken into consideration by the government such as arranging awareness programs for the animal owners regarding proper heat detection, nutritional requirements, stress management, and balanced feeding of animals. A multidimensional approach considering various aspects to improve fertility of dairy animals through AI is needed. More number of easily accessible platforms such as online websites and mobile apps in local languages need to be created for imparting knowledge and first-hand information regarding artificial insemination. Further, zero gap in adoption of seven scientific practices reveals the strength and good working of the state animal husbandry department of the four states which needs to be highlighted for motivating the paraveterinary professionals in other states as well.

Author contribution 1. Dr. Pratikshya Panda was the Principal Investigator of the research work and dealt with all the budgetary and human resource allocations and sanctions.

2. Dr. Rupasi Tiwari was the Chairperson, student advisory committee, and research guide.

3. Dr. Pragya Joshi and Dr. Amandeep dealt with data analysis and scripting.

4. Dr. Triveni Dutt was the co-advisor and member of student advisory committee

Data Availability Primary data was collected in the present study through pre-tested questionnaire.

Code availability For data analysis, Statistical Package for Social Sciences (SPSS) was used.

Declarations

Ethics approval The manuscript does not contain clinical studies.

Consent to participate Before collection of socio-personal data, consent was taken from the human subjects.

Consent for publication At the time of primary data collection, consent was taken from the human subjects to publish their data.

Conflict of interest The authors declare no competing interests.

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