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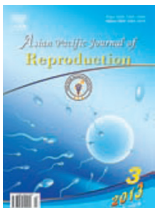

Document heading doi: 10.1016/S2305-0500(13)60150-5

Trivers-Willard hypothesis revisited: Does heat stress peri-insemination alter secondary sex ratio in crossbred dairy cattle?

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ARTICLE INFO

Article history:
Received 22 May 2013
Received in revised form 15 July 2013
Accepted 16 July 2013
Available online 20 September

Keywords:
Dairy cattle
Heat stress
Secondary sex ratio
Birth weight

ABSTRACT

Objective: To test the hypothesis that heat stress peri-insemination skews towards female the secondary sex ratio in dairy cattle. In addition, the effect of heat stress peri-insemination on birth weight of resultant calves was investigated. **Methods:** Data on the date of insemination and sex and birth weight of the resultant calf were collected for a total of 934 single births on a crossbred dairy farm and grouped into thermoneutral and heat stress peri-insemination groups on the basis of temperature humidity indices on the day of insemination. **Results:** Logistic regression revealed no difference in the secondary sex ratios between thermoneutral (53.4:46.6) and heat stress (52.5:47.5) peri-insemination groups. These sex ratios were not different from the expected 50:50 ratio on Chi-square goodness of fit test. Differences in birth weight of calves between thermoneutral and heat stress peri-insemination groups did not approach statistical significance. **Conclusions:** These results indicate that heat stress peri-insemination does not affect secondary sex ratio and calf birth weight in crossbred dairy cattle.

1. Introduction

Fisher in his genetic theory of natural selection proposed that natural selection favors a 50:50 sex ratio at birth when one sex does not require greater maternal investment than the other [1]. Deviations from this ratio are, however, expected when differential parental investment improves the future reproductive success of a particular sex [2]. Adaptive hypotheses predict systematic variation in the sex ratio when the fitness returns of producing sons and daughters vary between individual parents [3,4]. According to Trivers-Willard hypothesis (TWH), the most influential of these hypotheses, if one sex has more variable reproductive success (males in polygynous species), then (i) mothers in good condition with more resources to allocate would be advantaged by producing sons, as highly competitive sons would out-reproduce highly competitive daughters, who are constrained to a less variable reproductive rate, and (ii) mothers with less resources to allocate would be advantaged by producing a daughter, since even a moderately successful daughter would out-reproduce an unsuccessful son [5]. Application of the TWH model to dairy cattle would predict that cows in good physiological condition are more likely to produce male offspring, while skewing of the sex ratio towards female could be expected under stressful conditions.

Trivers-Willard hypothesis has been extensively tested in a wide range of mammalian species under natural and experimental conditions. In dairy cattle, skewing of secondary sex ratio has been observed with variations in plane of nutrition and body condition score [6,7]. However, it has not been tested whether heat stress alters the secondary sex ratio in dairy cattle. Based on the observations that consistent support for TWH occurs when condition scores are taken around conception rather than at other times during the reproductive cycle, it has been suggested that sex ratio adjustment is most likely to occur around conception [8]. The

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objective of this study was to test whether heat stress affects secondary sex ratio in dairy cattle. We hypothesized that heat stress peri-insemination would skew towards female the secondary sex ratio in dairy cattle. In addition, the effect of heat stress peri-insemination on birth weight of resultant calves was investigated.

2. Materials and methods

This study was conducted in Pantnagar, located in the Terai region of Uttarakhand at 29°N latitude and 79.3°E longitude at an altitude of 243.8 m above mean sea level. Data on temperature and humidity were collected from the metereological observatory at the Norman E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, India and mean daily THI indices were calculated using the following formula [9]:

Mean THI = [0.8 × mean T + (mean RH /100) × (mean T −14.3) + 46.4], where T is the temperature, and RH is the relative humidity.

Data on the date of artificial insemination (AI) and the corresponding calving data (number of calves; single or twin, sex of the calf, and birth weight) were extracted from farm records for crossbred dairy cows maintained at Instructional Dairy Farm, G.B. Pant University of Agriculture and Technology, collated between 2006 and 2012 (n=1021). Multiple and premature births were not included in the analysis.

Data were analyzed using SPSS version 16.0 software (SPSS Inc., Chicago, IL). Logistic regression analysis was done with calf sex (male or female) as dependent variable and THI class (thermoneutral or heat stress) as predictor variable. Deviations from the expected 50:50 secondary sex ratio were tested for statistical significance using *Chi*-square goodness of fit test. The effect of heat stress on birth weight of calf was tested using generalized linear model (GLM) with THI class and sex of the calf as fixed factors and birth weight as the dependent variable. Differences were considered significant at P<0.05.

3. Results

After removing data on multiple births, premature calving, and missing AI dates, a total of 934 births were included in the final analysis. The observed overall secondary sex ratio of 1.14 (53.3:46.7) was different (P<0.05) from the expected 50:50 sex ratio. Based upon the mean THI value on the day of insemination and previously established THI classification in dairy cattle[10], the inseminations were classified as having occurred either in thermoneutral (THI<72; n=498) or in heat stress (THI≥72; n=436) periods. Logistic regression revealed no difference in the secondary sex ratios between thermoneutral (53.4:46.6) and heat stress (52.5:47.5) periods peri-insemination. Moreover, these sex ratios were not different from the expected 50:50 ratio on Chi-square goodness of fit test. Further classification of the heat stress periods, based on the degree of stress [10], as mild (72 < THI ≥79; n=287) and moderate (79 < THI < 90; n=149) did not reveal any significant difference in secondary sex ratios (52.3:47.7 and 53.0:47.0, respectively).

Analysis of birth weight data by GLM showed that the main effects of THI class and sex of the calf and their interaction were not statistically significant. Birth weights of the male and female calves produced from thermoneutral peri-insemination group were (25.60±0.34) kg and (25.10±0.36) kg, respectively and of those from heat stress peri-insemination group were (25.9±0.34) kg and (25.80±0.33) kg, respectively.

4. Discussion

The difference in observed and expected overall secondary sex ratios could be attributed to the exclusive use of breeding by AI on the farm. An increase in the probability of a male calf being born following AI has been reported previously in dairy cattle [11]. However, there was no difference in sex ratios between thermoneutral and heat stress periods peri-insemination. The scenario did not change even when the heat stress periods were further classified based on the degree of stress. These sex ratios were not different from the expected 50:50 ratio. Therefore, our hypothesis that heat stress peri-insemination would skew towards female the secondary sex ratio in dairy cattle, was not supported. Daily THI values calculated from the metereological data showed that there is no period of severe heat stress (THI ≥ 90) to dairy cattle in the Terai region. It would be interesting to further test the above hypothesis in a geographical location with naturally occurring periods of severe heat stress or with experimentally induced severe heat stress. Comparison of birth weights of calves from inseminations performed in thermoneutral and heat stress periods indicated that heat stress peri-insemination does not affect the birth weight of calves in dairy cattle.

In summary, results of the present study indicate that heat stress peri-insemination does not affect secondary sex ratio and calf birth weight in crossbred dairy cattle.

Conflict of interest statement

The authors declare that they have no conflict of interest.

Acknowledgments

The authors are grateful to the authorities and staff of Norman E. Borlaug Crop Research Station and Instructional Dairy farm, G.B. Pant University of Agriculture and Technology for providing data on metereological and reproductive variables used in the study.

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