Theriogenology 82 (2014) 433–439

Contents lists available at ScienceDirect

Theriogenology

journal homepage: www.theriojournal.com

Calves' sex ratio in naturally and artificially bred cattle in central Ethiopia

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ARTICLE INFO

Article history:
Received 27 February 2014
Received in revised form 29 April 2014
Accepted 29 April 2014

Keywords:
Artificial insemination
Calf sex ratio
Estrus season
Natural mating

ABSTRACT

A study was undertaken with the objective to identify some intrinsic (genotype of the cow, estrus time and parity) and extrinsic factors (service type, service time and estrus seasons) that affect calf sex ratio in naturally and artificially bred cattle in the central highlands of Ethiopia. A total of 4657 calving events were extracted from the long-term dairy cattle genetic improvement experiment at Holetta Agricultural Research Center. Factors that affect the logit of the probability of a female calf being born were obtained by using PROC GENMODE in Statistical Analysis System. Moreover, multivariate analysis was performed using PROC LOGISTIC procedure using forward selection procedure. Accordingly, genotype of the cow, parity, estrus season, and service type had considerable influences on calf sex ratio. However, estrus time and service time did not affect calf sex ratio ($\chi^2 = 0.83$ and 0.79, respectively). In Ethiopia, smallholder dairy farmers often complain that artificial insemination (AI) skewed to producing more male calves. However, our study showed that AI did not alter female-to-male calf sex ratio. On the contrary, natural mating increases the probability of female calves born (odds ratio 1.38) over AI. Heifer/cows that showed estrus and bred during the harsh seasons of the years produced more female calves than those that bred during the good seasons of the year. This strongly agreed with Trivers and Willard sex allocation theory.

1. Introduction

Probability and evolutionary equilibrium theories indicate that the secondary sex ratio, which is defined as the ratio of male-to-female offspring at birth, should be 50:50 [1]. However, there is compelling evidence that in non-human species many intrinsic and extrinsic factors can significantly affect this universally accepted theory. Moreover, under certain circumstances, theories are inconsistent with results. For instances, an extensive review made by Rosenfeld and Roberts [2] and Demüral et al. [3] and references therein unanimously concluded that among others factors, liter size, mother's age, mother's parity, sex of the preceding calf, year, breeding season, mother's fecundity, maternal nutrition, mother's milk yield, maternal stress, habitat quality, population demography, maternal dominance, paternal breeding success, time, and type of insemination can significantly affect calf sex ratio.

Some reports also associate male-to-female sex ratio to the proportion of X- and Y-bearing spermatozoa. For instances, Gutierrez-Adan et al. [4] provided strong evidences that the proportion of X- and Y-bearing spermatozoa can significantly affect male-to-female sex ratio. They confirmed that the differential ability of X- or Y-bearing spermatozoa to fertilize oocyte depends either on the time of insemination or on the oocyte maturation state and the intrinsic differences in the physiological activity of X- or Y-bearing spermatozoa before fertilization.

An interesting theory that attracted several scholars into sex ratio investigations was the Trivers and Willard [5] sex

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0093-691X/$ – see front matter
http://dx.doi.org/10.1016/j.theriogenology.2014.04.027

ratio allocation theory. They stated that in species in which reproductive success varies more among one sex than the other, mothers in better physiological conditions would give birth to more male calves. Such phenomenon has been reported in several species, including human race [2]. The theory suggests that high-status individuals invest more in boys, and low-status individuals invest more in girls. In other words, mothers that experienced severe environmental shocks and poor in body conditions give birth to female calves. Many research results [1] conform to the theory of Trivers and Willard [5], suggesting that environmental calamities can modify male-to-female sex ratio at birth. Indeed, there are multitudes of intrinsic and extrinsic factors that potentially influence male-to-female sex ratio in large ruminants, rodents, marsupial, primates, and others species [2].

Several studies that have been undertaken on calf sex ratio in cattle have variable and in some cases conflicting outcomes. For instances, Berry and Cromie [6] reported that artificial insemination (AI) increases the probability of male calves born in beef cattle. On the contrary, Tadesse [7] observed that AI did not significantly affect calf sex ratio. Perhaps, results of the reports may vary depending on the analytical model used, size and quality of the data, and many other factors. Whatever the case is, the choice of sex of calves born at a farm primarily depends up on the production objective of producers. Berry and Cromie [6] indicated that beef producers need more male calves for increased growth rate and more efficient production of lean meat for economic reasons. On the other hand, dairy farmers generally like to have female calves for replacement purposes or lucrative sale, whereas male calves entail increased production costs. Nowadays, breakthroughs in reproductive biotechnologies like semen sexing enables dairy producers in technologically advanced counties to obtain a desired calf sex. However, this intervention seems expensive and is not within the reach of smallholder dairy farmers that operate in the low-input low-output dairy production systems.

In the tropics, the use of AI has already registered remarkable success and likely to expand further for dairy cattle genetic improvement programs in the future. Ethiopia, among many Sub-Sahara African countries, has been engaged in delivering AI service to dairy farmers since long time. Despite its long history, most smallholder farmers are skeptical toward AI services perceiving it to have calf sex bias. They complain that AI often results in higher number of male calves. Such concerns need to be addressed by producing objective evidences before large-scale application of AI services in the country. Therefore, this study was undertaken to identify some intrinsic and extrinsic factors that can affect calf sex ratio in naturally and artificially bred cattle in Ethiopia.

2. Materials and methods

2.1. Breeding plan and animal management

The dairy cattle crossbreeding and management experiments carried out at Holetta Agricultural Research Center mimics the management practices implemented by smallholder dairy producers in Ethiopia. All the cows were subjected to similar management practices, regardless of their breed type and level of exotic gene inheritances. They graze on natural pastures for 8 hours a day during the daytime. On their return to the barn, they were provided with hay conserved from the natural pasture. Milking cows were provided with an approximately 1 to 1.5 kg of concentrate ration during milking. Moreover, all the animals were supplemented with approximately 1 to 2 kg of concentrate feeds during dry seasons of the year when feed supply is scarce.

Cows in estrus were detected by teaser bulls that run after the herd for 24 hours and by herd attendants. The assigned herd attendant recorded the date and time of onset of estrus, and the collected data were kept in the central dairy database system to arrange mating plan or insemination. Cow services followed standard breeding procedures. Cows that showed estrus in the afternoon or during the evening were bred the next day in the morning. On the contrary, cows that showed estrus during the morning time were bred on the same day in the afternoon. Base dam populations that used in the crossbreeding program were selected from two well-known local breeds known as Boran and Horro. Semen from three selected exotic sire breeds (Holstein Friesian, Jersey, and Simmental) was imported from temperate regions to crossbred with the selected local dams. In most cases, local cows were artificially inseminated with imported semen to produce first generation (F_1) crossbred calves. Bull services were seldom used in case of repeat breeders. First generation (F_1) heifers/cows were inter se mated to selected F_1 bulls to produce second filial generations (F_2) crossbred calves. Furthermore, crossbred animals with higher level of exotic gene inheritances such as 75% exotic: 25% local were produced by backcrossing F_1 or F_2 heifers/cows to pure exotic semen.

2.2. Data extraction and editing

Data on calf sex, service sire and dam breed, estrus and service time, service type, service date, season and year of service, and parity number of the dam were extracted from dairy database platform established at Holetta Agricultural Research Center, central Ethiopia. The data used in this study span over the years between 1974 and 2013. Calves with no identified sire were removed as were records coded as abortions or still births. Records with no information on dam parity and twin births were also excluded. Seasons of mating/service were obtained from the effective mating/service date. Parity number of the cows were recorded from 1 to 8 and those parities greater than 8 were merged together and denoted as 9^+. The final data set consisted of a total of 4657 calving events.

A dichotomous variable was generated for service type, estrus time, calf sex, and time of insemination (Table 1). Service type was given a value 0 for AI, otherwise 1 indicating natural mating. Time of estrus detection was given a value 0 if estrus time was in late afternoon or during the evening, otherwise 1 indicating morning estrus and breeding on the same day in the afternoon. Service time was given a value 0 if it was in the morning, otherwise 1 indicating afternoon breeding. The most important and biologically plausible two-way interaction effects such as genotype × estrus season interaction were found significant and included in the final model. Four major seasons of