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Assessment and Comparison of Sex Ratio Following Artificial Insemination and Natural Mating in Small Scale and Modern Dairy Cattle Farms in Mekelle

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Abstract: Prospective and retrospective study was conducted to evaluate and compare the sex ratio of calves following artificial insemination and natural mating. In the present study, animals that are inseminated from 8-18h from the onset of estrus were considered as early insemination; while animals inseminated >18h were also considered as late inseminated animals. Questionnaire survey, observation and secondary data were used to collect the information in the present study and out of the total number of calves (N=307) born by artificial insemination; 147(47.9%) animals were female and the rest 160 (52.1%) were male calves. whereas the number of animals calved by natural mating were 193 in which 107 of them were females and 86 were males and the sex ratio (female/male) was 55:45. Similarly, based on the findings of the evaluation and comparison of sex ratio conducted on farm type, the total number of animals from small scale dairy farms were 250 out of this 121 calves were females and 129 were males with this result the sex ratio (female/male) in small scale dairy farm were 48:52 and out of the total number of 250 calves recorded from large scale dairy farm 133 were females and the rest 117 animals were males and the sex ratio (female/male) was 53:47. The present result showed that the sex ratio of calves, by both the service type (AI or natural) and farm type (small or large scale), though numerically slight effect was appreciated, it was not statistically significant (P>0.05). On the other hand, of the total number calves (407) born following early (the first 8-18h) AI/bull service, 225 were females and the rest 182 were males and the sex ratio (female/ male) of this animals was 55:45, whereas out of the total number of 93 calves, that are calved through late insemination/service, 26 (28%) of them were female and 67 (72%) of them were males. This result showed that the sex ratio of calves were significantly affected (P<0.5) by the time of insemination in relative to estrus onset. In conclusion, the chance of female calves were increased when performing the AI/bull service within the first 8-18h from the onset of estrus, whereas delaying the AI time increases the probability of male calves.

Key words: AI · Calve · Estrus Onset · Sex Ratio

INTRODUCTION

Livestock production consists one of the principal means of achieving improved living standards in many regions of developing world. In sub saharan African countries, livestock plays a crucial role both for the national economics and the livelihood of rural communities [1]. Livestock are vital sources of economy and social support for millions of poor people throughout Africa. In addition to this, livestock not only provide poor people with food, income, traction and fertilizer but also act as catalysts that transform subsistence farming in to income generating enterprises, allowing poor households to join the market economy [2].

However, production efficiency of cattle is low in Ethiopia despite their large population. Although Ethiopia is sufficient enough in meat production, still imports many dairy products [3].

In animal production systems, the possibility of modify sex ratio can result in a substantial increase of the production in intensive cattle farms. Also, sex ratio manipulation can sensibly enhance the effectiveness

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of selection and genetic improvement programs, through the differential increment of males or females born after AI [4].

Evaluating the reproductive ability of breeding stock is crucial for cow/calve operation [5]. Cattle breeding are mostly uncontrolled in Ethiopia making genetic improvement difficult and an appropriate bull selection criteria have not yet been established, applied and controlled [6]. Although artificial insemination, the most commonly used and valuable biotechnology [7] has been in operation in Ethiopia for over 30 years, the efficiency and impact of the operation has not been well-documented [8].

Artificial insemination has been defined as a process by which sperm is collected from the male, processed, stored and artificially introduced into the female reproductive tract for the purpose of conception [9, 7, 10]. Semen is collected from the bull, deep-frozen and stored in a container with liquid nitrogen at a temperature of -196^{0}C and made for use. Artificial insemination has become one of the most important techniques ever devised for the genetic improvement of farm animals. It has been widely used for breeding dairy cattle as the most valuable management practice available to the cattle producer and has made bulls of high genetic merit available to all [7, 11].

In Ethiopia, there is often complaint of the AI service, by service users for imbalance female and male ratios of calves born in which the latter exceeds in percentage, which is against the interests of most of the beneficiaries [12]. AI will increase the likelihood of a male calf or in other words natural mating is more likely to result in a female calf [13]. However, the reason why natural mating gave more female progenies than males for cows mating to AI is not clearly known [12].

Some researchers have studied the variation of the sex ratio depending on the time of the mating relative to ovulation [4, 14, 15]. Nevertheless, results have been very variable. In white-tailed deer, Verme and Ozoga [16] indicated that mating occurring near the onset of estrus produced a higher proportion of females, whereas late mating produced more males. This effect has been observed in other species human [14, 17, 18-21].

In cattle, results are controversial, since some authors have not observed such a relation [15, 22, 23] whereas other authors indicated that sex ratio can be altered varying the moment of AI relative to the onset of estrus [24-27]. Due to this lack of consensus, further research has been recommended.

The study of Berger *et al*. [28] reported that the sex ratio of calves following AI is 50:50. However, there are some problems of AI with regard to the sex ratio of calves that hinders the development of dairy farms. Berry and Cromie [13]states that AI increases the probability of a male calf in dairy farms. Similarly, the farm owner in the study area always complains about the increment of probability of male calves being born following AI (personal observation). Regarding to these contradicting studies assessment and comparison of calve sex ratio following AI and natural services, as well as the effect of time of insemination with regard to the onset of estrus need to be studied since it was not done so far in Tigray, specially in the study area Mekelle. Accordingly, this study is designed to give relevant information to all beneficiaries, to give scientific knowledge to a farmer who complains all the time about AI regarding to the sex ratio of calves and initiating researchers for further investigation on the assessment of sex ratio of calves following AI.

Therefore the Objectives of this Study Are:

- To assess and evaluate the effect of AI and natural mating on sex ratio of calves in Mekelle.
- To compare and differentiate the sex ratio of calves between small and modern dairy farms following AI and natural mating in the study area.
- To assess the variation of the sex ratio depending on the time of mating relative to estrus onset in the selected dairy farms in Mekelle.

MATERIALS and METHODS

Study Area: The study was conducted from October to May in Mekelle which is situated about 783 km north of Addis Ababa and lies between13° 23' North and39° 38' East. The total area of the city is estimated to be 53 km^2. The altitude ranges from 2000-2200m above sea level with the annual rain fall ranges from 150-250mm and an average daily temperature is 19^{0}C. The rainy season occur mainly between June to September, although a short rainy season occurs on March and April and the dry season is from middle of September to February. It has a moderate (woynadega) zone of climatic condition [29].

Study Animals and Sampling Method: The study was conducted in 500 calves in which 250 of them were from modern dairy farms and 250 of them were from small scale

dairy farms. The retrospective and follow-up studies were conducted by purposive (for selecting the different farms) and simple random (for individual animals within herds) sampling methods. The purposive selection was based on the voluntary of the dairy farm owners, presence of retrospective data about the service used and sex of calves and availability of transport.

Study Design: Prospective and retrospective type of study design was carried out on the assessment of sex ratio following AI and natural mating in selected small and modern dairy farms in Mekelle. According to ILRI [30] dairy farms containing less than or equal to 5 dairy cattle were categorized as small scale dairy farm and those farms having greater than 10 dairy cattle were categorized as large scale dairy farms. The retrospective data were collected from farm records.

Data Collection

Questionnaire Survey: All the farm owners in the selected dairy farms (smallholders and modern) were interviewed face to face using structured questionnaire. Information from Animal reproduction professionals (AI technicians) in the area were also used in the identification of sex ratio.

Data Analysis: The data collected from the study was entered in to Microsoft excel spread sheets, coded appropriately and analyzed using SPSS version 16. Descriptive statistics were used to compare the sex ratio of calves in dairy farms depending on the type of service used, the type of the farm and the time of insemination with regard to the onset of estrus and statistical significance was considered when $P < 0.05$.

RESULTS

Effect of Service on Sex Ratio of Calves: The number of calves born by artificial insemination was 307 out of this 147 (47.9%) were female and the rest 160 (52.1%) were male c and the ratio (female/male) was 48:52. Whereas, the number of calves calved borne using natural mating (bull) were 193 in which 107 (55.4%) of them were females and 86 (44.6%) were males and the ratio (female/male) was 55:45. Generally, the sex shift towards female calves was with a numerical difference by 10% when natural service was used, but it did not show a statistical variation as indicate in Table 1.

Effect of Farm Type on Sex Ratio of Calves: The total number of calves from small scale dairy farms were 250 out of this number of calves 121 (48.4%) were female and 129 (51.6%) were male with this result the sex ratio (female/male) in small scale dairy farm were 48:52 and out of the total number of 250 calves from large scale dairy farm 133 (53.2%) were females and the rest 117 (46.8%) were males and the sex ratio (female/male) was 53:47 as summarized in Table 2.

Table 1: The difference between AI and natural mating on sex ratio of calves

Service type	Total number of calves born	Female	Male	p-value
AI	307	147 (47.9%)	160 (52.1%)	0.100
Bull	193	107 (55.4%)	86 (44.6%)	
Total	500	254	246	

Table 2: The effect of farm type on the sex ratio of calves

farm type	Total number of calves born	Female	Male	p-value
Small scale	250	121 (48.4%)	129 (51.6%)	0.283
Large scale	250	133 (53.2%)	117 (46.8%)	
Total	500	254	246	

Table 3: The effect of time of insemination on sex ratio of calves.

Insemination time	total number of calves born	Female	Male	p-value
Early insemination (8-18h)	407	225 (55.3%)	182 (44.7%)	0.000
Late insemination (>18h)	93	26 (28%)	67 (72%)	
Total	500	251	249	

Effect of Time of Insemination with Regard to Estrus Onset on Sex Ratio of Calves: The animals were grouped in to two groups with regard to the time of insemination in which animals inseminated from 8-18h from the onset of estrus was considered as early inseminated animals while animals that are inseminated after 18h from the onset of estrus was also considered as late inseminated animals. So, the result indicates that the animals that are calved through early insemination were 407 out of this number of calves 225 (55.3%) were females and the rest 182 (44.7%) calves were males and the sex ratios (female/ male)of this calves were 55:48 whereas the sex ratio (female/ male) of calves that are calved through late insemination were 28:72 in which out of the total number of 93 calves 26 (28%) of them were female and 67 (72%) of them were males. So, the highest female ratio was obtained from the animals that are inseminated early and highest ratio of male animals were obtained from the animals that are inseminated late and this differences were significant ($P<0.05$) as indicated in Table 3.

DISCUSSION

The effects of some factors (type of service, type of the farm and the time of insemination with regard to the onset of estrus) on the sex ratio of calves have been carried out in dairy farms. So regarding to these results the type of service used whether it is AI or natural mating there was no occurrence of significant effect on the ratio of sex of calves in dairy farms which was different from the idea that significantly greater probability of a male calf being born when conceived through AI [13, 23, 31-33]. This might be due to the difference in the use of synchronization, the individual ovulation time difference, the type of semen used for insemination in the cow and the amount of data used. However, in the present study there was a difference in the sex ratio (female/male) of animals in which animals calved using AI was 48:52 and animals calved using natural mating was 55:45 with highest female to male sex ratio of using natural mating compared to AI. regarding with the time of insemination out of the 407 inseminated cattle in early 225 (55.3%) female and 182 (44.7%) male respectively but out of the 93 late inseminated cattle 26 (28%) and 67 (72%) are female and male respectively which clearly indicated that the percentage of female calves can be increased when using AI with in the first 18 h from the onset of the estrus, whereas delaying the AI time significantly increases the percentage of males. This finding agrees with the idea of Martinez *et al*. [27] which stated the percentage of females offspring could be increased using application of AI in the first 18 h after the onset of estrus while delayed AI (=30h) produces a significant deviation of the sex ratio towards the male. Similarly, Wehner *et al*. [25] stated that 90% of effectiveness regarding sex selection vary with time of insemination as confirmed using electronic device. In his finding he clearly put that 93% of females were born in cattle's inseminated at a time of 12 h from the onset of estrus and 92% of males inseminating 22 h from the onset of estrus, which is comparable to the use of flow cytometry to obtain sorted semen. Although the present study agrees with these outcomes, percentages and insemination times were different. This difference could be explained by the difference in the number of animal included in and methodological differences both in the detection of the estrus and in the AI protocol. Indeed, they used a more precise method in order to determine the estral state of the cow and the inseminations were carried out at fixed times. This difference in sex ratio of calves regarding to the time of insemination relative to the estrus on set can be explained considering that there are many physiological differences between Y and X spermatozoa. Rohde *et al*. [34] found that Y chromosome bearing sperm progress more quickly through cervical mucus than those carrying an X chromosome bearing sperm.There is a process of sperm selection in the oviduct, in which spermatozoa interact with the oviductal epithelium, forming a reservoir at the uterotubal-isthmus junction and undergo capacitation [35, 36]. Those sperm that reach an adequate capacitation state are released and can move to the fertilization place and also Martinez *et al*. [27] reported that the high percentage of female calves when cows are inseminated within the first 18 h from the onset of estrus can be explained by the fact that Y chromosome bearing sperm in the isthmus would achieve capacitation earlier than X chromosome bearing sperm, release from the oviductal epithelium and reach the fertilization place long before the ovulation. Having undergone capacitation, most of these cells would die. However, X chromosome bearing sperm, which would have undergone capacitation later and have longer lifespan, would reach the fertilization place at the adequate moment. Thus, in these conditions, it is more likely that X chromosome bearing sperm would fertilize the ovum [25]. On the other hand, if insemination were delayed (EI=30 h), Y chromosome bearing sperm

would have more chances of fertilizing the ovum, since they would arrive at the fertilization place around the moment of the ovulation and before X chromosome bearing sperm [27].

Powell *et al*. [24] and Pursley *et al*. [26] have also reported similar observations which support the present result. In contrast, Rorie *et al*. [15], Ballinger [22] and Foote [23] have not found a relation between the moment of AI and sex ratio in cattle and Orkun *et al*. [37] was also indicated that artificial inseminations performed at different times in the first half of the estrus period did not alter the sex ratio of offspring in dairy cows. This disparity of results between authors could be due to methodological differences, especially the detection of estrus and the use of different AI protocols [38, 39].

CONCLUSION

There was numerical difference in the ratio of female to male animals in which the number of male animals calved by AI was slightly higher than that of animals female calved through natural mating. Moreover, the sex ratio of calves was not affected by the type of farms (small or large scale dairy farms). In addition, early Artificial insemination was highly significant to have higher number of female calves. So, the increment of male animals in the study area (Mekelle) could be due to lack of knowledge to detect animals in early estrus aggravated by late insemination practice or due to carelessness of the attendants to detect animals in estrus.

Based on the above findings the following points were recommended

- There should be skilled person in the farm with enough knowledge about animal estrus.
- Animal owners should attend their animals by them self in order to detect while they are in estrus.
- It is better to inseminate animals while they are in the early estrus period in order to have female animals.
- It is better to use sexed semen (XX or YY).

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