Typology and status of cattle farms using artificial insemination in Burkina Faso

S. SANOGO[1], A. R. BADIARA[2], B. M. OROUNLADJI[1*], D. COULIBALY[2], S. KOANDA[3]

[1] *Centre International de Recherche Développement sur l'Élevage en zone Subhumide, Bobo Dioulasso, Burkina Faso*

[2] *Institut Polytechnique Rural de Formation et de Recherche Appliquée de Katibougou, Mali*

[3] *Direction Régionale des Ressources Animales et Halieutiques, Bobo Dioulasso, Burkina Faso*

** Corresponding author oromib@gmail.com*

Received 07/06/2022
Accepted 18/06/2022

Abstract

The aim of the study was to assess the challenges and prospects of cattle artificial insemination (AI) in Burkina Faso. Data were collected from 50 farms in the peri-urban area of Bobo-Dioulasso. The results show that AI is used by 40.4% of the respondents and 42.1% of them use both strategies (natural and induced estrus) of AI improvement to optimize their chance of success. These producers are gradually moving towards AI over natural estrus which they describe as better. The average cost of AI with state AI services was XOF 12 500 for natural estrus and XOF 17 500 for induced estrus, and about XOF 30 000 to 50 000 with private AI providers. The success rate of AI was 32.5%. The use of AI had a significant positive effect on milk production. Producers stated that AI was a good method of improving cattle production. Three groups of producers emerged based on their level of AI practice. Several constraints limit AI adoption. It is important to reconsider the opinions of farmers who are the first to be concerned in the implementation of the new innovation strategies of animal production, in order to achieve the goals of food and nutritional self-sufficiency.

Keywords: Artificial insemination, Biotechnology, Cattle, Rate of adoption, Typology

INTRODUCTION

The livestock sector is booming in West Africa due to the increasing demand for animal products (Kagone, 2001; Mcdermott *et al.*, 2010; FAO *et al.*, 2013). It plays multiple roles in the social, economic and environmental field (Alary *et al.*, 2011; Lebacq *et al.*, 2013). However, in the mixed crop-livestock family farms of the sub humid savannah zone, the contribution of livestock to the supply of meat and milk to the market, and the generation of income on farms as well as to the production of services (animal traction, organic manure, savings) is not sufficient (de Ridder *et al.*, 2015; Douxchamps *et al.*, 2015). This is particularly the case in Burkina Faso, although livestock contributes a significant share of the gross domestic product (18%), is practiced by more than 80% of the agricultural population and represents one of the main activities for diversifying and securing the income of family farms (MRA, 2012).

Indeed, the country has a large domestic ruminant herd (DGESS/MRAH, 2017) estimate to 9 720 615 cattle (MRAH, 2022). Despite this large number of animals, national production of milk products covers barely 10% of demand (DGESS/MRAH, 2017). This deficit in milk production is also linked to low milk productivity (1 to 4 liters/day) of the local breed cows and poorly performing reproduction parameters (Meyer and Denis, 1999). In order to stem this bottleneck, Africa imports 50% of the dairy products it consumes, mainly in the form of milk powder, which weighs heavily on the economic balance of importing countries (Meyer and Denis, 1999). These imports of milk and its derivatives had led to foreign exchange outflows estimated at fifteen (15) billion XOF in 2011 (MRA, 2012).

The limiting factors of the local milk sector are (i) the low dairy potential of local breeds; (ii) the high price of production factors; (iii) the low availability of fodder especially in the dry season; (iv) the insufficient control of milk quality; (v) the export of dairy cattle; (vi) the seasonal variation of supply and (vi) the low competitiveness of local milk compared to imported milk (Corniaux, 2015; GRET, 2018).

Faced with all these constraints, political authorities and development organizations have focused in recent years on the development of technical solutions for animal health and feeding, as well as animal production and technology.

The improvement of animal production performance is a growing interest in development programs through artificial insemination (AI) campaigns in cattle. The latter has been suggested as a way to improve performance with very ambitious programs to import improved semen to increase milk or meat production (Boly *et al.*, 2003).

In view of effectiveness of cattle AI in modernizing livestock production in Burkina Faso, it would be appropriate to assess the use of this biotechnology in animal reproduction in order to evaluate its prospects.

The main objective of this study is to assess the challenges and prospects of cattle AI in the peri-urban area of Bobo Dioulasso in Burkina Faso for better knowledge of this biotechnology of animal reproduction. The aim is to present, based on milk production, the contribution of AI in improving the living conditions of producers in the peri-urban area of Bobo Dioulasso, to identify the constraints faced by this biotechnology and to make suggestions for improving the results of its dissemination.

MATERIALS AND METHODS

Study area

Data collection was conducted on cattle farms located in the district of Bobo Dioulasso. It is located in the province of Houet, which covers an area of approximately 11 568 km² and is located between 3°20' and 4°60' West and between 10°30' and 12°20' North.

It is bordered to the North by the Banwa and Mouhoun provinces, the South by the Comoé province, the East by the Tuy and Bougouriba provinces, and the West by the Kénédougou province. Rainfall varies between 900 and 1250 mm of water per year in the last ten years (Savadogo, 2017). The climate of the Houet area is South Sudanian and is characterized by a dry season (November to April) and a rainy season that runs from May to October. The average temperature is 27°C with minima of 20°C in December and maxima of 35°C in April (Ouattara, 2014). The vegetation is of the South Sudanian type, composed of wooded savannahs, tree and shrub savannahs. There are tall woody formations with *Parkia biglobosa, Vitellaria paradoxa* and *Daniellia oliveri, etc*. These high woody formations are followed by low woody formations with *Detarium microcarpum* and grassy formations dominated by *Andropogon gayanus* (Mambila, 1999). To these natural formations are added exotic species: *Anacardium occidentale, Eucalyptus camadulensis*, etc. This important vegetation contains a numerous and varied fauna. However, there is an increasing degradation of the environment due to human activities (anthropic), which leads to a progressive regression of wildlife species (Zida/Bangré, 2009).

Sampling

The surveys were conducted among 50 cattle farmers, all from the urban district of Bobo Dioulasso. They come from several sociolinguistic groups, namely: Peulhs, Mossis, Bobo, Samo and Dafing spread over 08 villages. The sample size *n* was determined using Dagnelie's (1998) binomial distribution estimate.

$$n = \frac{U_{0.975}^2 * p(1-p)}{d^2} \quad (1)$$

where *n* is the number of respondents in the study area; *p* is the proportion of individuals raising cattle; $U_{0,975} \approx 1.96$ is the quantile of a standard normal distribution for a probability value of 0.05; and *d* is the marginal error set at 8%.

Data collection

Data were collected using KoBoCollect application with a semi-structured questionnaire. The farmers chosen were those listed in the database of the cattle artificial insemination service of the district, which are easily accessible and available. The interview was conducted in the local languages (Dioula, Mooré) of the respondent and in some cases in French at his request. The data collected during the interviews were related to the sociological characteristics (age and gender) of the cattle farmers and information on the use of artificial insemination.

Data analysis

Descriptive statistics were used to determine the relative frequencies of categorical variables. For each relative frequency, a confidence interval (CI) of 95% was calculated using the formula below:

$$CI = P \pm 1.96\sqrt{\frac{P(1-P)}{N}} \quad (2)$$

Where *P* is the relative frequency and *N* is the sample size.

An analysis of variance was performed with the quantitative variables followed by Student Newman Keuls test through agricolae package (de Mendiburu, 2020) in case of significant difference ($p < 0.05$). Some variables of interest (level of education, main activity, AI practice, reproductive management, and other additional variables) were retained in order to classify the farms according to a degree of AI application. To this end, multiple component analysis with ascending hierarchical classification was performed through the factoextra package (Kassambara and Mundt, 2020) using R 4.1.2 software (R Core Team, 2021). This data analysis allowed the emergence of homogeneous classes of farms with regard to the variables considered, and consequently the degree of implementation of AI in the groups.

RESULTS

Cattle farmers' socio-demographic characteristics

The respondents came from several sociolinguistic groups, the most represented being Peulh (58%) and Mossi (22%) while 36% of respondents were illiterate (Table 1). 44% of them had attended Koranic school. Most (70%) of the respondents were engaged in livestock farming as their main activity. The most experience (66%) in practicing AI ranged from 0 to 2 years.

Status of artificial insemination

All the farmers surveyed (100%) were aware of artificial insemination but only 40% of them continued to practice it during the survey period (Table 2). Most (90%) of the producers stated that they know how to recognize a cow in estrus through signs such as: acceptance of overlap (72%), presence of mucus (16%), bellowing (8%) and swelling of the vulva (4%). However, 50% of the respondents said that these signs were present at all times, while 32% and 18% said that these signs were observed in the morning and evening respectively.

AI is done on natural estrus (21.0%), induced estrus (36.8%) and also by combining natural estrus with induced estrus (42.1%) (Figure 1a).

Artificial insemination cost

Among producers using AI, prices ranged from XOF 10000 (USD 17.3) to XOF 15000 (USD 26.0) for AI on natural estrus and between XOF 15000 (USD 26.0) and XOF 20000 (USD 34.7) for AI on induced estrus per cow (Figure 1b). These were the prices charged by the utilities. Although expensive according to 84% of producers, some farmers (16%) were willing to pay between XOF 30000 (USD 52.0) and XOF 50000 (USD 86.7) for private AI services to inseminate a cow.

Table 1: Socio-demographic characteristics of respondents

Variables	Modalities	Number of respondents	Frequency (%)	IC
Socio-linguistic groups	Bobo	3	6	[-0.005; 0.12]
	Dioula	2	4	[-0.01; 0.09]
	Dogon	1	2	[-0.01; 0.05]
	Lélé	1	2	[-0.01; 0.05]
	Mossi	11	22	[0.1; 0.3]
	Peulh	29	58	[0.4; 0.7]
	Samo	1	2	[-0.01; 0.05]
	Sénoufo	2	4	[-0.01; 0.09]
Level of education	Illiterate	18	36	[0.2; 0.4]
	Other	22	44	[0.3; 0.5]
	College	2	4	[-0.01; 0.09]
	High School	1	2	[-0.01; 0.05]
	Primary	7	14	[0.04; 0.23]
Main activity	Agriculture	3	6	[-0.005; 0.1]
	Other	2	4	[-0.01; 0.09]
	Trade	8	16	[0.05; 0.2]
	Breeding	35	70	[0.5; 0.8]
	Private employee	2	4	[-0.01; 0.09]
Experience in AI practice (year)	[0;2]	33	66	[0.5; 0.7]
	]2;4]	_		_
	]4;6]	3	6	[-0.005; 0.4]
	> 6	14	28	[0.1; 0.4]

CI: Confidence interval

Table 2: Status of artificial insemination in the peri-urban area of Bobo-Dioulasso

Variables	Modalities	Number	Frequency (%)	IC
Knowledge of AI	Yes	50	100	1
	No	0	0	0
Current implementation of AI	Yes	20	40	[0.26; 0.53]
	No	30	60	[0.46 ; 0.73]
Recognition of a cow in estrus	Yes	45	90	[0.81; 0.98]
	No	5	10	[0.01; 0.18]
Signs of a cow in estrus	Overlap acceptance	36	72	[0.59; 0.84]
	Presence of mucus	8	16	[0.05; 0.26]
	Bellowing	4	8	[0.004; 0.15]
	Swelling of the vulva	2	4	[-0.01; 0.09]
Period of signs' appearance	At any time	25	50	[0.36; 0.63]
	Morning	16	32	[0.19; 0.44]
	Evening	9	18	[0.07; 028]

Success rate of artificial insemination

The calving rate was considered by the producers as the success rate of AI, which was 32.5% for the farms that practiced it (Figure 1c). The cows inseminated were composed of 57.9% local breeds and 42.1% crossbreds. The most used semens were from the Montbeliard, Holstein and Alpine Brown breeds for 89.5% of the farmers against 10.5% who used other semen from Tarentaise and Gir breeds. Insemination of crossbred cows had a success rate of 57.9% compared to 21.2% for local breeds.

Constraints of artificial insemination

According to the farmers, the main constraints were related to the high cost of AI (100%) and the unsatisfactory success rate (42%) (Figure 1d). In addition, the high cost of the cow feeding in stalls (28%) before and after AI (flushing), the maintenance of the crossbred (12%), and the difficulty of obtaining female products (4%).

Perspectives

AI is a technology that has been widely disseminated by the government and adopted by farmers despite the poor results of some campaigns. Faced with the various constraints, perspectives were diverse (Figure 2). It can be seen that 25% of respondents want quality assurance for AI inputs, especially semen, 17.1% want feed subsidies, 14.6% want an increase in the number of technicians (inseminators), 12.2% want inseminators to be trained and equipped. In addition, 12.2% of the respondents want the price of AI to be set according to the success rate. 7.31% want the promotion and subsidization of successful breeders, 4.90% suggest that farmers should be informed and trained, and 2.23% want the promotion of a permanent AI outreach service to address farmers' concerns. These include easing the obligations of managing animals before and after AI, lowering the price of AI and promoting sexed semen.

Typology of cattle farms in the peri-urban area of Bobo Dioulasso

The correlations between the variables considered made it possible to retain for the Multiple Component Analysis (MCA), a set of active variables giving modalities. The cumulative contribution to the total inertia of the first six (06) factorial axes retained was 51.3% (Table 3).

Table 3: Contribution of the axes to the total inertia of the factorial designs

Axes	Eigenvalue	Percentage of variance	Cumulative percentage of variance
1	0.70	14.6	14.6
2	0.44	9.33	24.0
3	0.41	8.56	32.5
4	0.34	7.12	39.7
5	0.30	6.40	46.1
6	0.25	5.28	51.3

The axes 1 and 2 with the highest percentages of variance, 14.6% and 9.33% respectively, clearly defined the different groups (Figure 3a). In order to define more precisely the groups of farmers, an Ascending Hierarchical Classification was performed by taking into account all the factors retained (Figure 3b).

The distribution of the groups on the MCA graphs made it possible to identify the characteristics of each group presented in Table 4. Thus, group 1, composed of farms with a low gradient of AI practice, was made up mostly (94.1%) of illiterate people who practice livestock farming as their main activity and adopt AI very little (5.9%) despite the fact that these farms were made up of large numbers (46.1 ± 29.0) of cattle. In group 2, the respondents were divided between Koranic school (91.7%) and secondary school (8.3%). This group 2 was made up mainly (91.7%) of farmers who do not practice cattle AI. However, they were the ones with the highest herd size (53.3 ± 21.3) ($p<0.05$). Group 2 was designated as the group with a zero gradient in AI practice. Group 3 was made up of farmers (62.5%) who attended Koranic school for the most part (62.5%). The latter adopt AI at

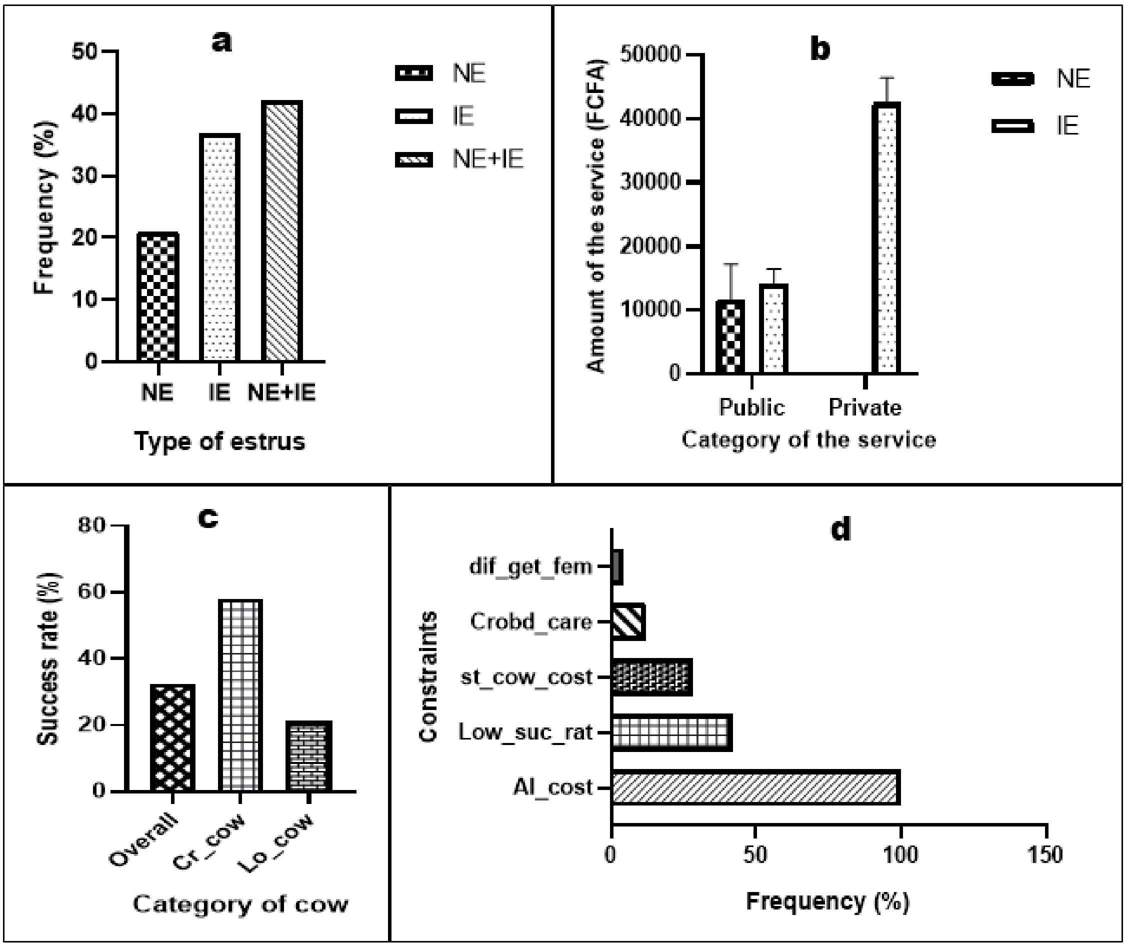

Figure 1: a. ***Types of ovulations used by farmers;*** **b.** ***Cost of AI based on estrus types and insemination service;*** **c.** ***AI success rates;*** **d.** ***Constraints of artificial insemination***

__NE__: Natural estrus; __IE__: Induced estrus; __Cr_cow__: Crossbred cow; __Lo_cow__: Local cow; __dif_get_fem__: Difficulty to get female; __Crobd_care__: Crossbreed care; __st_cow_cost__: Cost of stalled cow; __Low_suc_rat__: Low success rate; __AI_cost__: Artificial insemination cost

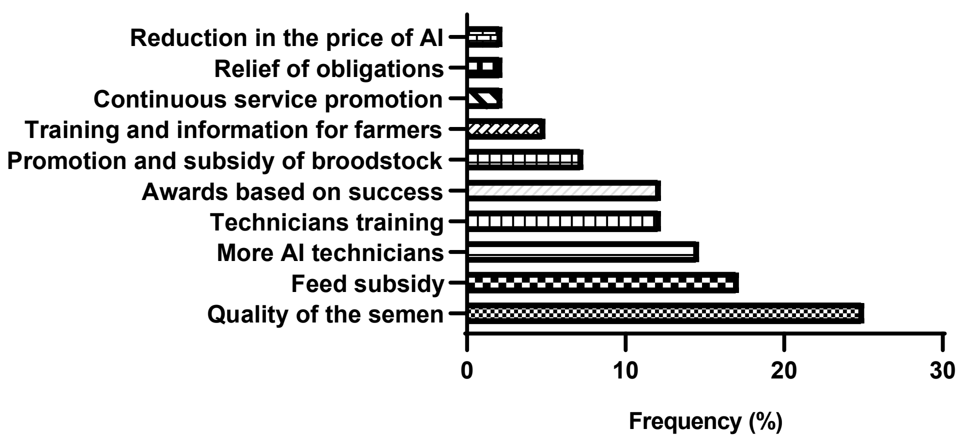

Figure 2: Different perspectives on improving AI practice

100% and their good reproductive management allows them to have a high milk production (8.81±7.81 L/cow/day). Group 4 was made up of traders (100%) who have livestock farms as their second activity. They practice AI and also obtain a better milk production (7.5 ± 0.71 L/cow/day). Groups 3 and 4 were designated as high AI practice farms.

DISCUSSION

The purpose of this study was to assess the current situation and identify the obstacles to the use of AI on cattle farms in the peri-urban area of Bobo-Dioulasso using a questionnaire in order to formulate perspectives for improvement. The majority (58%) of cattle farmers in the study area were Peulhs. The latter were culturally and

Table 4: Variables explaining the typology of livestock in the peri-urban area of Bobo Dioulasso

		AI practice gradient →						
		Null (26%)	Low (36%)	Strong (38%)				
Variables	**Modalities**	Group 2 (n=13)	Group 1 (n=18)	Group 4 (n=2)	Group 3 (n=17)	Global	χ^2	p-value
Level of education	**Illiterate**	0.0	94.1	0.0	12.5	38.3	90.4	< 0.001
	Other	91.7	0.0	0.0	62.5	44.7		
	College	0.0	0.0	100.0	0.0	4.3		
	High School	8.3	0.0	0.0	0.0	2.1		
	Primary	0.0	5.9	0.0	25.0	10.6		
Main activity	**Crop farming**	8.3	0.0	0.0	0.0	2.1	39.8	< 0.001
	Other	0.0	0.0	0.0	12.5	4.3		
	Trading	0.0	23.5	100.0	12.5	17.0		
	Livestock farming	91.7	76.5	0.0	62.5	72.3		
	Private employee	0.0	0.0	0.0	12.5	4.3		
AI Practice	**No**	100.0	94.1	0.0	0.0	59.6	43.1	< 0.001
	Yes	0.0	5.9	100.0	100.0	40.4		
Reproduction management	**No**	100.0	100.0	0.0	0.0	61.7	47.0	< 0,001
	Yes	0.0	0.0	100.0	100.0	38.3		
Milk production (L/cow/day)		1.08 ± 2.19^{b}	1.29 ± 1.69^{b}	7.5 ± 0.71^{a}	8.81 ± 7.81^{a}	4.06	-	< 0.001
Size of the herd		53.3 ± 21.3^{a}	46.06 ± 29.0^{a}	16.0 ± 12.7^{b}	32.2 ± 22.3^{b}	41.9	-	0.04*
Number of females		41.58 ± 25.67	32.12 ± 26.68	16.0 ± 12.7	22.4 ± 16.8	30.5	-	0.15

*(a ; b): Means with unlike superscripts in the same row differ significantly (p<0.05) ; *: Significant difference and p < 0.05*

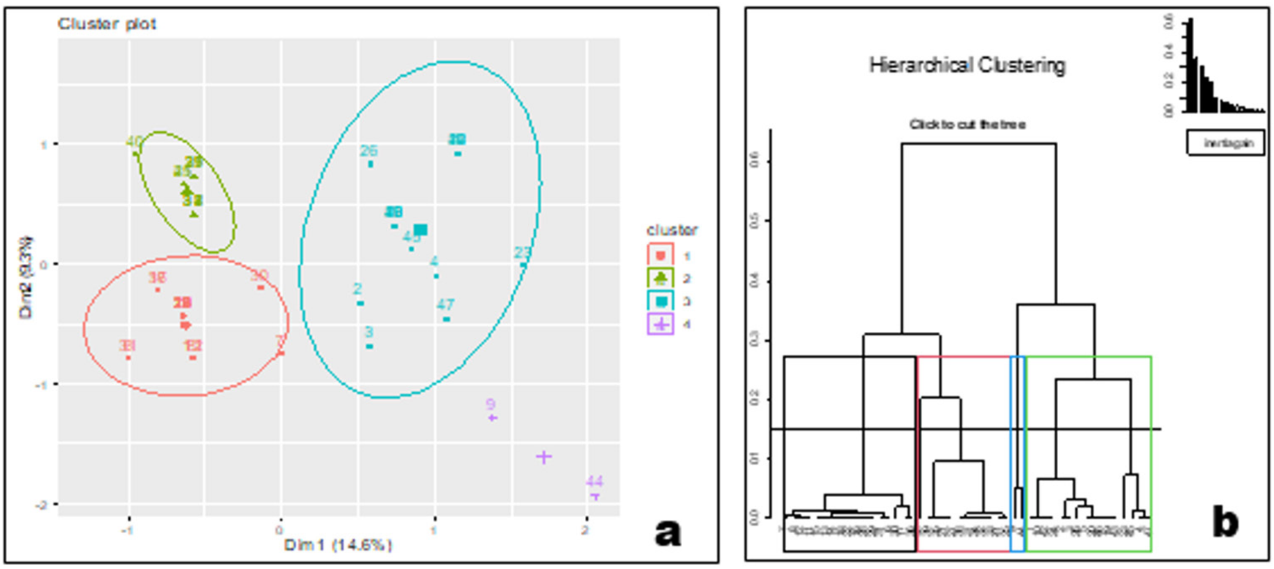

Figure 3: **a.** ***Distribution of cattle farms in the peri-urban area of Bobo Dioulasso on the main factorial axes;*** **b.** ***Dendrogram of cattle farms in the peri-urban area of Bobo Dioulasso***

traditionally herders, which explains their primary ownership of livestock (Asseu, 2010). Some (40%) of the farmers were located in Bobo Dioulasso. This, facilitates the supply of animal products, particularly milk, to the cities. According to Cesaro and Apolloni (2020), as vegetables, milk and meat are perishable foods, in order to adequately supply cities and markets, production or processing units must be located in the city or at least in its close suburbs. 76% of farmers practice a semi-intensive system. The provision of feed supplements to their animals is done by 98% of the farmers and recognize, moreover, that feeding is paramount for achieving their breeding objectives (growth and reproduction). According to Niang (2012), the practice of supplementing the feed ration with concentrate influences the pregnancy rate in cows.

Producers know how to recognize a cow in estrus and were relatively adopting the combination of the two estrus methods (natural and induced) for cattle artificial insemination. Indeed, farmers use both AI application strategies to optimize their chance of success and were gradually moving towards AI on natural estrus, which they consider better. These findings were similar to those of Asseu (2010) with farmers in the Kaolack department in Senegal. The enthusiasm of farmers for this method was surely a sign of its effectiveness.

Regardless of the type of actor, the cost of insemination varies according to the location of the animal, the type of semen, accessibility, the type of ovulation used (natural or induced) and the number of services requested on the farm. The price of AI on induced estrus from state services obtained in this study is similar to that obtained by Messine *et al.* (1993) which was XOF 18 300 (USD 31.8) in Cameroon. These prices were lower than those reported by Ngono (2007) in Kaolack which were XOF 21080 (USD 36.6) for AI on natural estrus and XOF 33800 (USD 58.7) for AI on induced estrus . Depending on the producer, insemination through private AI services cost between XOF 30 000 (USD 52.1) and XOF 50 000 (USD 86.8). These prices were similar to XOF 48 148 (USD 83.6) and XOF 50 000 (USD 86.8) obtained by Diaphoumpa (2003) and Kalandi (2011) in the groundnut basin in Senegal. This price difference between public and private AI services was explained by the state subsidy of public services. The adoption of cattle AI is highly dependent on the quality/price ratio of this biotechnology.

The farrowing rate obtained during our study was 32.5%. This rate was low compared to the reference rate of 60 to 70% (Kouamo *et al.*, 2009). The calving rate found was close to that reported by Niang (2012) during the insemination campaign of the Livestock Development Project in Eastern Senegal and Upper Casamance which was 32.6%. This rate was lower than 38% reported by Kouamo (2007) in the Matam region. It was also higher than the rates found during AI campaigns conducted by the Projet d'Appui à la Promotion de l'Élevage (PAPEL) in Burkina Faso in 1995, 1996, and 1998, i.e., 26.4%, 26.9%, and 29% respectively. This rate was also higher than that of the AI campaigns conducted by the Ministry of Livestock in 1999/2000, i.e. 15.6% (ISRA, 2003). These findings differences can be explained by the farming technique, the technicality of the inseminator and other factors related to the environment. However, they were far from the estimates given by Pousga (2002) in the framework of the "Projet de Développement de l'Agriculture Péri-urbaine" in Bamako, Mali, who reported a calving rate of 97%. The rates are usually overestimated since most projects do not regularly monitor cows once they are diagnosed as pregnant. Pregnancy rates vary depending on several factors that are either intrinsic or extrinsic to the animal at the time of AI. In our study, the factors that would have influenced this rate were not studied.

The classification carried out shows that the farms practicing AI have more milk than those that do not adopt it. Thus, artificial insemination has significantly increased the production level of animals in the area of milk production. However, in most studies, the results were poorly documented (Kassa *et al.*, 2017).

Among the farmers interviewed, 89.48% used AI to improve the milk production of their herds. This was similar to the results obtained in the farms of Thiès and Dakar where the results were respectively 74.2% and 91% for the improvement of milk production according to the results of the work of Sery (2003) and Nkolo (2009). This was also the finding of Kabera *et al.* (2016) in Kigali farms where the proximity of services offered by the Rwanda Agriculture Board (RAB) has resulted in the majority of farmers adopting AI as a technique for developing their milk production. These results can be explained by the proximity of the study area to urban areas and markets for the sale of their goods (milk).

However, the constraints of artificial insemination negatively influence its adoption. Some of the constraints highlighted by farmers during our surveys were important for a better analysis of the limits of adoption. These include the non-respect of appointment dates set by the veterinary services for both synchronization and insemination, the lack of follow-up after insemination, the absence of semen during insemination, and the clientelism practiced by inseminators. In addition, some religious reasons were listed, as well as the failure to take into account the opinions of farmers on the choice of semen type (breeds) to inseminate. However, the high cost of the service was a major constraint in line with the observations of Diaphoumpa (2003).

CONCLUSION

From this study, it emerged that despite the efforts of the "Centre de Multiplication des Animaux Performants" (CMAP) and other structures of dissemination and promotion of cattle AI, the analysis of success rates shows a weakness compared to the optimum rate of 60-70 recommended for the strategy to be profitable.

The practice of cattle AI contributes to the improvement of the standard of living of farmers through the increase in milk productivity of the farms, i.e. 8.81 ± 7.8 L/cow/day against 1.08 ± 2.19 L/cow/day for those who have not adopted it. Thus, artificial insemination is a good technique for the intensification of animal production.

However, constraints such as the high cost of AI, the flushing of cows in stalls before and after AI, the maintenance of crossbred, the unsatisfactory success rate and the difficulty of obtaining female products constitute a bottleneck for the promotion of this activity. It will thus be necessary to take into account the opinions of the farmers who constitute the most important link in the chain of dissemination of this innovation in the field of animal productions, for an effective achievement of the objectives of food and nutritional self-sufficiency, especially in the field of dairy products.

REFERENCES

Alary V., Duteurtre G., Faye B. (2011). Élevages et sociétés: les rôles multiples de l'élevage dans les pays tropicaux. *INRA Prod. Anim.,* 24: 145– 156.

Asseu K.C.A. (2010). Évaluation du degré d'acceptation de L'insémination Artificielle Bovine à Kaolack au Sénégal. Université Cheikh Anta Diop de Dakar. 121 p.

Boly H., Coulibaly I., Pitala W., Ba Y., Sawadogo L. (2003). Comportement sexuel et maturation folliculaire chez la femelle zébu Goudali au Burkina Faso. 71p. https://beep.ird.fr/collect/upb/index/assoc/IDR-2002-COU-COM/IDR-2002-COU-COM.pdf

Cesaro J-D., Apolloni A. (2020). Élevage et urbanité, dans les villes développées ou en développement, quelles oppositions et quelles complémentarités ? *Territoire en mouvement Revue de géographie et aménagement*, 4445.

Corniaux C. (2015). L'industrie laitière en Afrique de l'Ouest: Histoire, stratégies et perspectives. https://agritrop.cirad.fr/575311/1/document_575311.pdf

Dagnelie P. (1998). Statistiques théoriques et appliquées. Bruxelles, Belgique, De Boeck Services, 517 p. http://www.dagnelie.be/docpdf/st2table.pdf

de Mendiburu F. (2020). Agricolae: Statistical Procedures for Agricultural Research. R package version 1.3-3. https://CRAN.R-project.org/package=agricolae

de Ridder N., Sanogo O.M., Rufino M.C., van Keulen H., Giller K.E. (2015). Milk: The new white gold? Milk production options for smallholder farmers in Southern Mali. *Animal*, 9: 12211229.

DGESS/MRAH (2017). Effectif du cheptel au Burkina Faso. Ministère des ressources animales et halieutiques. https://bit.ly/3HIsDL6

Diaphoumpa M. (2003). Analyse coût/bénéfice de l'insémination artificielle bovine au Sénégal. École Inter États de Science et de Médecine de Dakar. Mémoire de DEA, 38p. https://beep.ird.fr/collect/eismv/index/assoc/MEM03-3.dir/MEM03-3.pdf

Douxchamps S., Van Wijk M.T., Silvestri S., Moussa A.S., Quiros C., Ndour N.Y.B., *et al* (2015). Linking agricultural adaptation strategies, food security and vulnerability: evidence from West Africa. *Reg. Environ. Change,* 16: 1305-1317.

FAO, FIDA, PAM. (2013). L'état de l'insécurité alimentaire dans le monde 2013. Les multiples dimensions de la sécurité alimentaire. Rome: FAO. https://www.fao.org/3/i3434f/i3434f00.htm

GRET (2018). Quelles politiques commerciales pour la promotion de la filière "lait local" en Afrique de l'Ouest. 100p. https://www.alimenterre.org/system/files/ressources/pdf/1088-rapport-synthese-etude-lait-afouest-gret-cfsi2.pdf

ISRA (Institut Sénégalais de Recherches Agricoles). (2003). Actes de l'atelier de restitution des résultats du projet PROCORDEL au Sénégal à Dakar: Évaluation de la productivité des bovins métis dans le bassin arachidier, 85p. https://proceedingsprocordel-conferencesenegal.pdf

Kabera F., Ntawubizi M., Makuza R. (2016). Adoption de services d'insémination artificielle chez les bovins laitiers au Rwanda: Étude de cas de la ville. 6: 16851691. https://doi.org/10.5455/jasa.20160916044139

Kagone H. (2001). Profil fourrager Burkina Faso. Rome: FAO. https://docplayer.fr/51588104-Profil-fourrager-burkina-faso-par-dr-ir-hamade-kagone.html

Kalandi M. (2011). Evaluation financière de l'insémination artificielle sur chaleurs naturelles dans les petits élevages traditionnels de la région de Kaolack au Sénégal. École Inter-États des Sciences et de Médecine Vétérinaire de Dakar, Mémoire de fin de cycle, 40p. https://beep.ird.fr/collect/eismv/index/assoc/MEM11-17.dir/MEM11-17.pdf

Kassa K.S., Ahounou S., Dayo G.K., Salifou C., Issifou M.T., Dotche I., Gandonou P.S., Yapi-Gnaore V., Koutinhouin B., Mensah G.A., Abdou Karim Youssao I. (2017). Performances de production laitière des races bovines de l'Afrique de l'Ouest. *International Journal of Biological and Chemical Sciences*, 10: 2316.

Kassambara A., Mundt F. (2020). factoextra: Extract and Visualize the Results of Multivariate Data Analyses. R package version 1.0.7. https://CRAN.R-project.org/package=factoextra

Kouamo J. (2007). Évaluation des stratégies d'insémination artificielles plus efficientes basées sur les chaleurs naturelles et synchronisées des vaches zébus locales et métisses dans la région de Louga au Sénégal. École Inter États des Sciences et de Médecine Vétérinaire de Dakar, Mémoire de DEA en Productions animales, 30p.

Kouamo J., Sow A., Leye A., Mbacke D., Sawadogo G.J., Ouédraogo G.A. (2009). Étude comparative de deux stratégies d'insémination artificielle, basées sur les chaleurs naturelles et les chaleurs synchronisées des vaches locales et métisses en milieu traditionnel au Sénégal. *Revue Africaine de Santé et de Productions Animales*, 7:8995.

Lebacq T., Baret P.V., Stilman T. (2013). Sustainability indicators for livestock farming. A review. *Agron. Sustain. Dev.,* 33: 311– 327.

Mambila G. (1999). Élevage laitier périurbain de Bobo Dioulasso: systèmes d'élevage identification des bassins laitiers pratiques de production laitière gestion de la reproduction Université Polytechnique de Bobo Dioulasso (UPB). Mémoire de fin de cycle ingénieur, 94 p.

McDermott J., Staal S.J., Freeman H.A., Herrero M., Van de Steeg J.A. (2010). Sustaining intensification of smallholder livestock systems in the tropics. *Livest. Sci.* 130: 95– 109.

Messine O., Mbah D.A., Saint-Martin G. (1993). Synchronisation de l'estrus chez les femelles zébus Goudali au CRZ de Wakwa (Cameroun). Pp13-19. In: Maîtrise de la reproduction et amélioration génétique des ruminants: Apport des nouvelles technologies. 290.

Meyer C., Denis J.P. (1999). Élevage de la vache laitière en zone tropicale. Montpellier: CIRAD, 318 p.

MRA (2012). Direction Générale de la Prévision des Statistiques et de l'Économie de l'Élevage: Rapport annuel d'activités (année 2011). Ouagadougou: Ministère des Ressources animales, 151 p.

MRAH (2017). Organisation des Nations Unies pour l'Alimentation et l'Agriculture. DGESS. https://www.interreseaux.org/wpcontent/uploads/FichePaysBurkinaOffensiveLaitFinal.pdf

MRAH (2022). Première enquête nationale sur le cheptel (ENC1): les résultats validés. https://www.agriculture.bf/jcms/pv10_104263/fr

Ngono E.P.J. (2007). Évaluation de l'impact potentiel et de l'acceptabilité des stratégies d'insémination artificielle bovine plus efficients basées sur les chaleurs naturelles et induite dans le bassin arachidier: Cas des régions de Kaolack et Fatick. École Inter États des Sciences et de Médecine Vétérinaire de Dakar, Mémoire de DEA en Productions animales, 40p.

Niang M.M. (2012). Évaluation de l'efficacité de l'insémination artificielle bovine dans la campagne d'insémination artificielle 2010-2011 réalisée par le PDESOC dans la région de Kolda. Université Cheikh Anta Diop de Dakar. Thèse en médecine vétérinaire, 104p.

Nkolo S. (2009). Typologie des élevages bovins pratiquant l'insémination artificielle en milieu traditionnel au Sénégal : Cas de la Région de Thiès. École Inter États des Sciences et de Médecine Vétérinaire de Dakar. 130p.

Ouattara K.A. (2014). Inventaire et caractérisation des ressources alimentaires du bétail dans la zone de Bobo-Dioulasso et production des cultures fourragères. Université Polytechnique de Bobo Dioulasso (UPB). Mémoire de fin de cycle ingénieur, 59 p.

Pousga, S. (2002). Analyse des résultats de l'IA bovine dans des projets d'élevage laitiers: Exemple du Burkina Faso, Mali et du Sénégal. Ecole Inter États des Sciences et Médecine Vétérinaire de Dakar. 112 p.

R Core Team. (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Savadogo K.W.I. (2017). Étude des paramètres démographiques du cheptel bovin des élevages péri-urbains de la ville de Bobo-Dioulasso, Université Nazi Boni, Bobo-Dioulasso, Burkina-Faso. Mémoire de fin de cycle ingénieur, 54 p.

Sery, A. (2003). Typologie des fermes laitières peri-urbaines de Dakar et Thiès, Thèse, Université Cheick Anta Diop.

Zida/Bangré, H. (2009). Monographie de la commune urbaine de Bobo Dioulasso: Recensement Général de la Population et de l'Habitation (RGPH) de 2006. Institut National de Statistique et de la Démographie. 107p. http://web.insd.bf/contenu/autres_publications/monographie/monographie_bobo.pdf