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Farm typologies and reproductive management organisation associated with pregnancy per artificial insemination in peri-urban cattle farms around Ouagadougou, Burkina Faso.

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Abstract

Pregnancy outcomes following bovine artificial insemination (AI) remain highly variable in peri-urban cattle systems of sub-Saharan Africa, limiting the effectiveness of genetic improvement programmes. This study aimed to identify farm typologies based on reproductive management characteristics and to determine organisational factors associated with pregnancy per AI (P/AI) in peri-urban cattle systems of Burkina Faso. A cross-sectional multi-stakeholder survey was conducted in 52 cattle farms and involved interviews with 52 farmers, 52 resident herders and 12 inseminators across four peri-urban zones surrounding Ouagadougou between November 2025 and May 2026. Data were analysed using multiple correspondence analysis, hierarchical cluster analysis and non-parametric statistical tests. The overall P/AI rate was 42.7 ± 23.7% (95% CI: 36.3–49.2%), ranging from 0 to 90% across farms. Three farm typologies exhibiting contrasting reproductive performances were identified. High-performing farms (n = 17) achieved a mean P/AI of 52.9 ± 16.5% and were characterised by systematic reproductive record-keeping, whereas low-performing farms (n = 6) showed markedly lower P/AI (5.0 ± 12.2%) and limited reproductive monitoring. Intermediate farms (n = 29) achieved a mean P/AI of 44.5 ± 21.7%. Farms maintaining reproductive records had significantly higher P/AI than those without records (48.8% vs 13.4%; $P < 0.001$). Farmers identified inseminator unavailability (78.8%) as the main operational constraint, whereas inseminators highlighted inadequate oestrus detection by farm personnel (75%). These findings suggest that organisational aspects of reproductive management, particularly reproductive record-keeping, timely AI service delivery and effective oestrus detection, represent important leverage points for improving AI performance in peri-urban cattle systems.

INTRODUCTION

Artificial insemination (AI) is one of the most widely used reproductive biotechnologies for improving dairy productivity and accelerating genetic progress in cattle populations worldwide (Van Eenennaam 2025). In sub-Saharan Africa, AI has been promoted as a strategic tool to enhance milk production and improve the genetic value of local herds (Kathambi et al. 2025; Kouamo 2025). Its importance is particularly evident in peri-urban livestock systems, where rapid urbanisation, population growth and increasing demand for dairy products are placing growing pressure on local production systems (Balehegn et al. 2021; FAO 2024). However, despite its recognised potential, reproductive performance following AI remains suboptimal under field conditions (Abebe and Alemayehu 2021; Hamid et al. 2021). Pregnancy per artificial insemination (P/AI), one of the most widely used indicators of AI effectiveness, generally ranges from approximately 30% to 45% under routine field conditions in sub-Saharan Africa (Tadesse et al. 2022; Sanogo et al. 2022; Mekonnen and Gebremariam 2024), remaining below the ≥ 50% benchmark commonly considered indicative of satisfactory reproductive performance in smallholder cattle systems (Tola and Deresa 2025). This persistent shortfall suggests that AI success depends not only on the technical execution of insemination itself but also on the organisation and management of reproductive activities at farm level.

Successful AI relies on a sequence of interconnected events, including accurate oestrus detection, timely communication between farm personnel and inseminators, prompt service delivery and appropriate reproductive follow-up (Hamid et al. 2021; López-Gatius 2022; Hambisa 2025). Consequently, P/AI reflects not only the outcome of a single reproductive procedure but also the overall effectiveness of reproductive management within the farm (Cardoso Consentini et al. 2021). Several studies conducted in African cattle systems have identified recurrent constraints associated with reduced AI performance, notably poor oestrus detection, limited inseminator availability and insufficient training of farm personnel (Mwanga et al. 2019; Allan et al. 2024; Mekonnen and Gebremariam 2024; Kathambi et al. 2025). However, these constraints are generally investigated in isolation, despite operating within a broader organisational framework that includes reproductive monitoring, record-keeping practices, breeding strategies and coordination among actors involved in AI delivery. As a result, analyses based solely on population-level averages may obscure substantial inter-farm heterogeneity and limit the identification of management practices associated with successful reproductive outcomes.

Peri-urban cattle systems in Burkina Faso are highly heterogeneous and comprise improved, semi-improved and traditional farms operating predominantly under semi-extensive management conditions (Gnanda et al. 2016). Beyond structural differences, farms may vary considerably in the organisation of reproductive management, including the use of reproductive records, integration of AI into breeding strategies and monitoring of reproductive events (Abebe and Alemayehu 2021; Sanogo et al. 2022; Kouamo et al. 2024). Such variability cannot be adequately captured through population-level averages alone. Typological approaches have increasingly been used to characterise heterogeneity and identify management profiles associated with contrasting performance in smallholder livestock systems (Tittonell et al. 2010; Zoma-Traoré et al. 2020; Sanogo et al. 2022). Despite their relevance, typological approaches remain underutilised in studies of bovine AI in West African peri-urban systems. Previous studies have either described constraints affecting AI performance (Mwanga et al. 2019; Sanogo et al. 2022) or characterised farm types without explicitly relating them to reproductive outcomes (Gnanda et al. 2016; Kouamo and Pa-ana 2017). Furthermore, analyses of AI performance generally focus on a single category of stakeholders, most often farmers, whereas resident herders and inseminators are rarely included despite their complementary roles in the reproductive process (Omondi et al. 2017; Mwanga et al. 2019; Allan et al. 2024). Consequently, the relationship between farm typologies, reproductive management organisation and pregnancy per AI remains poorly documented in peri-urban cattle systems of Burkina Faso.

No published study has yet combined a typological analysis of AI-practising cattle farms with a multi-stakeholder assessment of reproductive management organisation in peri-urban Burkina Faso. Therefore, the objectives of this study were (i) to identify farm typologies based on reproductive management characteristics and (ii) to determine the organisational factors associated with pregnancy per artificial insemination in peri-urban cattle farms. We hypothesised that variability in P/AI is associated with differences in reproductive management organisation, particularly reproductive record-keeping, breeding system organisation and coordination among actors involved in AI delivery, rather than with structural herd characteristics alone.

MATERIALS AND METHODS

Study area and survey period

The study was conducted between November 2025 and May 2026 in four peri-urban cattle production zones surrounding Ouagadougou, Burkina Faso: Kadiogo, Nando, Oubri and Nazinon (Fig. 1). These zones constitute the principal dairy-oriented livestock basin supplying the capital and represent the main operational areas for bovine artificial insemination services in the region. Located within the North Sudanian agro-ecological zone, the area is characterised by a unimodal rainfall regime (700–900 mm/year) extending from May to October and a dry season from November to April, including a cool period (November-January) and a hot period (February-May), during which maximum temperatures may reach 39–42°C.

The study area comprises heterogeneous cattle production systems, including improved, semi-improved and traditional farms operating predominantly under semi-extensive conditions that combine natural grazing with varying levels of feed supplementation (Gnanda et al. 2016). This diversity of production systems and reproductive management practices provided a relevant framework for investigating variability in pregnancy outcomes following artificial insemination and the organisational determinants associated with AI performance.

Red dots indicate surveyed localities. GPS coordinates were recorded during field surveys conducted between November 2025 and May 2026. Maps were produced in the WGS 84 coordinate system using R software. Administrative boundaries were obtained from the GADM database (version 4.1, 2023), and road network data were extracted from OpenStreetMap via Geofabrik (2024). Spatial visualisation was generated using the R packages sf, ggplot2, ggspatial, cowplot and ggrepel.

Sampling design and study population

A cross-sectional survey design was adopted. The study targeted the main stakeholders involved in the bovine artificial insemination (AI) service chain in four peri-urban cattle production zones around Ouagadougou, including cattle farmers, resident herders responsible for daily herd monitoring and active inseminators operating in the study area.

In the absence of an official registry of cattle farms practising AI, a criterion-based purposive sampling strategy was employed (Patton 2002). An initial list of 120 farms was compiled using records provided by regional coordinators of farmer organisations. Farms were eligible for inclusion if they met the following criteria: (i) at least one AI procedure performed during the three years preceding the survey; (ii) a minimum of three breeding females; and (iii) informed consent from the farm owner to participate in the study and to authorise interviews with the resident herder.

Of the 120 farms initially identified, 68 were excluded prior to data collection: 12 due to ongoing infectious disease outbreaks, unusually high recent mortality or veterinary quarantine; 31 due to refusal to participate; and 25 due to repeated unavailability despite two follow-up visits. The final sample

comprised 52 farms distributed across 21 localities. In each farm, one farmer and one resident herder were interviewed independently, resulting in 52 farmers and 52 herders. In addition, all 12 inseminators operating in the study zones agreed to participate, yielding a total sample of 116 respondents.

Although the non-probability sampling approach may limit the representativeness of the findings, the explicit eligibility criteria, inclusion of farms from 21 localities and complete participation of active inseminators operating within the study area strengthen the relevance of the sample for exploring organisational factors associated with AI performance in peri-urban cattle systems.

Assessment of reproductive management organisation

Three structured questionnaires were developed specifically for farmers, resident herders and inseminators. Questionnaire development involved three successive stages: (i) identification of investigation domains through a review of the scientific literature; (ii) content validation by a panel of specialists in bovine reproduction and artificial insemination; and (iii) pilot testing in five farms located outside the study area, leading to minor modifications in the wording and sequencing of questions. Interviews were conducted face-to-face by trained enumerators in French, Dioula or Mooré according to respondent preference.

The questionnaires were designed to capture complementary information from the three stakeholder groups involved in the AI service chain, allowing triangulation of perspectives on reproductive outcomes and perceived constraints. Farmers provided information on farm characteristics, reproductive management practices, use of AI, breeding strategies, record-keeping systems, annual AI activity and perceived constraints. Resident herders provided information on socio-professional characteristics, reproductive management training, oestrus detection practices and operational difficulties encountered during herd monitoring. Inseminators provided information on professional experience, annual AI workload, self-reported pregnancy outcomes, cold-chain management practices and organisational constraints affecting service delivery.

Particular attention was given to variables describing reproductive management organisation at farm level. These included the mating system used (AI only, natural mating only, or mixed), maintenance of reproductive records, duration of AI use, annual AI activity and perceived economic benefit derived from AI. These variables were selected a priori because they captured complementary aspects of reproductive management practices and farmers' engagement with AI that could influence reproductive outcomes.

Outcome variable

The primary outcome variable was pregnancy per artificial insemination (P/AI), defined as the proportion of inseminated cows resulting in an established pregnancy during the 24 months preceding the survey. The method used to estimate P/AI depended on the availability of reproductive records at farm level.

In farms maintaining reproductive records, pregnancy outcomes were obtained from documented diagnoses based on ultrasonographic examinations performed approximately 30 days after

insemination and, when required, confirmed by transrectal palpation at around 60 days post-insemination.

In farms lacking reproductive records, reproductive outcomes were retrospectively reconstructed from reported calving events and cross-checked using information obtained independently from farmers and resident herders to improve consistency of the estimates. Because pregnancy status could not be directly verified in these farms, the resulting values should be interpreted as proxy measures of P/AI rather than strictly equivalent estimates. This methodological heterogeneity should therefore be considered when interpreting comparisons across farms.

Statistical analyses

Statistical analyses were performed using Python version 3.10 and the pandas, scipy, scikit-learn, prince, scikit-posthocs and matplotlib libraries. Normality assumptions were assessed using the Shapiro-Wilk test. Since the variables involved in inferential analyses did not satisfy normality assumptions, non-parametric methods were applied throughout. Comparisons among three or more groups were conducted using the Kruskal-Wallis test. When significant ($P < 0.05$), pairwise comparisons were performed using Dunn's test with Holm adjustment for multiple testing. Statistical significance was set at $P < 0.05$.

Reproductive management typologies were identified using a three-step multivariate approach. First, Multiple Correspondence Analysis (MCA) was performed using four active qualitative variables selected a priori, based on previous literature and biological plausibility, as key dimensions of reproductive management organisation potentially associated with pregnancy outcomes following AI: mating system, reproductive record-keeping, perceived economic benefit from AI and duration of AI use. Herd size, number of breeding females and annual number of AI procedures were included as supplementary quantitative variables to aid interpretation without influencing construction of the factorial space. Explained inertia was estimated using the Benzécri-Greenacre correction (Benzécri 1979; Greenacre 2017). The first two MCA dimensions were retained for subsequent analyses because they captured the major proportion of the corrected inertia and provided an interpretable representation of the factorial structure. Second, Hierarchical Cluster Analysis (HCA) using Ward's linkage method (Ward 1963) was applied to farm coordinates derived from the retained MCA dimensions. The optimal number of clusters was determined by combining visual inspection of the dendrogram with examination of changes in agglomeration distances. The adequacy of the hierarchical clustering solution was assessed using the cophenetic correlation coefficient (Sokal and Rohlf 1962). Third, Principal Component Analysis (PCA) performed on standardised quantitative variables (mean = 0, standard deviation = 1) was used as a complementary exploratory tool to visualise the distribution of HCA-derived clusters within the quantitative-variable space. Cluster dispersion was illustrated using 95% concentration ellipses projected onto the first two PCA dimensions.

RESULTS

Characteristics of farms and stakeholders

The structural characteristics of the surveyed farms and the socio-professional profiles of stakeholders are summarised in Table 1. Farms were predominantly semi-intensive (96.2%; n = 50/52), whereas two farms operated under extensive conditions (3.8%).

Mean herd size was 27.4 ± 16.4 cattle, including 18.0 ± 11.4 breeding females and 2.7 ± 3.1 bulls per farm. The mean annual number of artificial insemination (AI) procedures was 12.9 ± 10 per farm.

Most farms (73.1%; n = 38/52) used a mixed reproductive system combining AI and natural mating. AI-only systems accounted for 17.3% of farms (n = 9), whereas 9.6% (n = 5) had reverted to exclusive natural mating. Reproductive records were maintained in 82.7% of farms (n = 43).

Among resident herders, 98.1% (n = 51/52) had not received formal training in bovine reproductive management. Mean age and herd management experience were 31.7 ± 8.5 and 16.1 ± 9.4 years, respectively. Inseminators were predominantly private practitioners (83.3%; n = 10/12) and had a mean professional experience of 12.6 ± 5.4 years (range: 5–20 years).

Table 1
Structural characteristics of surveyed farms and socio-professional profile of actors (n = 52 farms, 52 herders, 12 inseminators), peri-urban influence zone of Ouagadougou.

Variable	**Category**	**n**	**%**
Production system	Semi-intensive	50	96.2
	Extensive	2	3.8
Reproduction system	AI + natural mating	38	73.1
	AI only	9	17.3
	Natural mating only	5	9.6
Record keeping	Yes	43	82.7
	No	9	17.3
Herder formal training in reproductive management	None	51	98.1
	Trained	1	1.9
Inseminator sector	Private	10	83.3
	Public	2	16.7

AI: artificial insemination. Data expressed as number (n) and percentage (%).

Pregnancy rates and reproductive management practices

The overall pregnancy per artificial insemination (P/AI) rate was 42.7 ± 23.7% (95% CI: 36.3–49.2%), with a median of 47.5%, a range of 0–90%, and a coefficient of variation of 55.6% (Fig. 2A). Eighteen farms (34.6%) achieved P/AI ≥ 60%, 23 (44.2%) recorded values between 30% and 60%, and 11 (21.2%) had P/AI < 30%, including six farms (11.5%) with no recorded AI pregnancies.

P/AI differed according to mating system (Kruskal-Wallis: H = 13.41; P = 0.001) (Fig. 2B). AI-only farms showed the highest P/AI (52.8 ± 21.1%; median: 55.0%), followed by farms combining AI and natural mating (45.9 ± 20%; median: 50%). No AI pregnancies were recorded in farms that had reverted to exclusive natural mating during the reference period.

Farms maintaining reproductive records had higher P/AI than those without records (48.8 ± 19.2% vs. 13.4 ± 22.1%; Mann–Whitney U = 332; P < 0.001).

Pregnancy rates reported by inseminators averaged 53.1 ± 14.4% (95% CI: 44.9–61.2%), with a median of 58.5% and a range of 30–75% (n = 12). No significant difference was detected between farmer-reported P/AI and pregnancy rates reported by inseminators (Mann–Whitney U = 235; P = 0.184).

Figure 2 Distribution of pregnancy per artificial insemination (P/AI) and comparison according to mating system across 52 peri-urban cattle farms.

Panel A: Frequency histogram of P/AI values (n = 52). The orange dashed line indicates the recommended minimum threshold of ≥ 50% for satisfactory field performance (Tola and Deresa, 2025); the red dashed line indicates the median (47.5%); and the black dash-dot line indicates the mean (42.7%). Panel B: Boxplot comparing P/AI according to mating system (Kruskal–Wallis H = 13.41, P = 0.001). Dots represent individual farm values, and values below each box indicate mean ± SD. AI: artificial insemination. The natural-mating category comprised farms that had previously practised AI but had discontinued its use at the time of the survey.

Farm typologies based on reproductive management characteristics

Multiple Correspondence Analysis (MCA) performed on the four active categorical variables identified two principal dimensions accounting for 17.6% and 13.9% of the raw inertia, respectively (cumulative raw inertia: 31.5%). After Benzécri–Greenacre correction, these dimensions explained 61.7% and 22.1% of the adjusted inertia, corresponding to a cumulative adjusted inertia of 83.8%.

Hierarchical Cluster Analysis (HCA) based on farm coordinates derived from these dimensions identified a three-cluster solution. Examination of the dendrogram revealed a marked increase in Ward's agglomeration distance between mergers 49 (d = 2.37) and 50 (d = 4.42), supporting the retention of three clusters. The cophenetic correlation coefficient was 0.76 (Fig. 3).

The dashed line indicates the partition threshold retained for the three-cluster solution, supported by a marked increase in Ward's agglomeration distance between mergers 49 (d = 2.37) and 50 (d = 4.42). The

cophenetic correlation coefficient was 0.76. The three clusters corresponded to Group A (high-performing; n = 17), Group B (low-performing; n = 6) and Group C (intermediate-performing; n = 29).

The resulting typology was associated with significant differences in reproductive performance (Kruskal–Wallis: H = 15.17, P < 0.001). Group A (n = 17) exhibited the highest P/AI (52.9 ± 16.5%; median: 60.0%) and was characterised by widespread reproductive record-keeping (94.1%) and strong integration of AI within breeding strategies. Group C (n = 29) showed intermediate performance (44.5 ± 21.7%; median: 45.0%) and included a high proportion of farms perceiving AI as economically beneficial (93.1%). Group B (n = 6) recorded the lowest P/AI (5.0 ± 12.2%; median: 0.0%), with limited record-keeping (16.7%) and 83.3% of farms having discontinued AI in favour of natural mating (Table 2).

Table 2
Characteristics of the three farm typologies identified by Ward's hierarchical clustering in peri-urban cattle farms

Variable	**Group A** **High-performing** **(n = 17)**	**Group B** **Low-performing** **(n = 6)**	**Group C Intermediate** **(n = 29)**
Reproductive performance			
P/AI, mean ± SD (%)	52.9 ± 16.5 a	5.0 ± 12.2 b	44.5 ± 21.7 a
P/AI, median (%)	60.0	0.0	45.0
Farm management characteristics			
Reproductive record-keeping (%)	94.1	16.7	89.7
AI only (%)	11.8	0.0	24.1
AI + Natural mating (%)	88.2	16.7	75.9
Natural mating only (%)	0.0	83.3	0.0
Structural characteristics			
Herd size (mean ± SD)	35.2 ± 19.4	23.0 ± 20.5	23.7 ± 12.0
Reproductive cows (mean ± SD)	24.1 ± 12.8	17.8 ± 17.9	14.5 ± 7.2
Annual AI acts (mean ± SD)	21.9 ± 10.3	0.0 ± 0.0	9.6 ± 5.2
Economic indicators			
Perceived economic benefit from AI (%)	94.1	50.0	93.1

Values are expressed as mean ± SD or n (%), unless otherwise stated.

Differences in P/AI among clusters were significant (Kruskal–Wallis: H = 15.17, P < 0.001). Post hoc pairwise comparisons using Dunn's test with Holm adjustment showed significant differences between Groups A and B (P = 0.001) and between Groups C and B (P = 0.001), whereas no significant difference was detected between Groups A and C (P = 0.154).

 Values within the same row sharing no common superscript differ significantly (P < 0.05).

AI: artificial insemination; P/AI: pregnancy per artificial insemination; SD: standard deviation.

Natural mating only: farms that had previously practised AI but had discontinued its use at the time of the survey.

Projection of cluster membership onto the PCA factorial plane showed partial overlap of the 95% concentration ellipses of Groups A and C, whereas Group B remained distinct from the other clusters (Fig. 4).

DISCUSSION

The mean pregnancy per AI rate observed in the present study (42.7 ± 23.7%) falls within the range reported under field conditions in sub-Saharan Africa. Published estimates vary widely according to breed composition, management intensity and technical support, with pregnancy rates generally ranging from approximately 30% to 45% under routine field conditions (Sanogo et al. 2022; Tadesse et al. 2022; Mekonnen and Gebremariam 2024), while values exceeding 60% have been reported under structured synchronisation programmes (Hamid et al. 2021; Tchoffo et al. 2024; Hambisa 2025). Nevertheless, the mean P/AI observed in the present study remains below the ≥ 50% benchmark commonly considered indicative of satisfactory reproductive performance in smallholder cattle systems (Tola and Deresa 2025). Comparable pregnancy rates (32.5%) have also been reported under routine field conditions in peri-urban Bobo-Dioulasso (Sanogo et al. 2022), suggesting that suboptimal AI performance remains a challenge in peri-urban cattle systems of Burkina Faso.

Beyond the average pregnancy rate, the most notable finding was the substantial inter-farm variability observed (CV = 55.6%; range: 0–90%). Such heterogeneity indicates that farms operating within the same agro-ecological environment may achieve markedly different reproductive outcomes. This observation suggests that farm-level factors, particularly those related to reproductive management practices and service organisation, may contribute more strongly to AI performance variability than environmental conditions shared across farms. This interpretation is supported by studies reporting pregnancy rates of 62% following mass synchronisation programmes in Ethiopia (Tegegne et al. 2016), 60.6% in synchronised Goudali cattle in Cameroon (Tchoffo et al. 2024) and 61.6% in peri-urban Ouagadougou under hormonal synchronisation (Tapsoba et al. 2022), illustrating the potential gains achievable when reproductive activities are supported by structured management and monitoring systems.

The multi-stakeholder approach adopted in this study revealed that constraints affecting AI performance operate at different stages of the reproductive process. Farmers primarily identified inseminator unavailability as the main limiting factor, whereas inseminators emphasised inadequate oestrus detection by farm personnel. Similar constraints have been reported in several African countries, where delayed inseminator intervention, limited service accessibility and poor heat detection compromise the effectiveness of AI programmes (Omondi et al. 2017; Mwanga et al. 2019; Sanogo et al. 2022; Allan et al. 2024). Rather than reflecting isolated deficiencies, these findings suggest that reproductive inefficiencies arise from the accumulation of weaknesses occurring sequentially along the AI delivery pathway, from heat detection to service provision.

The typological analysis further demonstrated that farms sharing similar agro-ecological conditions may differ markedly in their reproductive outcomes according to how reproductive activities are organised. Farms belonging to the highest-performing cluster combined systematic reproductive record-keeping, sustained use of AI and the highest pregnancy rates, whereas the lowest-performing cluster was characterised by discontinuation of AI and limited reproductive monitoring. Farms with intermediate performance displayed mixed organisational characteristics and reproductive outcomes. Collectively, these findings suggest that greater organisational integration of reproductive management may contribute to improved AI outcomes beyond structural herd characteristics alone.

Among the organisational components examined, reproductive record keeping emerged as one of the organisational features most consistently associated with higher P/AI. Farms maintaining reproductive records achieved substantially higher pregnancy rates than those without records. Recording reproductive events may facilitate the identification of cows eligible for breeding, improve scheduling of insemination activities and support communication between farmers and inseminators. Similar associations between reproductive recording systems and improved reproductive performance have been described in smallholder cattle systems elsewhere in Africa (Nishimwe et al. 2015; Mwanga et al. 2019). Beyond their immediate managerial value, reproductive records also provide the reliable phenotypic information required for monitoring herd performance and supporting genetic improvement programmes (Muchadeyi et al. 2020).

Overall, the findings indicate that variability in pregnancy outcomes following AI is closely associated with the organisation of reproductive management within farms. Reproductive record-keeping, timely oestrus detection and operational accessibility of insemination services may therefore represent practical targets for intervention in peri-urban cattle systems. Strengths of this study include its multi-stakeholder design and the integration of typological and reproductive performance analyses. However, the cross-sectional design precludes causal inference, and pregnancy outcomes reconstructed retrospectively in farms lacking reproductive records should be interpreted with caution. Longitudinal studies integrating animal-level reproductive monitoring are warranted to confirm the associations identified.

CONCLUSION

This study identified three distinct farm typologies associated with contrasting organisational profiles and pregnancy outcomes following artificial insemination in peri-urban cattle systems of Burkina Faso. Pregnancy per artificial insemination showed marked inter-farm variability, ranging from complete reproductive failure to highly satisfactory outcomes under field conditions. Farms characterised by systematic reproductive record-keeping, sustained use of artificial insemination and more structured reproductive practices consistently achieved higher pregnancy rates than farms with limited reproductive monitoring and discontinuation of AI.

The findings also indicate that constraints affecting AI efficiency operate at multiple stages of the reproductive process, notably through limited inseminator availability and inadequate oestrus detection by farm personnel. Taken together, these results suggest that variability in AI performance is more closely associated with the degree of organisational integration of reproductive management than with structural herd characteristics alone.

From a practical perspective, strengthening reproductive recording systems, improving oestrus detection skills and increasing the operational accessibility of insemination services may represent feasible leverage points for enhancing AI outcomes in peri-urban cattle systems. These organisational dimensions should therefore be considered priority targets in the design of AI development and genetic improvement programmes in West Africa. Further longitudinal studies incorporating animal-level reproductive monitoring are needed to confirm the causal pathways underlying the associations observed in this study.

Declarations

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The authors declare that no specific funding was received for this research.

Competing interests

The authors declare that they have no competing interests.

Author contributions

ATY contributed to conceptualization, methodology, software, formal analysis, investigation, data curation, visualization, project administration, and writing of the original draft. AO contributed to conceptualization, methodology, investigation, and review and editing of the manuscript. CH contributed to supervision, validation, and review and editing of the manuscript. All authors read and approved the final manuscript.

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Data availability

The datasets generated and analysed during the current study are not publicly available due to confidentiality agreements with participating farms but are available from the corresponding author on reasonable request.

Ethics approval

Ethical approval was not required because the study was non-interventional and involved only questionnaire-based data collection from consenting adult participants. No experimental procedures were performed on animals.

Consent to participate

Written informed consent was obtained from all participants prior to enrolment.

Statement of animal rights

No experimental procedures involving animals were conducted as part of this study. All artificial insemination activities were performed independently of the research protocol and followed routine veterinary practices

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Figures

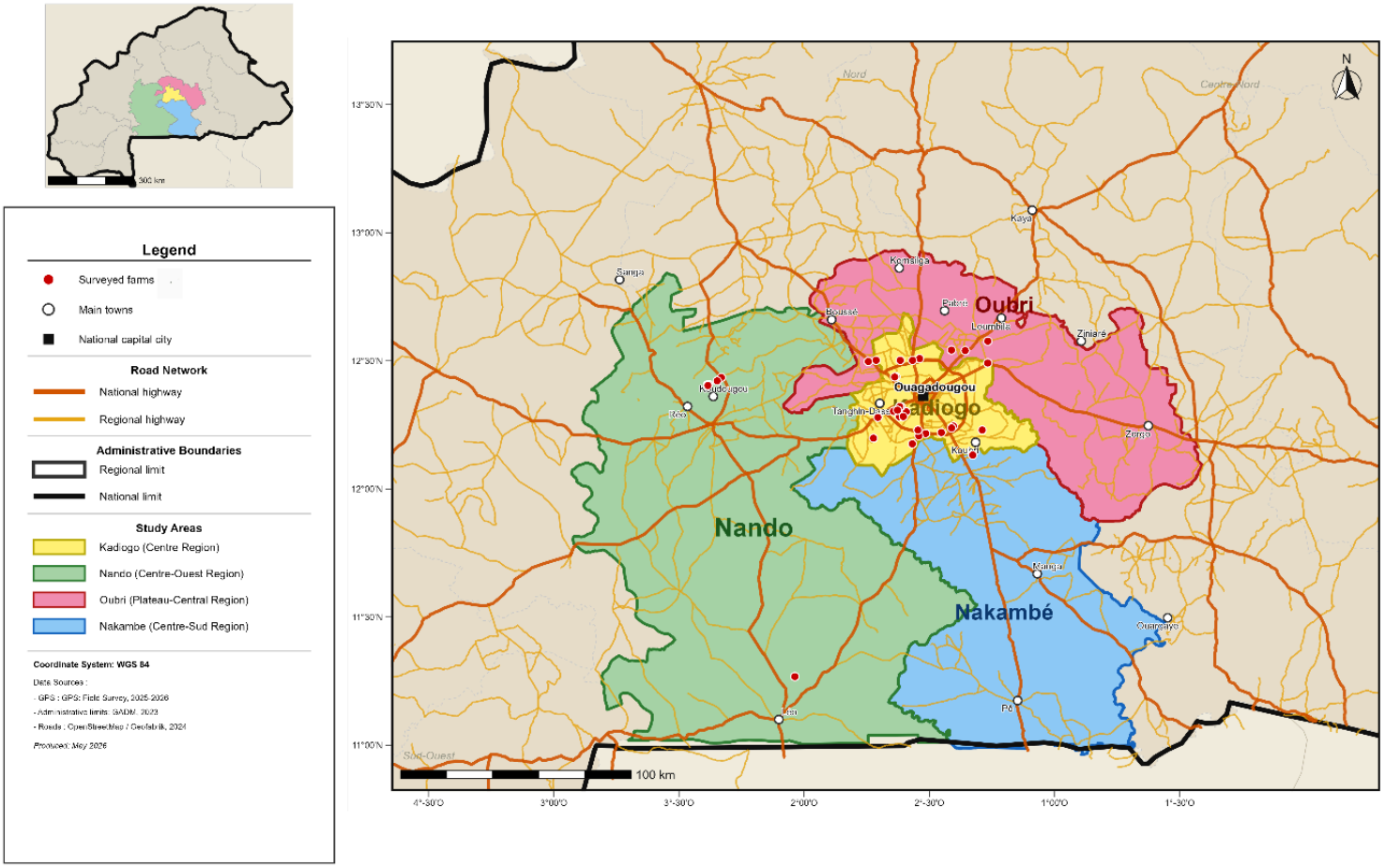


Figure 1

Geographical distribution of the 52 surveyed cattle farms across 21 localities within four peri-urban cattle production zones surrounding Ouagadougou, Burkina Faso.

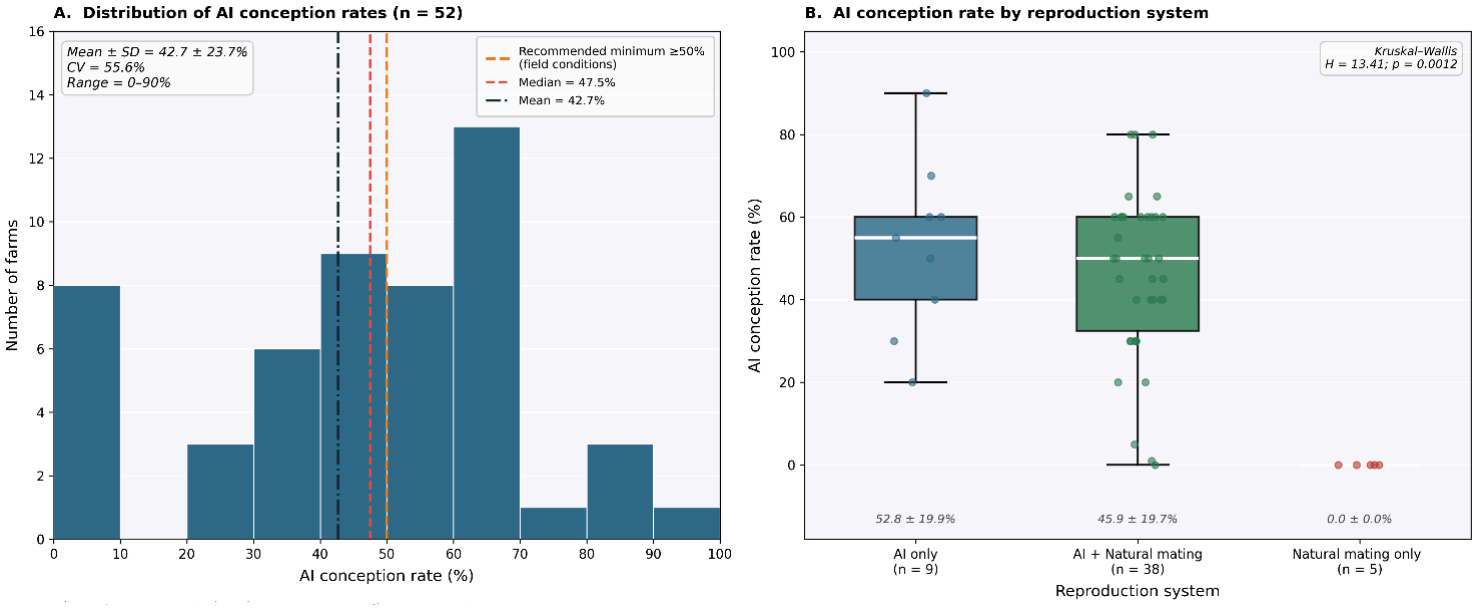


Figure 2

Distribution of pregnancy per artificial insemination (P/AI) and comparison according to mating system across 52 peri-urban cattle farms.

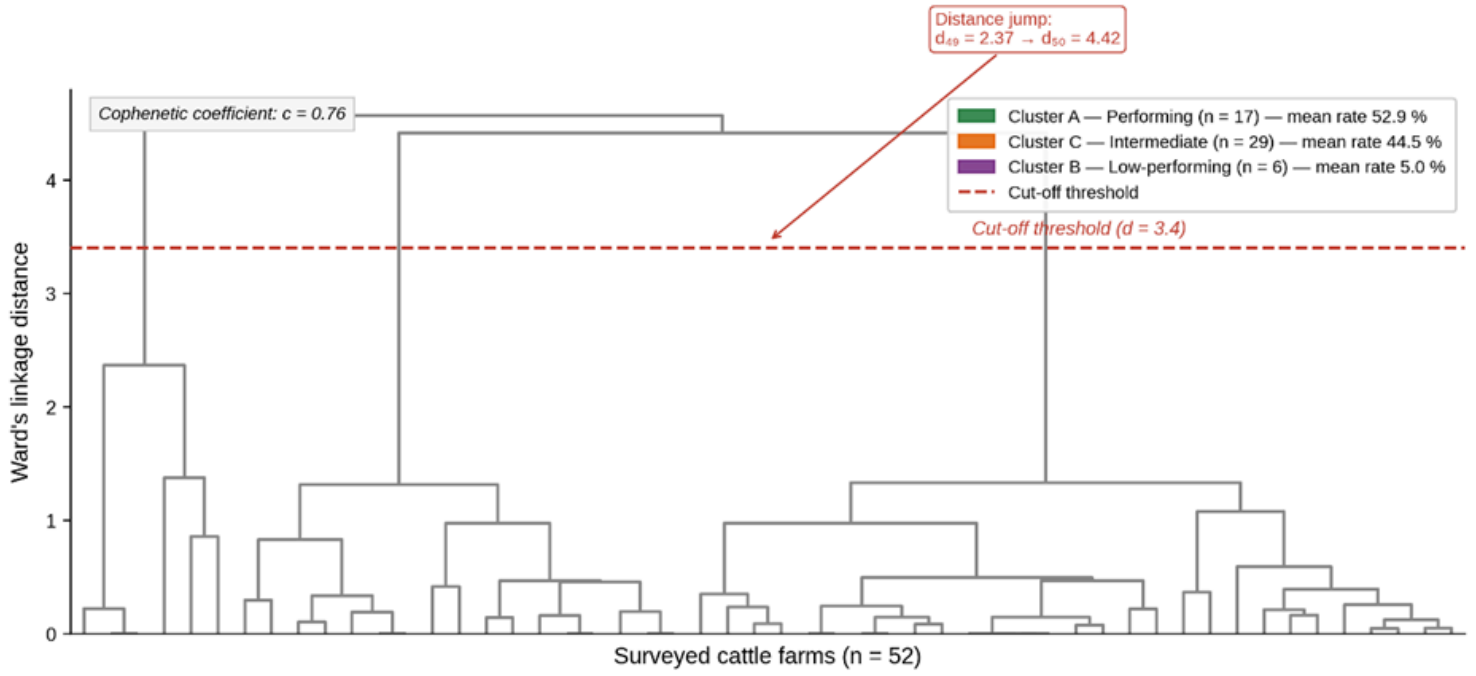


Fig. 3. Dendrogram of the Hierarchical Cluster Analysis (Ward's method, n = 52). The dashed line indicates the cut-off threshold retained.

Figure 3

Dendrogram of Ward's hierarchical clustering of the 52 cattle farms based on Multiple Correspondence Analysis (MCA) coordinates.

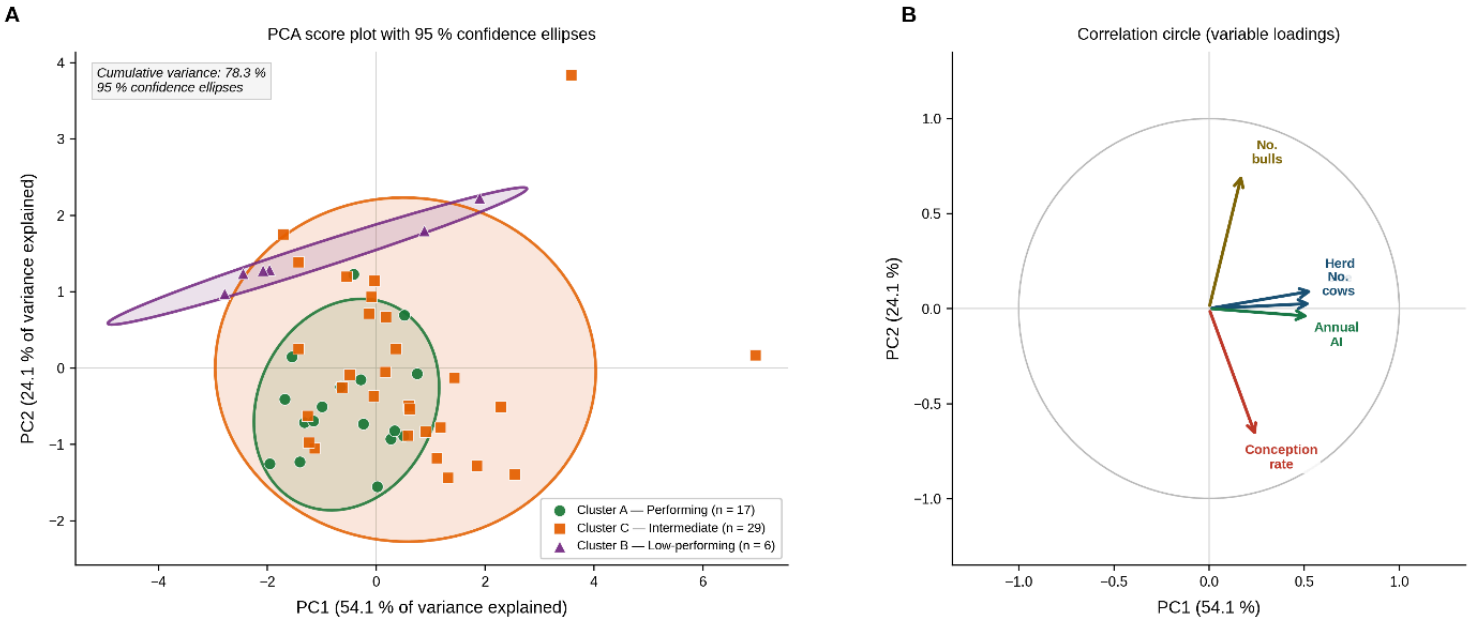


Fig. 4. PCA cross-validation of farm typologies (n = 52)

Figure 4

Principal Component Analysis (PCA) biplot of the three farm typologies derived from hierarchical clustering. Each point represents a farm, coloured according to cluster assignment. The 95% concentration ellipses depict within-group dispersion in the quantitative-variable space. Partial overlap between Groups A (high-performing; n = 17) and C (intermediate-performing; n = 29) suggests similarities in quantitative characteristics, whereas Group B (low-performing; n = 6) forms a distinct cluster.