Reproductive status and breeding practices in dairy cows in Ethiopia

A. Kemal, B. Bekele*, W. Ayele, B. Wolde, T. Tadesse

Department of Animal Science, College of Agricultural Science, Wachemo University, Po.box 667, Ethiopia
*Corresponding author email: berhanub06@gmail.com / berhanu2016@wcu.edu.et

Journal of Livestock Science (ISSN online 2277-6214) 15: 259-266
Received on 25/4/24; Accepted on 10/6/24; Published on 20/7/24
doi. 10.33259/JLivestSci.2024.259-266

Abstract

This study was conducted at two agro ecological zones (midland and lowland) of the Hulbareg district to assess reproductive status and dairy cattle breeding practices. Data was collected by using semi-structured questionnaire from a total of 290 households selected by systematic random sampling technique for interview. The collected data were presented using descriptive statistics, index and Chi-Square test. The mean age at first calving and dry period of local dairy cows were significantly varied ($p<0.05$) between midland ad lowland agro-ecologies. The mean milk production per cow per day in midland and lowland were significanty differrent ($p<0.05$) for local cows. The study further indicated that most of the respondents selected trait of animals for breeding by considering the expected milk yield, parents' history, size/body appearance and growth rate. The reproductive problem, sickness, productive problem, persistent poor body condition and unwanted physical characteristics used criteria for culling. The minimum and maximum number of pregnancy rate was 8.4% and 18.3% in the studied district. The major constraint for low conception rate of dairy cows was animal selection, technicians' efficiency, protection of farmers, and hormone problems. In general the breeding practices of study area were traditional and poor breeding systems and the perception of estrous synchronization were very low. Most of the respondents were not satisfied with the results of the estrus synchronization and mass insemination (ESMI) program as the conception rate in local dairy cows were very much below their expectation.

Key words: Breeding practice; Dairy cattle; Ethiopia; Hulbareg; Synchronization

Introduction

Ethiopia is known to have a large number of livestock, 70 million cattle, 42.9 million sheep, 52.50 million goats and 57 chickens CSA (2021). It should be noticeable that animal products and by-products made in the form of meat, milk, honey, eggs, cheese, and butter provide the necessary animal protein that helps to improve the nutritional status of humans. However, the productivity of the indigenous cattle is low due to their poor genetic makeup, low level of inputs, and traditional husbandry practice besides environmental stress (Tegegne et al. 2010). Artificial insemination (AI) is one of the assisted reproduction technologies (ART) that increases the use of outstanding males, dissemination of superior genetic material, improve the rate and efficiency of genetic selection, introduction of new genetic material by import of semen rather than live animals Verma et al. (2012). However, dairy cows are mostly bred via natural mating, with some amount of assisted reproductive technology used for breeding and to improve the milk production of dairy cows. Though, it is generally understood that the artificial insemination (AI) provision in the country is not successful to advance reproductive performance of milk production industry (Godadaw et al. 2015). Furthermore, it is widely believed that the AI service in Ethiopia has Inconsistent service, substandard nutrition; poor management and infrastructure were some of the reasons for low success rates Lemma and Kebede (2011). To increase the efficacy of AI service delivery system and to enhance the access of smallholders farmers to improved dairy cows with in short period of time in areas where dairy development is feasible, synchronization of estrus was triggered as a solution. Gonadotropin releasing hormone (GnRH), prostaglandins (PGF2α) and their different synthetic analogues have been used for estrus synchronization in cattle & buffaloes in low breeding season under field conditions (Chandra Prasad et al 2019).

According to Tegegne et al. (2016) the initial idea of mass hormonal estrus synchronization in Ethiopia was determined by different reasons such as the shortage and high price of crossbred dairy type animals for smallholder farmers to participate in market-oriented milk production, the unavailability of artificial insemination service (both private and public) in areas where smallholder farmers have the opportunity to participate in milk production and marketing, and the slow progress made over a long period of time in genetic improvement of cattle for milk production using the traditional approach of AI in the country. This overall resulted in underdeveloped dairy sector despite the high potential the country has for dairy production. Shortage and high price of improved crossbred dairy type animals also limited smallholder farmers from participation in production and marketing of milk.

Statement of the problem

Hulbareg district was one of the areas in which estrus synchronization and mass artificial insemination had been widely implemented. However, there was no information on the reproductive and productive performance, status of estrus synchronization and mass artificial insemination of local cattle. In addition to this there is limited information about local dairy cattle management practice, unplanned strategic feed supplementation of estrus synchronized cattle and selection of problem associated cow and also there is no research works conduct in the study area. Hence, it is hypothesized that agroecology was major factors that can influence reproductive and productive performance local dairy cows. Furthermore, there was a need of assess oestrus synchronization mass AI service and retrospective study of estrus synchronization mass AI technology to identify weak point of this service. So, the study was conducted with the objectives of assessing reproductive status and breeding practices of indigenous dairy cattle in the studied agro-ecologies.

Materials and methods

Description of the study areas

This study was carried out at Hulbareg district of Silte Zone, Central Ethiopia. Hulbareg district is far away 188km south of Addis Ababa, which is the capital city of Ethiopia. It is located between 7°45'42" to 8°05' N latitude and 380° 46'41" to 390° 07'12" E longitude. The District has an altitude ranging from 1250 to 2300 masl. The mean annual rainfall of the district was 1209mm and the minimum and maximum temperatures are 19ºc and 23ºc, respectively The short rain occur from March to May whereas the long rains occur from June to September. The rainfall pattern was bi-modal. The dominant soil types of the district are eutric Cambisols, chromic Luvisols, chromic Vertisols, eutric Fluvisols, and pellic Vertisols On. the basis of altitude of the area, the district divided in to Weynadega, kola but dominantly Weyna Dega (75 % mid altitude) in agro climatic condition.

Table 1. Description of agro-ecological zones

Agro-ecology	Features
Lowland	Hot semi-arid, 800-1100 m.a.s.l, low vegetation, rain fall (400-500mm), agro-pastoral, poor infrastructure
Midland	Hot sub humid, 1501-2500 m.a.s.l, high vegetable, rain fall (1001-1200 mm/year), temperature (16-20°C), mixed farming system, moderate infrastructure

m.a.s.l = meter above sea level, **°C =** degree Celsius

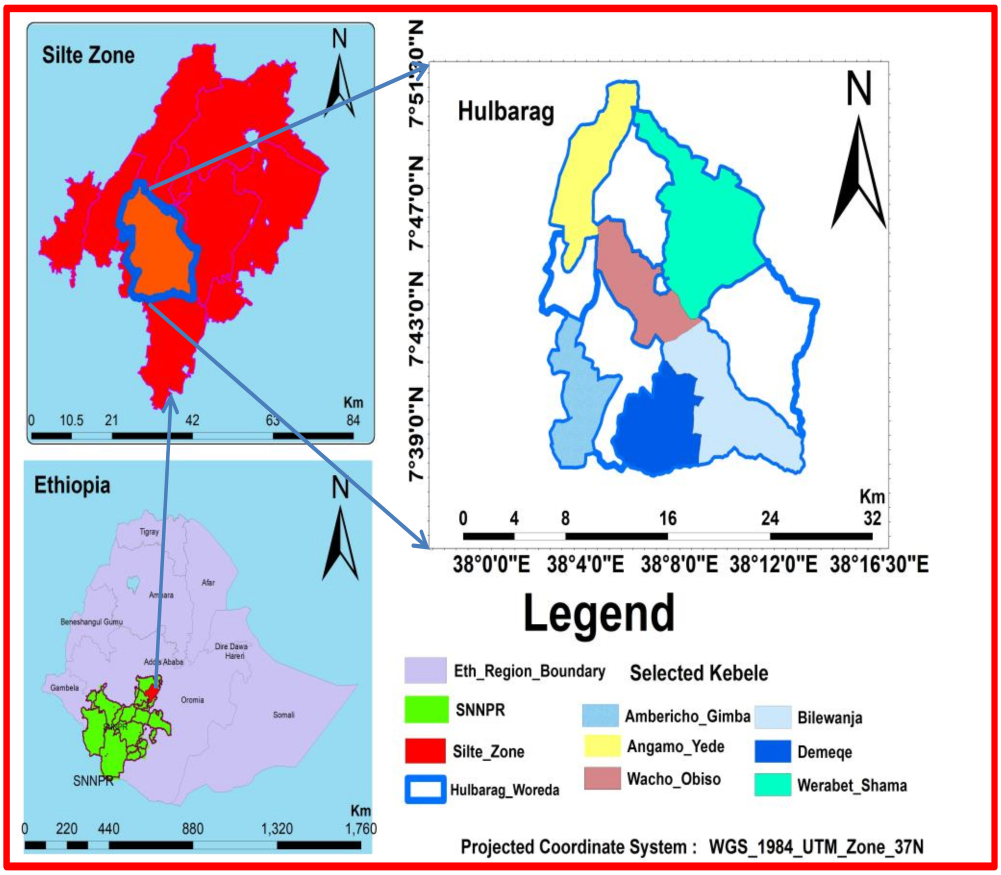

Figure 1 . Map of the Study Area

Study design

Study was supported by primary and secondary data sources. In addition, retrospective data was collected from record of district Animal and fishery office covering the period from 2017 to 2021 on oestrus synchronization and total mass insemination. Data on mass insemination includes number of cows/heifers with hormone treatment, insemination and pregnancy examination.

Sampling technique and sample size determination

Multi stage sampling method was carried out. The district was selected purposively based on dairy cattle production potential and agro-ecological conditions. In the second stage the district was stratified into two agro-ecologies, namely midland and lowland. Finally, the 290 respondents were selected by using systematic random sampling technique from 1050 AI users who have experience on dairy cattle rearing and for interview who owned local cows . The sample size was determined by using a simplified formula provided by Yamane (1967) with 95% of confidence level.

The formula was given as, $\mathbf{n} = \frac{N}{1+N(e)^2} = \frac{1050}{1+1050(0.05)^2} = 290$

Where n= is the sample size

N = total population size;

e= sampling error

Data type and collection methods

Based on the questionnaire, herd size and composition, management practices, daily milk yield, lactation length, days open, breeding practices, factors like agroecology, constraints of dairy production and reproductive performance, productive performance, availability of AITs and status of AI technician, estrus synchronization status and services were gathered.

Focus group discussion was conducted from each study sites to strengthen the informations for study. The group was formed from youngsters, women, village leaders, AITs, development agents, animal production expert and socially respected individuals. The focus group discussions were focused on the history of the breeding practices of dairy cows, utility pattern of the dairy cow and status of mass AI services, and major constraints of the mass AI practices and services, major reproductive problems of dairy cow after AI, production system, indigenous knowledge on management, husbandry practices and farmers' perceptions about synchronization and conception rate of mass AI practiced on indigenous dairy cows using a prepared check list.

Moreover, retrospective study was conducted to evaluate mass hormonal synchronization, number of cows treatment, number of cows responded, number of inseminated cow, and conception rate from year 2017-2021 recorded data was collected from livestock and fishery resource development office of the districts.

Methods of data analysis

All data gathered during the study period were coded and recorded in Microsoft Excel 2010. Preliminary data analysis like homogeneity test, normality test and screening of outliers is employed for quantitative data before conducting the main data analysis. Different types of statistical analysis were used depending upon the nature of the data. All data were analyzed by SPSS version 20.

Chi-square (x^2) test was carried out to assess the statistical significance among categorical variables. An index was computed using weighed frequencies and indexes were ranked using auto ranking with MS-Excel 2010. The following formula was used to compute index as employed by the following formula

Index = $\sum (R_n \times C_1 + R_{n-1} \times C_2 ... + R_1 \times C_n)$ for individual criteria /$\sum (R_n \times C_1 + R_{n-1} \times C_2 + ... + R_1 \times C_n)$ for overall criteria

Where, R_n = the last rank (example if the last rank is 7^{th}, then $R_n = 7$, $R_{n-1} = 6$, $R_1 = 1$) C_n = number of respondents in the last rank, C_1 = number of respondents ranked first

Model for productive and reproductive performance is

$Y_{ij}=\mu+A_i+\varepsilon_{ij}$

Where

Y_{ij}= the response variables (milk yield, lactation length, AFC, CI, dry period, …)

μ= overall mean

A_i=Fixed effect of i^{th} agroecology (i=2, midland and lowland)

E_{ij}=residual error

Rate of estrus and Conception rate is calculated according to Khatun et al. (2014).

Estrous rate = Number of cow showed estrous/number of cow treated*100

Conception rate = Number of heifers or cow pregnant/number of cow or heifers inseminated*100

Results and discussion

Purpose of keeping livestock

The purpose of rearing cattle in the study areas are presented in Table 2. In midland, milk production (36%) was prioritized followed by source of income generation (31%). Whereas, in the lowland, 32% of the respondents were prioritized income generation, followed by milk production (28%). In general, main purpose of livestock keeping in both agro-ecologies were identified as milk production and income generation.

This in lined with (Aduna and Ayalew 2019) and Hailemariam et al. (2022) who reported that the primary purposes of keeping cattle are milk production and income source in Guraghe and Gedio zones, respectively. In addition, the farmers reared dairy cattle for farming/draft power and manure.

Mating system

Mating system and sources of bull were shown in the Table 3. Most of the breeding practices used by dairy cow owners were (63.4%) natural mating, followed by AI with synchronization (19%). The current result is in line with (Beriso et al. 2015), who reported that most of farmers in Aleta Chuko District of Sidama, Ethiopia practiced natural mating.

Selection criteria for dairy cattle

The result presented in the Table 4 revealed the trait preference of farmers for selection of dairy cattle in the study areas. Most farmers used that a selection trait of animals takes place by considering expected parental history and milk yield for bulls and cows/heifers. Highly preferred trait for selecting bull was parental history followed by appearance, growth rate, libido, color, and disease resistance in midland. While, size or appearance followed by parental history, growth rate, color and disease resistance and libido in lowland.

On the other hand, for cows/heifers, the prioritized selection criteria is milk yield followed by growth rate. This in agreement with the report of Godadaw et al. *(*2015), Ftiwi and Tamir (2015), Girma et al. (2016), and Belay and Zeleke (2021) who reported that milk yield is the primary interest of the livestock keepers in a different part of the Ethiopia. Moreover, Ftiwi and Tamir (2015) stated that physical appearance is one of the preferred traits in the selection of breeding animals in western Tigray. Farmers focus on body shape, udder size and teat position as primary interests when looking at the appearance of the dairy animals. In general, cattle owners' selection criteria are related to production traits in a different parts of the country.

Table 2. Purpose of keeping indigenous dairy cattle around the study sites

Agroecology									
Purposes	Midland (N=197)				Lowland (N=93)				Over all
	Rank 1	Rank 2	Rank 3	Index	Rank 1	Rank 2	Rank 3	Index	
Milk production	57	90	75	0.36	22	33	27	0.28	0.32
Income generation	82	40	38	0.31	37	25	16	0.32	0.31
For banking	7	26	31	0.09	11	18	21	0.16	0.13
Traction	30	28	25	0.14	9	9	13	0.10	0.12
Manure	21	13	28	0.10	14	8	16	0.13	0.12

N = number of respondents

Table 3. Mating system and sources of bull in the study areas

	Agroecology				Total	
Mating system and source of bull	Midland		Lowland			
	N	%	N	%	N	%
Sources of breeding bull						
Own bull	76	38.6	51	48.4	132	43.5
Neighbor bull	121	61.4	42	51.6	128	56.5
χ^2						2.500
P-value						0.114
Mating system						
Natural mating	112	56.9	65	69.9	177	63.4
AI only	44	22.3	12	12.9	56	17.6
AI with synchronization	41	20.8	16	17.2	57	19.0
χ^2						5.089
P-value						0.079

χ^2 = chi-square, N = number of household

Table 4. Respondents selection criterias use for bull and heifer

Criteria	Rank			Index	Rank				Overall
	1	2	3		1	2	3	Index	
Cows/heifer									
Milk yield	64	55	46	0.33	27	20	22	0.29	0.31
Parent history	41	34	31	0.21	27	21	15	0.28	0.24
Size/b/appearance	27	31	46	0.18	17	16	28	0.22	0.20
Growth rate	34	45	34	0.22	5	20	13	0.14	0.18
Color and DR	8	9	17	0.06	7	6	5	0.08	0.07
Bull									
Parent history	62	58	58	0.34	26	22	25	0.31	0.33
Size appearance	46	59	50	0.29	20	31	27	0. 33	0.31
Growth rate	36	31	40	0.20	16	12	14	0.18	0.19
Libido	22	19	21	0.12	3	5	8	0.07	0.09
Color and DR	10	9	7	0.05	13	8	4	0.11	0.08

DR = disease resistance

Table 5. The major culling criteria for indigenous dairy cattle of respondents

Criteria	Midland				Lowland				Overall
	Rank 1	Rank 2	Rank 3	Index	Rank 1	Rank 2	Rank 3	Index	
Reproductive problem	65	44	50	0.32	27	27	14	0.35	0.33
Disease	46	45	46	0.26	18	9	16	0.20	0.23
Productive problem	32	38	37	0.20	14	19	12	0.21	0.21
PPBC	17	38	30	0.15	9	15	17	0.17	0.16
UWPC	13	8	10	0.06	4	2	13	0.07	0.07

PPBC = persistent poor body condition, UWPC = un wanted physical characteristic

Criteria for culling of dairy cattle

The results concerning culling of dairy cattle in the study areas are presented in Tables 5. The results showed that farmers reported that the first major criteria of culling animals takes place by considering reproductive problem (33%).

Reproductive performances of dairy cows

Reproductive performances of dairy cows in study sites are shown in Table 6. Age at first calving for female was significantly different between midland and lowland agro-ecologies. In this study, the higher age at first calving (AFC) was recorded in lowland (53.3)months. This is unlikely greater than the report of Tadele and Nibret (2014) who revealed that 39.8months for local breed dairy cattle in Ethiopia.

The calving interval is the period between two successive parturitions, and ideally should be in the region of 12 to 24 months. Calving interval (CI) is one of the chief components of reproductive performance that can affects livestock production system (Dessalegn et al. 2016). The overall mean of calving interval in this study was 21 months. Calving interval (CI) was not significantly ($p>0.05$) different between a studied agro-ecologies. This might be also due to the nearly same management level (feeding, housing and animal health service) and genetic merit. This is comparable with the reported values of 622.6 days in Boran cows at Tatesa cattle breeding center in Guraghe Zone, Ethiopia by Yifat et al. (2012). The current result was lowrer than the report of Yifat et al. (2012) who revealed the dry period of local dairy cow is 340 days in Guraghe Zone, Ethiopia.

Production performance of dairy cattle

Productive performances of indigenous dairy caws are presented in Table 6. The production performance of dairy cattle was significantly different ($p<0.05$) between agro-ecologies. The result showed that daily milk yield of indigenous cow as 2.03 and 1.65 liters in midland and lowland agro-ecologies, respectively. The overall average milk yield of a cow per day for local was 1.91 liters. Under smallholder management conditions the lower average daily milk yield per cow were obtained and the lower milk yield per day per cow could be due to attributed to poor management.

The average lactation period for indigenous dairy cattle was 7.92 months. The estimates of average lactation period for local cows in study area was shorter than the standard lactation period of 305 days. The variation in lactation length is due to attributed to, improper feeding for the dairy cattle, poor nutritive value of pastures and forages offered to the animals, lack of proper supplementary feeds, health challenge, agroecological variations and poor genetic potential of the studied population.

The major reasons for the failure of hormoe treatment

The major reasons for failure of synchronization program in study area are shown in Table 7. The major reasons for failure of hormone treatment were selection of inappropriate animals (poor body condition, pregnant, diseased and fatty cows/heifers), problem of AI technicians, protection of farmers, dose of hormone and injection of expired or inefficient hormone.

According to the farmers' perception, selection of inappropriate cows/heifers was the primary reason for failure of synchronization in both mid and lowland agro-ecologies. In lowland, artiffiecial insemination (AI) technicians' efficiency, hormone problem and poor protection of farmers ranked as second, third and fourth failures of synchronization, respectively. The major reasons for the failure of hormone treatment in this study are slightly reliable with the result of Tegegne et al. (2016) who reported that, the major reasons for the failure of hormone treatment in Ethiopia were feed problem, inappropriate season and low awareness of farmers on the technology such as taking hormone injection for insemination and providing sterile and non-cyclic animals for PGF2α treatment. As a solution towards the challenges of reproduction, prevention and treatment measures should be implemented on the farm to control the parasite infections and hence improve the cattle's production (Nur-Sebrina et al. 2024).

Retrospective study of estrus synchronization trend

Restrospective information is presented alternatively in Tabale 8 and Figure 2. The data were collected from records of mass AI service covering the period from 2017 to 2021 in the study district. Artificial insemination records were obtained from the inseminators' record book of district animal and fishery office.

The implementation progress of the program in terms of estrus response to hormone was very high, but the pregnancy rate was very low (ranging from 8.4% to 18.3%). According to the data obtained from district AITs record book there is increase in number of mass insemination from 2017 to 2021. It is evident from figure 2 that animals with hormonal treatment increased progressively from 190 in 2017 to 360 in 2021.

Evedience concised during discussions with farmers and experts revealed that management factors such as feeding and watering system, AITs, farmers protection, hormone and semen quality are the sources of variation in performances. According to Saha et al. (2014) management and environmental factors account for 95% of the variation in conception rate and the remaining 4% of variation accounts for genetic factors for cows as well as 1% for service bull.

Table 6. Reproductive and productive performances of local dairy cattle

Parametres	Agroecology			P value
	Midland	Lowland	Average	
	Mean±S.D	Mean±S.D	Mean±S.D	
Reproductive performance				
AFC (Month)	52.0± 3.41	53.3±3.23	52.41±3.40	0.003
CI (Month)	21.2±3.79	20.5±3.30	21.0±3.65	0.099
DP (Month)	7.21±2.12	8.56±2.19	7.64±2.23	0.000
Productive performance				
Amount of milk per cow per liter per day	2.03±0.41	1.65±0.40	1.91±0. 0.44	0.000
Lactation period (Month)	8.12±2.00	7.48±2.11	7.92±2.10	0.014

S.D = standard deviation, AFC = Age at first calving, CI = Calving interval, DP = Dry period

Table 7. The major reasons for the failure of synchronization program

Variables	Agroecology								Over all
	Midland				Lowland				
	Rank 1	Rank 2	Rank 3	Index	Rank 1	Rank 2	Rank 3	Index	
Animal selection	45	50	45	0.31	24	40	28	0.42	0.37
AIT efficiency	44	40	49	0.29	22	12	26	0.27	0.28
Protection of farmers	37	31	37	0.23	13	8	10	0.15	0.19
Hormone problem	25	30	20	0.17	14	13	8	0.16	0.16

Table 8. Restrospective information of the study district

Years	2017	2018	2019	2020	2021	Overall
No cow/ heifers hormone treated animal	190	175	195	280	360	1200
Hormone response rate (%)	84.2	88.6	90.3	92.5	83.6	87.8
Conception rate (%)	11.9	8.4	13.1	16.2	18.3	13.6

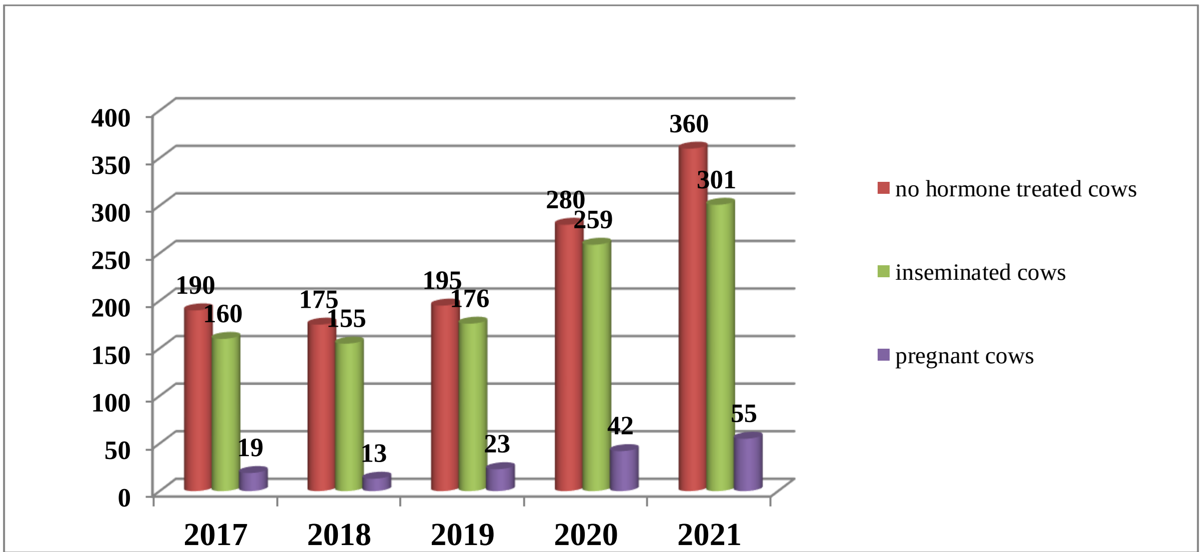

Figure 2. Retrospective study of ESMAI trend

Conclusion

The main purpose of rearing cattle in many parts of Ethiopia is milk production for consumption, income generation and banking. The poor performance rate of dairy sector is due to inaccessibility of artiffficial insemination (AI), lack of AI connection to improved bull service, the problem of heat detection, lack of technology, knowledge of farmers, and cattle management. Farmers lose their faith in AI because of their low performance. In addition to that, community awareness of synchronization and AI was created and farmers' negative attitudes toward estrus synchronization to be taken in to consideration. As recommendation, AI technicians and farm owners need continuous training to improve their skills in heat detection and increase their knowledge and obtain a successful business.

Acknowledgements

We are grateful to Wachemo University for proding of fund, field enumirators and farmers. And also our thanks goes to the silte zone to for facilitating the research and funding.

References

1) Aduna, T., Ayalew, W. 2019. Assessment of dairy cattle management in Gurage Zone, Southern Nation Nationalities and Peoples Region, Ethiopia. International Journal of Research Studies in Agricultural Sciences, 5(4):1-10.
2) Belay, D., Zeleke, B. 2021. On-Farm phenotypic characterization of indigenous cattle in its production environment in Sidama, Ethiopia. Global Journal of Science Frontier Research: D Agriculture and Veterinary, 21(3).
3) Beriso, K., Tamir, B., Feyera, T. 2015. Characterization of smallholder cattle milk production system in Aleta Chukko district, Southern Ethiopia. Advances in Dairy Research, 3(1):1-8.
4) Chandra Prasad V., Srinivas M., Sadasiva Rao K. 2019. Comparative Efficacy of Ovsynch and Double PG Protocols in Postpartum Anoestrus Graded Murrah Buffaloes (Bubalus bubalis). Journal of Livestock Science 10: 6-8. doi. 10.33259/JLivestSci.2019.6-8
5) CSA, 2021. Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey Volume II Report on Livestock and Livestock Characteristics (Private Peasant Holdings).
6) Dessalegn, G., Berhan, T., Gebreyohannes, B. 2016. Study of reproductive and production performance of cross breed dairy cattle under smallholders management system in Bishoftu and Akaki Towns. International Journal of Advced Research in Biological Sciences, 3(2):151-157.
7) Ftiwi, M., Tamir, B. 2015. Phenotypic characterization of indigenous cattle in Western Tigray, Northern Ethiopia. The Journal of Agriculture and Natural Resources Sciences, 2(1):343-354.
8) Girma, E., Alemayehu, K., Abegaze, S., Kebede, D. (2016). Phenotypic characterization, population structure, breeding management and recommend breeding strategy for fogera cattle (Bos indicus) in northwestern amhara, Ethiopia. Animal Genetic Resources, 58:13–29.
9) Godadaw, M., Zewdu, W., Workneh, A. 2015. Breeding practices in indigenous dairy cattle breeds in Northern Amhara, Ethiopia. Livestock Research for Rural Development, 26(4).
10) Hailemariam, S.E., Tezera, B.T., Engidashet, D.H. 2022. Husbandry practices and constraints of smallholder dairy production in Dilla Zuriya district, Gedeo Zone, Ethiopia. Heliy, 8(3).
11) Khatun, M.A., Bari, F.Y., Alam, M., Ali, M.R., Sarkar, P.K. 2014. Post AI conception rate in cattle at Rajarhat, Kurigram, Bangladesh. Wayamba Journal of Animal Science, 6:845-854.
12) Lemma, A., Kebede, S. 2011. The effect of mating system and herd size on reproductive performance of dairy cows in market oriented urban dairy farms in and around Addis Ababa. Revue de Medicine Veterinary, 162(11):526-530.
13) Nur-Sabrina, A.M., Muhamad-Ali, H.A.M., Nur-Amalina, N., Wan-Ladiana, W.A., Hasimah, H., Salma, C.W., Wan, K.L., Basripuzi, N. Hayyan. 2024. Relationship between parasitism with milk yield and body weight of Mafriwal cattle. Veterinary Integrative Sciences, 22(1):141-159.
14) Saha, R., Ashraf, A., Rahman, Z., ADV, J. 2014. Comparative study on conception rate of cow in using frozen and liquid semen. Journal of Animal Science Advances, 4(3):749-772.
15) Tadele, A., Nibret, M. 2014. Study on reproductive performance of indigenous dairy cows at small holder farm conditions in and around Maksegnit Town. Global Veterinaria, 13(4):450-454.
16) Tegegne, A., Gebremedhin, B., Hoekstra, D. 2010. Livestock input supply and service provision in Ethiopia: Challenges and opportunities for market-oriented development. https://cgspace.cgiar.org/handle/10568/1988
17) Tegegne, A., Hoekstra, D., Gebremedhin, B., Gizaw, S. 2016. History and experiences of hormonal oestrus synchronization and mass insemination of cattle for improved genetics in Ethiopia: From science to developmental impact. International Livestock Research Institute.
18) Verma, O.P., Kumar, R., Kumar, A., Chand, S. 2012. Assisted reproductive techniques in Farm Animal-From Artificial Insemination to Nano biotechnology. Veterinary World, 5(5):301-310.
19) Yifat, D., Bahilibi, W., Desie, S. 2012. Reproductive performance of Boran cows at Tatesa cattle breeding center. Advances in Biological Research, 6 (3):101-105.