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Typology of Cattle Farming Systems and the Use of Artificial Insemination in the North and Center Regions of Côte d'Ivoire

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Abstract

Artificial insemination (AI) appears as a key technique for sustainably improving the productivity of the Ivorian cattle herd. However, its implementation remains confronted with obstacles related to breeding practices, the socio-economical characteristics of the farmers, and access to technical services. A survey conducted among farmers in the Northern and Center regions of Côte d'Ivoire assessed the context of its use. Results show that 70.8% of farmers are indigenous, with a higher proportion in the Center (81.13%) than in the North zone (55.56%). Farmers in the Center zone are more educated, with 56.6% having formal education, compared to 27.78% in the Northern. Also, 50.6% of farmers adopt a semi-intensive system and 44.9% an extensive system. AI is used by 20.2% of farmers, mainly in the North zone (41.7%) where it is motivated by the increase in milk productivity (94.4%). This study also revealed the emergence of a new type of farmer in the Center zone, oriented towards a market economy, which contrasts with the standard type found in cattle breeding areas in West Africa. Finally, two profiles of farmers were identified based on the context of artificial insemination use. The first profile represents 20.2% of the population including structured, experienced farmers who adopt modern techniques as well as artificial insemination for improving the herd and milk production. The second profile represents 79.8% of the population and is traditional farmers favoring simple and inexpensive methods. The study shows the necessity of strengthening capacities and facilitating access to biotechnologies, in order to optimize breeding systems and meet production objectives.

Keywords

Artificial Insemination, Cattle Breeding, Productivity, Farmer Profiles,

Biotechnologies

1. Introduction

Artificial insemination is a common reproductive technique in cattle used to improve the genetic quality of the herd. It consists in introducing a well-selected semen from a superior bull into the reproductive tract of the cow [1]. This method offers several advantages over natural reproduction, such as the ability to control semen quality and maximize the chances of conception. It allows breeders to obtain superior genetic heritage from high-performing bulls without having to keep them on the farm [2] [3]. It also contributes to improving the quality of meat and milk produced by the cattle, thus benefiting both breeders and consumers [4]. These advances have enabled long-term semen storage, favoring the emergence of selection programs [5]. It is currently one of the most widely used reproductive biotechnologies worldwide, used on one-fifth of the world's reproductive female population [6] [7]. AI remains one of the most used assisted reproductive technologies. Its three major advantages are its simplicity, low cost, and effectiveness [8]. Furthermore, its impact on the spread of genetic progress is considerable [9]. This technology is suitable for the quantitative and qualitative improvement of the cattle herd in developing countries such as Côte d'Ivoire. This country has an extremely low meat and milk production compared to its needs and remains dependent on the Sahelian region for its supply of livestock meat [10] [11]. However, the implementation of artificial insemination remains confronted with several obstacles in the farming community, hence the importance of this study, which aims to document the state of use of artificial insemination in different breeding systems in Côte d'Ivoire. More specifically, it proposes to establish the typology of cattle farms while describing them according to their use of artificial insemination.

2. Materials and Methods

2.1. Study Area

The study was conducted in two main areas: first, in the north, specifically in the Savanne District (Poro, Tchologo, and Bagoué regions); and second, in central Côte d'Ivoire, specifically in the Yamoussoukro Autonomous District, the Bélier and Gbêkê regions (**Figure 1**). The regions of Poro, Gbêkê, and Bélier were selected as part of IAEA Project No. IVC2020003, to which this study is linked. This choice is also based on the national livestock development policy defined by the 2018-2025 National Development Plan (PND). The Bagoué and Tchologo regions and the Yamoussoukro Autonomous District were selected because they are adjacent to the project areas and play an important role in the national cattle herd due to the intensity of their livestock activities.

The Savanes district covers the Sub-Sudanian and Sudanian zones. They are

located between 8˚30 and 10˚30 North latitude and 4˚ to 7˚ West longitude [12]. The climate is tropical with a rainy season from May to November (900 to 1700 mm of precipitation) and a dry season dominated by Saharan winds [13]. The second zone is located in the Center of Côte d'Ivoire, between latitudes 06˚47 and 06˚49 North and longitudes 05˚15 and 05˚16 West. It benefits from a humid tropical climate with four seasons, namely two rainy seasons, from mid-March to mid-July, and from September to mid-November, and two dry seasons, from mid-November to mid-March, and from mid-July to August. The annual rainfall varies from 900 to 1100 mm, with an average temperature oscillating between 25˚C and 38˚C. The vegetation is typical of a pre-forest savanna, marked by the presence of small trees and gallery forests in the lowlands [14]. The vegetation is composed of gallery forests, shrub savannas, and oil palm groves, favorable for fodder production [15].

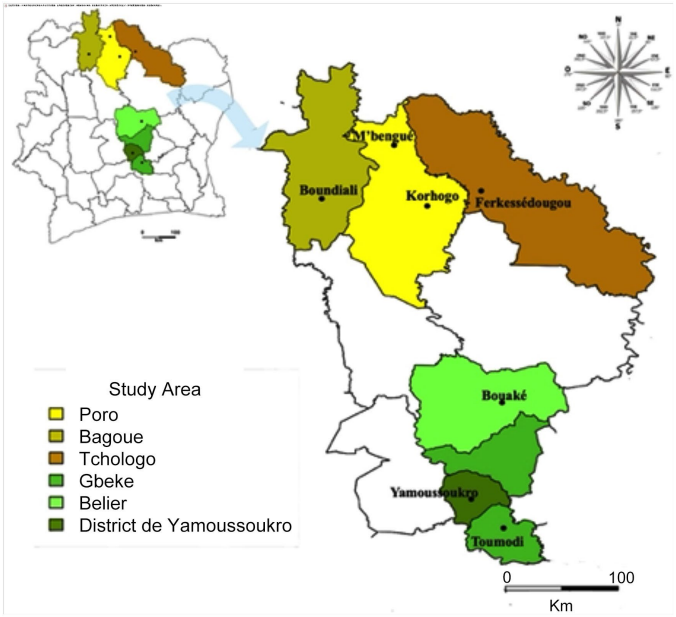


Figure 1. Study area map.

2.2. Data Collection Method

Data were collected using a structured questionnaire designed to gather the necessary information from livestock farmers. The survey was conducted during the rainy season, between July and November. The interviews were recorded using a tape recorder. The questionnaire focused on: the socioeconomic profile of the farmers, livestock feeding practices, animal health care, and cattle breeding practices, with particular attention to the use or non-use of artificial insemination.

The identification and location of the farms were carried out in collaboration with the Ministry of Animal and Fisheries Resources. The sample was selected based on specific inclusion and exclusion criteria. Included were livestock owners of cattle farms with at least 10 adult cattle, who had been engaged in commercial activities for at least two years and who utilized veterinary services. Participation

was contingent upon the voluntary consent and availability of the farmers. Excluded were farms with fewer than 10 adult cattle, subsistence farms not oriented toward commercialization, those without any veterinary oversight, as well as farmers who refused to participate.

A total of 89 farmers participated in the study, distributed as follows: 36 in the Savanes District, 21 in the Bélier Region, 13 in the Gbêkê Region, and 19 in the Yamoussoukro Autonomous District. A follow-up survey was then conducted with veterinary services to verify the information provided by the farmers who reported using artificial insemination.

2.3. Statistical Analysis of the Collected Data

The collected data were analyzed using Excel 2021 and R 4.3.3. A descriptive analysis was first conducted to identify the general characteristics of the farms surveyed. The variables were described in terms of counts and percentages and presented in tabular form. Chi-square independence tests at the 5% significance level were performed; when the conditions for applying the Chi-square test were not met (theoretical counts < 5), Fischer's exact test was used.

A multiple correspondence analysis (MCA) was then performed to establish a typology of the farms, using the factomineR, ggplot2, and Ade4 packages. Variables related to the use of artificial insemination were included as active variables to assess their contribution to the structure of the obtained profiles, in addition to the other variables related to livestock management practices. The coordinates of the individuals on the first two axes were subsequently used to perform an Ascending Hierarchical Classification (AHC). The number of groups was determined based on the inter-class inertia jump observed on the dendrogram. The interpretation of the groups was based on the values of the variables contributing most to the two factor axes and on the comparison of profiles using chi-square tests at the 5% significance level.

3. Results

The study's results are presented in two complementary sections. The first section provides a descriptive overview of the sample and evaluates the effectiveness of artificial insemination based on success rates, calving rates, and farmer satisfaction rates, comparing the northern and central regions. The second part uses Multiple Correspondence Analysis and Ascending Hierarchical Classification to identify breeding profiles and examine the extent to which the practice of artificial insemination contributes to characterizing them.

3.1. Social Profile of Surveyed Farmers

Table 1 shows us that across all surveyed areas, 70.8% of the breeders are Ivorian. In the center zone, indigenous people represent 81.13% of the breeders, while those in the Northern zone have a proportion of 55.56%. Indigenous people are statistically more numerous in the Center zone than in the North zone. Regarding

education, the distribution of breeders according to the type of instruction presents a significant difference at the 5% threshold between the Center and the North. Indeed, breeders who benefited from formal instruction represent 56.6% of the workforce in the Center zone compared to 27.78% in the Northern zone. Those who benefited from Coranic instruction were 0% and 33.33% respectively in the Center zone and the Northern zone. The category "no instruction" recorded frequencies of 43.4% in the Center versus 38.89% in the North. The results also revealed that 43.82% of the breeders' main activity is breeding. Conversely, 56.18% practiced it as a secondary activity, including 14.61% as farmers (crop production) and 34.83% as merchants. Only 6.74% of respondents combined all three activities (farming, breeding, and commerce). In the Center, breeding was often the unique activity (58.49%), while in the Northern zone, breeders were more frequently multi-active, combining farming, breeding, and commerce (77.78%).

Table 1. Social profile of breeders.

Variables	Modalities	Northern (N = 36)	Center (N = 53)	Total (N = 89)	Khi2 (p. value (5%))
Citizenship	Ivorian	55.56 (20)	81.13 (43)	70.8 (63)	5.6013 (0.0179)
	Foreign	44.44 (16)	18.87 (10)	29.2 (26)	
Type of instruction	None	38.89 (14)	43.4 (23)	41.6 (37)	10.838 (1.907×10^{-05})
	Coranic	33.33 (12)	0 (0)	13.5 (12)	
	Formal	27.78 (10)	56.6 (30)	44.9 (40)	
Secondary activity	None	22.22 (8)	58.49 (31)	43.82 (39)	30.646 (1.009×10^{-06})
	Farmer	33.33 (12)	1.89 (1)	14.61 (13)	
	Merchant	27.78 (10)	39.62 (21)	34.83 (31)	
	Farmer and Merchant	16.67 (6)	0 (0)	6.74 (6)	

N: number of respondents; (): number of answers.

3.2. Breeding Practices

The results of the study showed that breeders acquired their cattle mainly by purchase (62.9%) or by inheritance (37.1%). The distribution between acquisition methods varies according to the regions. Purchase is more frequent in the Center zone (83.02%), while inheritance is more common in the Northern with a percentage of 66.67% (Table 2). The study of the experience (how long a breeder is practicing) showed that in the North, 69.4% of breeders and in the Centre 39.6% of breeders had more than 20 years of experience. 25% of the breeders in the North have an experience between 10 and 20 years while 28.3% of those in the Center have the same experience. Breeders with the least years of experience (<10 years) had respective frequencies of 32.1% and 5.6% in the Center and the Northern. The distribution of breeders between the categories of the variable "Years of practice" according to the zones shows significant differences at the 5% threshold (Table 2). Meat production was the main breeding objective for 43.8% of the breeders,

closely followed by meat production combined with milk production (41.6%). Milk production was less represented (14.6%). However, production objectives varied significantly according to the zones. In the Center, meat production dominated (69.8%), and 22.6% of breeders had both meat and milk production as objectives. In the Northern, 69.4% of breeders favoured mixed farming and 25% milk production (Table 2).

Regarding the types of breeding system, 50.6% of breeders adopted a semi-intensive system and 44.9% of breeders an extensive system. In contrast, the intensive system is marginal and represents 4.5% of the farms surveyed. There is no significant difference between the zones concerning the distribution of farms according to the farming system. Breeders mainly used two methods of animal identification. Memorization (48.3%), marking (47.2%) and only 4.5% of breeders used both methods at once. Preferences varied statistically according to the regions. In the North, marking exclusively is used by 69.4% of breeders, while in the Center 60.4% of breeders used memorization (Table 2).

Table 2. Characteristics of the farms.

Variables	Modalitis	North (N = 36)	Center (N = 53)	Total (N = 89)	Khi2 (p. value (5%))
Livestock acquisition	Buy	33.33 (12)	83.02 (44)	62.9 (56)	20.605 (5.65×10^{-06})
	Inheritance	66.67 (24)	16.98 (9)	37.1 (33)	
Years of practice	<10 years	5.6 (2)	32.1 (17)	21.3 (19)	10.838 (0.0044)
	10 - 20 years	25 (9)	28.3 (15)	27 (24)	
	>20 years	69.4 (25)	39.6 (21)	51.7 (46)	
breeding objectives	Meat	5.6 (2)	69.8 (37)	43.8 (39)	35.966 (1.55×10^{-08})
	Milk	25 (9)	7.6 (4)	14.6 (13)	
	Mixte	69.4 (25)	22.6 (12)	41.6 (37)	
Breeding system	Extensive	36.1 (13)	50.9 (27)	44.9 (40)	0.2683
	Intensive	2.8 (1)	5.7 (3)	4.5 (4)	
	Semi-extensive	61.1 (22)	43.4 (23)	50.6 (45)	
Identification of animals	Tag	69.4 (25)	32.1 (17)	47.2 (42)	0.0009
	Memorisation	30.6 (11)	60.4 (32)	48.3 (43)	
	Mixte	0 (0)	7.5 (4)	4.5 (4)	

N: number of survey participants; (): number of respondents.

3.3. Adoption of Artificial Insemination

Regarding reproduction, half of the breeders (50.56%) did not take into account the kinship between the parents, so natural mating took place without control. This observation does not differ statistically between zones. In the North, we have 47.2% of breeders and 52.8% of breeders in the Center. Among all breeders aware of artificial insemination (46.07%) and other biotechnologies (3.37%), only 20.2%

used artificial insemination. This includes 41.7% of breeders in the North and 5.7% in the Center (Table 3). Regarding the justification for the choice of the reproduction technique, the distribution of responses according to the choice showed a significant difference between the two zones. Breeders who favored natural mating represent 79.78%. Their choice is justified by their mastery of this technique and its low cost. However, 20.2% of breeders used artificial insemination and recognized that it allowed for increased productivity with a high success rate (Table 3). The main motivation for using artificial insemination was the increase in the milk productivity of cows (19.1%). This reason was mentioned by 38.9% of breeders in the North and 5.7% of breeders in the Center. The absence of a performing male is a minor motivation (2.8%) in the North and the lack of an AI center (Table 3).

Table 3. Current status of reproductive biotechnologies.

Variables	Modalities	North (N = 36)	Center (N = 53)	Total (N = 89)	Khi2 (p. value (5%))
Kinship	Yes	52.8 (19)	47.2 (25)	49.44 (44)	0.0920 (0.7616)
	No	47.2 (17)	52.8 (28)	50.56 (45)	
Biotechnologia known	None	19.4 (7)	71.7 (38)	50.56 (45)	8.412×10^{-07}
	AI	77.8 (28)	24.5 (13)	46.07 (41)	
	Mixte	2.8 (1)	3.8 (2)	3.37 (3)	
Biotechnologia used	None	58.3 (21)	94.3(50)	79.8 (71)	37.1 (8.46×10^{-18})
	AI	41.7 (15)	5.7 (3)	20.2 (18)	
Justification of the choice of reproduction technique	(NS) master and cost	58.3 (21)	94.3 (50)	79.8 (71)	15.067 (0.0001)
	(AI) succes and productivity	41.7 (15)	5.7 (3)	20.2 (18)	
Reason of used of biotechnologia	(NS) None	58.3 (21)	94.3 (50)	79.8 (71)	1
	(AI) abs of perfor male	2.8 (1)	0 (0)	1.1 (1)	
	(IA) Incr prod	38.9 (14)	5.7 (3)	19.1 (17)	

N: number of respondents; (): number of respondents; AI: artificial insemination; NS: natural service; Abs of perfor male: absence of performing male; Incr prod: increase the milk production of cows

3.4. Indicators of Artificial Insemination Effectiveness

The effectiveness of artificial insemination differs significantly between the Northern and Central regions (Table 4). The artificial insemination success rate is 48.5% in the North compared to 94.6% in the Central region; this difference is statistically significant at the 5% level. Similarly, the calving rate ranges from 34% in the North to 86.3% in the Center, with a significant difference at the 5% level. In contrast, the satisfaction rate among farmers does not differ significantly between the two regions; it is 48.9% in the North and 100% in the Center.

Table 4. Indicators of artificial insemination effectiveness.

Indicators	North	Central	Total	Khi2 (p. value (5%))
Number of cows inseminated	103	92	195	
Number of pregnant cows	50	87	137	62.435
Number of non-pregnant cows	53	5	58	(2.754×10^{-15})
Insemination success rate	48.5%	94.6%	70.3%	
Number of calvings	35	81	116	56.713
Number of non-calvings	15	6	21	(5.043×10^{-14})
Calving rate	34%	86.2%	59.5%	
Number of satisfied farmers	11	3	14	1
Number of dissatisfied farmers	4	0	4	
Satisfaction rate	48.9%	100%	77.8%	

3.5. Multiple Correspondence Analysis

The multiple correspondence analysis (MCA) performed on the 13 active variables related to farmers' characteristics, their practices, and their farming context identified the main dimensions structuring the variability of the sample.

The first two axes together account for a cumulative 39.4% of the total variance (Figure 2). Axis 1 has an eigenvalue of 0.35, explaining 23.8% of the total variance, while Axis 2 has an eigenvalue of 0.23, explaining 15.6% of the total variance.

The contribution of the variables to the formation of these two axes is summarized in Figure 3. Axis 1 is primarily structured by the group of variables related to knowledge and use of biotechnologies. The highest contributions come from four variables: biotechnology used (Biotech), reason for using biotechnology (BtechRaison), justification for the choice of reproduction method (JustifRepro), and breeding objective (Obj). Axis 2 is mainly composed of sociodemographic and structural variables. The most contributive variables are: sector of activity, level of education, farming system, and nationality.

The multiple correspondence analysis highlights two major dimensions: a technical dimension linked to the mastery of reproductive biotechnologies, and a structural dimension related to the farmer's profile and environment. The coordinates of the individuals on these two axes, which together account for 39.4% of the inertia, were used as the basis for the hierarchical cluster analysis. The optimal number of clusters was determined using the relative inertia loss method. The plot of within-cluster inertia as a function of the number of clusters showed a clear elbow at two clusters, as indicated in Figure 4. The two-cluster partition was therefore retained. It explains approximately 96% of the total inertia, indicating good partition quality and satisfactory homogeneity within each group. The projection of the clusters onto the first factorial plane of the MCA confirms the relevance of this partitioning (Figure 5). The two clusters are clearly distinguished along Axis 1 and, to a lesser extent, along Axis 2.

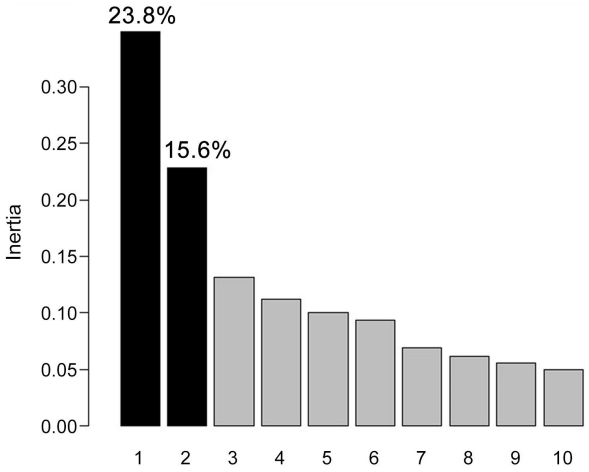
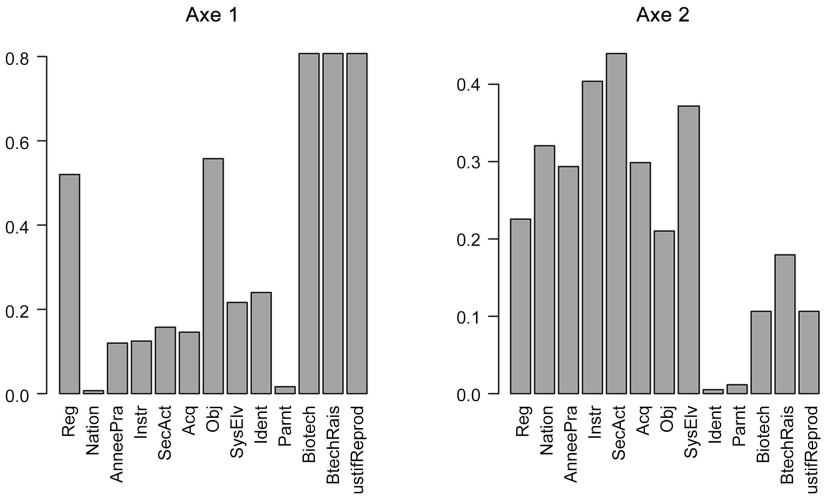


Figure 2. Inertia and percentage of variability on a few factorial axes (MCA).



The x-axis presents the different qualitative variables used to construct the multivariate factorial analysis (MCA) and the y-axis presents the different contributions to the construction of these axes.

Figure 3. Contribution of variables to the formation of the two axes of the multivariate factorial analysis (MCA).

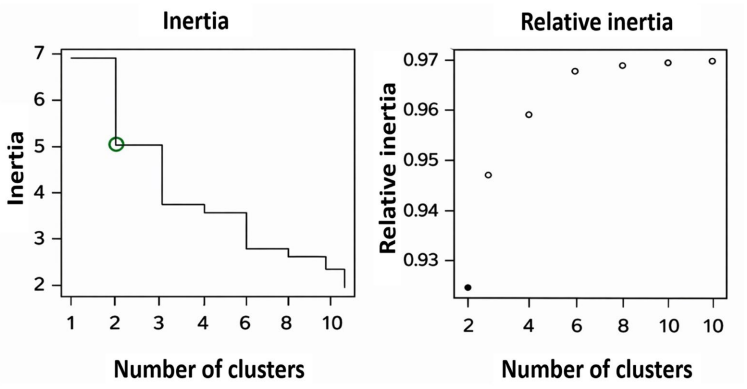


Figure 4. Determination of the optimal number of groups using the relative loss of inertia method.

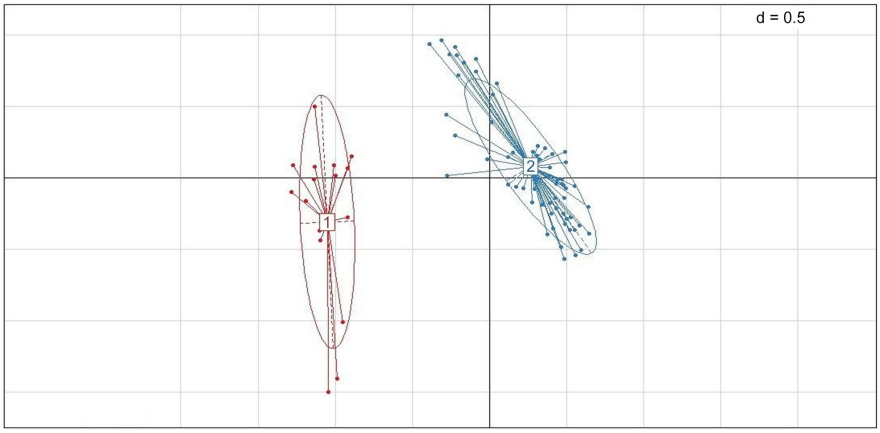


Figure 5. Presentation of the different groups obtained after partitioning using the MCA method; axis 1 of the multiple correspondence analysis explains 23.8% of the total variability, versus 15.6% for axis 2.

3.6. Group 1

This group represents 20.2% of the surveyed farms and includes 83.3% of the breeders from the North and 16.7% of the breeders from the Centre, whose breeding characteristics are marked by a milk and mixed production objective, a semi-extensive farming system, animal identification by marking, the use of artificial insemination motivated by the search for milk productivity and the lack of a high-performing male, and justified by increased productivity and speed. These structured and experienced breeders adopt modern techniques to improve their milk production (Table 5).

3.7. Group 2

This group represents 79.8% of the surveyed farms. It is composed of 29.6% of the breeders from the North and 70.4% of the breeders from the Center, having as breeding characteristics a breeding objective related to meat production, an extensive farming system, animal identification by memorization, the absence of the use of biotechnology, and the choice of natural mating justified by the control and reduced cost of this reproduction technique. These traditional breeders favor simple and inexpensive methods (Table 5).

Table 5. Links between the group and qualitative variables.

Variable	Modalities	Group 1 (%)	Group 2 (%)	Khi2	p. Value (5%)	Ddl
Region	North	83.3	29.6	15.067	0.0001	1
	Center	16.7	70.4			
Citizenship	Ivorian	83.3	67.6	1.0413	0.3075	1
	Foreign	16.7	32.4			
Years of practice	<10 years	16.7	22.5	4.1763	0.1239	2
	10 - 20 years	11.1	31			
	>20 years	72.2	46.5			

Continued

Type of instruction	Formal	45	45	1.6478	0.4387	2
	Coranic	22	11			
	None	33	44			
Secondary activity	Merchant	44.4	32.4	2.3607	0.3072	2
	Farmer	27.8	19.7			
	None	27.8	47.9			
Livestock acquisition	Inheritance	50	33.8	0.9951	0.3185	1
	Buy	50	66.2			
Breeding objectives	Meat	0	54.9		1.224×10^{-07}	
	Milk	50	5.6			
	Mixte	50	39.4			
Breeding system	Intensive	22.2	0		0.0012	
	Semi-intensive	66.7	46.5			
	Extensive	11.1	53.5			
Identification of animals	Tag	83.3	38	10.079	0.0015	1
	Memorisation	16.7	62			
Kinship	yes	61.1	46.5	0.7142	0.3981	1
	No	38.9	53.5			
Biotechnologia used	AI	100	0		$<2.2 \times 10^{-16}$	
	None	0	100			
Reason of used of biotechnologia	(NS) None	0	100		$<2.2 \times 10^{-16}$	
	(AI) abs of perfor male	5.6	0			
	(AI) Incr prod	94.4	0			
Justification of the choice of reproduction technique	(NS) master and cost (AI) success and	0	100		$<2.2 \times 10^{-16}$	
	productivity	100	0			

AI: artificial insemination; NS: natural service; abs of perfor male: absence of performing male; Inc prod: increase the milk production of cows

4. Discussion

The results of the survey conducted in the Northern and Center zones of Côte d'Ivoire showed that cattle breeding is an activity practiced exclusively by men. These results are similar to those of [16] in southern Senegal. These authors affirm that this activity is exclusively reserved to men. According to [17], the absence of women in this sector would be due to a sociological factor and to the physical demands of this sector. Women own little livestock, and their rights focus on the use of milk [18]. The proportion of allochthonous breeders was 18.87% in the

Center versus 44.44% in the North. The proportion of allochthonous breeders in the North is statistically higher than in the Center. These results are like those of [17], who revealed proportions of allochthonous people in the Poro and Tchologo region of 52.3% from the sub-region. These results are explained by the fact that the North is a zone of historical migration due to the transhumance from neighboring countries such as Burkina Faso and Mali, where breeding is an important activity [19].

The distribution of surveyed individuals based on the type of instruction shows a significant difference at the 5% threshold between the populations of breeders in the Northern and those in the Center of Côte d'Ivoire. In the North, 38.89% are without instruction, 33.33% with exclusively Coranic instruction, and 27.78% of them with formal instruction. These results are similar to those of [20] who stipulated that 41.51% of the surveyed individuals were without instruction, compared to 39.62% who had Coranic instruction. The proportion of breeders with formal instruction in the Savannas district according to this author is 18.87%. In the Center, however, the proportions of breeders without instruction were 43.3% and 56.60% received formal instruction. These results are consistent with those of [21]. These authors, in a study characterizing the breeding of lagoon cattle in the South of Côte d'Ivoire, stipulated that in this zone, the vast majority of the surveyed breeders had benefited from a formal education during their lives. Regarding the secondary activities of the breeders, the results also showed a significant difference in the distribution of secondary activities. Indeed, the proportion of breeders having solely breeding as professional activity is 58.49% in the Center versus 22.22% in the North, while those combining breeding and farming represent 1.89% in the Center versus 33.33% in the North. Those whose secondary activity was commerce represented 39.62% and 27.78% respectively in the Center and the North. These results are similar to those of [20], which revealed 44.44% of agropastoralists in the Northern zone of our study areas. However, these results differ from those of the same author in the Zanzan region (70.59%). These results indicate that breeders are rarely the unique source of livelihood for herders' households [22]. The differences between the zones suggest distinct economic dynamics. Indeed, studies of the livestock sector allow for the distinction of three zones in Côte d'Ivoire. The North (Poro, Bagoué, Tchologo, etc.) represents the supply zone. It is characterized by high availability and low meat consumption. The South (Abidjan, San-Pedro), which represents the main consumption zone. This zone is characterized by low local production and very high consumption of beef. The Center (Yamoussoukro, Bélier, Gbêkê, etc.), which is the redistribution zone. This area is characterized by a significant transit market [23]. The particular dynamics of this latter region have allowed the emergence of a new type of cattle breeders, namely "emboucheurs" (fatteners). They are characterized by settling in urban or peri-urban areas, acquiring their livestock through purchase, and having fewer years of practice. This reality reflects a more monetized livestock economy in the Center, probably due to better accessibility to markets and infrastructure,

especially for urban and peri-urban farming. According to [24], cattle farming through fattening constitutes one of the best-represented sectors in urban agriculture. It helps to make the trade of these livestock profitable, as they are affected by poor import conditions (duration of the journey, overcrowding in vehicles and/or wagons, poor feeding, parking at the transit point, etc.) of the animals [25] [26]. About the production objectives, the Center favors meat production (69.8%) through the sale of live animals, while the North prioritizes mixed production (69.4%). Furthermore, 25% of the farms in the Northern zone are specialized exclusively in milk production. These trends suggest marketing strategies adapted to local markets. These results differ from [27], who state that among Baoulé taurine cattle breeders in the Southwest of Burkina Faso, 90.83% of the surveyed farms marketed only live animals. The semi-intensive system dominates in the North (61.1%), while the extensive system is more widespread in the Center (50.9%). These observations are similar to those of [28]. The latter attest that farms where cattle management is semi-intensive present diversified production. According to these authors, farms adopting the semi-intensive system produce both beef and milk production. The method of identifying animals in the North is by tags (69.4%). According to [29], this practice is a mechanism to combat animal theft. In the Center, however, memorization is the most frequent identification method (60.4%). This method relies on the farmer's ability to individually recognize animals without recourse to technological devices. It is widely used in pastoral and traditional systems. It is effective when the number of animals remains limited. In large herds, the probability of identification errors increases significantly [30]. The results obtained on breeding practices revealed marked regional trends and underlying economic motivations. The data showed that 79.8% of breeders prefer natural mating, while 20.2% opt for artificial insemination. These results are similar to those of [31]. The latter asserts that despite the recognized advantages of artificial insemination, many milk breeders worldwide continue to use natural service bulls for the reproduction of their cows. This massive preference for natural mating is mainly explained by its mastery and its low cost (78.8%) compared to artificial insemination. Indeed, the costs of artificial insemination include labor, equipment, liquid nitrogen, semen, and three ratios of "services per conception" [32]. The availability of affordable liquid nitrogen for semen cryopreservation also constitutes a major constraint on the use of artificial insemination [33]. Furthermore, natural mating is a traditional method well assimilated by breeders, requiring low investment in equipment or specialized training, which makes it accessible to small farms. In addition, the effectiveness of an artificial insemination program is influenced by various factors, including infrastructure, management and financial constraints, as well as technical issues such as the artificial insemination system, the skills of the inseminators, the lack of suitable resources, estrus detection, the choice of the optimal time for insemination, management and feeding, staff awareness, cow-related factors, sperm quality, and political instability [34]. This complexity in implementation may explain the high

percentage of breeders practicing natural mating in both zones. The use of artificial insemination in breeding reveals significant disparities between the North and Center, which can be analyzed from several angles. Data shows that 20.2% of farmers practice artificial insemination, with a significantly higher usage in the North (41.7%) than in the Center (5.7%). This difference is explained by the fact that 77.8% of farmers in the North are aware of artificial insemination, compared to 24.5% in the Centre. The lack of information and training in the Center limits the adoption of this technique. This observation was made by [35]. In a study conducted in two districts of Botswana, they revealed that the lack of knowledge about artificial insemination was the major reason for its non-use. The main motivation for artificial insemination is the increase in milk productivity (19.1%). This motivation is even stronger in the Northern than in the Center zone, showing an increased awareness of the economic benefits of artificial insemination in this area. Some of the advantages and reasons mentioned by cattle breeders in our study concerning the use of artificial insemination align with the conclusions of. [2] and [35]. According to these latter authors, the fact that breeders perceive benefits from using artificial insemination is encouraging for the cattle industry, as they will share their experience with other breeders and encourage them to adopt this technology. The other reason mentioned is the absence of a performant male (2.8% in the North), which suggests low awareness of the genetic advantages of artificial insemination. The results reveal a statistically significant difference in the technical performance of artificial insemination between the Northern and Central regions at the 5% significance level. In the Central region, the insemination success rate is 94.6% and the calving rate is 86.3%, whereas in the North, these rates are only 48.5% and 34%, respectively. This disparity is mainly due to the conditions under which artificial insemination is performed. Indeed, our survey shows that the Central region benefits from a local inseminator who ensures strict adherence to protocol and monitors inseminated cows until calving. Conversely, in the Northern region, the absence of a local inseminator necessitates relying on a technician based in Mali. The geographical distance makes it impossible to ensure adequate monitoring of the cows before and after insemination, which compromises the technique's effectiveness.

Regarding the satisfaction rate, it reaches 100% in the Central region compared to 48.9% in the North, but the difference is not significant according to Fischer's exact test. This lack of significance is explained by the very small number of farmers surveyed in the Central region—3 out of 3 were satisfied.

The analysis of the typology of cattle farms identified two (2) distinct groups of breeders, each with specific characteristics influencing their breeding practices and reproductive choices. Group 1 consists of breeders with a semi-intensive farming system, aiming for milk production for some and mixed (meat and milk) for others. The use of artificial insemination is motivated by the desire to increase milk production and the need to compensate for the lack of high-performing males. The adoption of artificial insemination by this group would be guided by

the desire to improve the productivity and genetic quality of the herd, favoring innovation and increasing income. These structured and experienced breeders adopt modern methods to optimize their milk production and the quality of the livestock. However, group 2 represents the majority of breeders (79.8%), their objective is meat production, with an extensive system and animal identification by memory. The absence of biotechnology and the choice of natural reproduction are justified by control and reduced cost. This could be explained by a lack of access to resources and training on biotechnologies, the priority given to simple and economical traditional methods, or the objective of meat production, which is less dependent on advanced techniques like insemination.

This study highlights the importance of production objectives and economic resources in the choice of breeding techniques, as well as the need to inform and train breeders, particularly those in group 2, on the advantages of using biotechnologies, especially artificial insemination.

5. Limitations of the Study

This study has several limitations. First, the sample size and sampling method limit the generalizability of the results beyond the study area. Second, since the data are based on self-reports from farmers, they are subject to social desirability bias. Finally, the first two axes of the Multiple Correspondence Analysis explain only 39.4% of the total inertia, indicating that a significant portion of the variability is not accounted for in the typology.

6. Conclusions

This study on breeding practices in the Northern and Center zones revealed different trends. Breeders in the North and Center have distinct social profiles, with different levels of education and experience. In the Center, indigenous people are much more interested in breeding than in the North. The latter have benefited from formal education, unlike those in the North. Regarding farming practices, breeders in the North and Center have diverse production objectives, with more significant meat production in the Center. Farming systems also vary, with a semi-intensive system more common in the North and an extensive system in the Center. On the adoption of artificial insemination, it should be noted that the use of artificial insemination is more widespread in the North, where breeders are more motivated by increasing milk productivity. However, certain factors limit its adoption such as financial constraints, lack of information and training for breeders on this reproduction practice.

In summary, this study shows that breeding practices in the North and Center zones are influenced by social, cultural, and technical factors. To improve the productivity and competitiveness of livestock farming, it is important to take these regional specificities into account and propose solutions adapted to the needs of breeders while strengthening the capacities of breeders and facilitating access to biotechnologies.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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