MALE OFFSPRING DISTRIBUTIONS IN CALVING AND FARROWING DATA

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INTRODUCTION

Evidence that the ratio of male to female producing sperm differed significantly from 1:1, between ejaculates of a bull, was presented in the 1996 Louisiana Dairy Report. This finding was based on DNA testing for the percentage of sperm in a sample that contained the Y chromosome. Obvious advantages could result from such natural variation in this “sperm sex ratio”, but only if corresponding differences are reflected in the sex ratio of calves produced. This report contains results of efforts to determine if such a relationship exists.

The presence or absence of a Y chromosome in the fertilizing sperm cell ultimately determines the sex of a calf. If the fertilizing sperm cell contains a Y chromosome, the calf will be male . If the sperm does not contain a Y chromosome, the calf will be female. However, due to chance and a variety of biological factors, a given sex ratio in sperm, does not necessarily lead to exactly the same sex ratio in fertilized eggs (primary sex ratio) or in the calves born (secondary sex ratio).

Unusual strings of bull or heifer calves born to a particular cow or bull have been observed by dairymen for years. It is difficult to convince a dairyman, that an AI bull which has produced 12 bull calves in a row, is not a “bull calf” sire. If the two sexes were equally likely to occur in his calves, the probability of 12 out of 12 being bulls would be .00024. This means that it should happen 1 out of 4,097 times. Conversely, it should not happen 4,096 out of 4,097 times. To many people this is proof enough some bulls produce bull calves. It also implies that the probability of the two sexes is not equal for a particular bull. How could this be true when we know that, considering all calves born, the ratio of males to females is close to 50:50?

Based upon our 1996 research, differences in sperm sex ratios occur from one ejaculate to the next within a bull and may provide a possible explanation for bulls that seem to produce predominantly one sex of calf. Because of the way that semen is typically handled by A.I. organizations, there is a good chance that all straws of a particular bull’s semen purchased by a dairyman, are from a single ejaculate. It is reasonable that sperm sex ratio, which would be the same for these straws, should be reflected in the number of male and female calves produced.

Bulls used in AI typically produce around 500 straws of semen per ejaculate and many calves may result from each ejaculate. Sex ratios in calves born from a particular ejaculate of a bull can be observed in the calves that are born. The magnitude of differences in sex ratios of calves born, due to the fact that they are from different ejaculates or bulls, can be estimated using calving data.

It is important to note that differences between observed sperm sex ratio and resultant calf sex ratio may be due to chance, maternal influences, environmental influences, combinations of these factors, or other unknown factors. All known and possible influential factors must be considered and accounted for in the design, analysis, and interpretation of research. The idea of maternal, environmental, or other influences on calf sex ratio would seem dubious at first thought, since we know that calf sex is determined by the bull. However, many things can happen between fertilization of an egg and the birth of a live calf and may not affect both sexes equally.

Research does not require that all such factors be known or even that they exist. All that is required is that they be accounted for in designing the research, analyzing data, and interpreting results. An example of such a consideration is the fact that artificial insemination generally results in half siblings or calves that have the same sire but different dams. As a result, potential maternal contributions to variation in the secondary sex ratio cannot be measured or separated out effectively using AI data from dairy calves. This results in reduced ability to detect ejaculated differences. However, in litter-bearing species, such as swine, a number of offspring are produced from a single breeding of a single female. In these animals, the secondary sex ratio can be studied within individual dams, making it possible to account for this source of variation.

The studies described herein were designed to characterize the secondary sex ratios in calves of Holstein bulls used in A. I. programs In addition, secondary sex ratio data from the LSU Swine Breeding Station was used to study possible ejaculate differences in data where maternal influences could be removed.

METHODS AND FINDINGS

Technician breeding receipts were collected at Genex, Inc. (Eastern Artificial Insemination Cooperative) representing 320,367 breeding records which contained identification of the herd, cow, sire, ejaculate number, and breeding date. Breeding records did not include information about whether a calf resulted and, if so, what sex. This information was present in calving data. This calving data is routinely collected by AI cooperatives for the National Association of Animal Breeders for evaluation of dystocia (calving ease) of cows bred to AI bulls. The breeding data were match merged with the calving data to produce a record per calf containing the sire, dam, farm identification, breeding date, birth date, semen collection date and calf sex. Records were then edited and only used if the birth date was within 265 to 295 days after the breeding date. Also, a sires breeding records were included only if the sire had at least two ejaculates and at least five calves per ejaculate. This produced 7,550 calf records identified by sire, ejaculate, herd, and sex. These 7,550 records were from 704 ejaculates within 178 sires across 195 herds.

Statistical analysis of the data showed that sire was not a significant source of variation. However, individual ejaculates within sires did contribute significantly to variation in sex ratios of

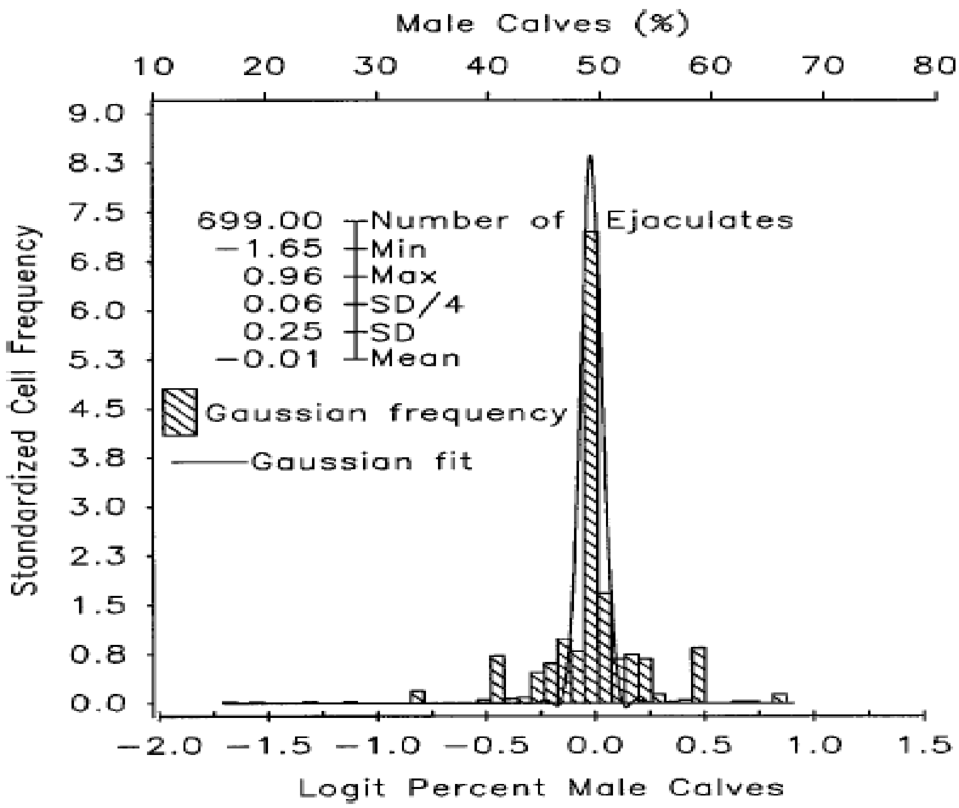

Figure 1. Distribution of ejaculates within Holstein sires per standardized percent male calves class (class interval = std/4)

calves born. The population distribution picture is depicted in Figure 1, with an overall mean percentage of male calves of 49.8%. Figure 2 illustrates the percentage male calves on an ejaculate or collection basis from a grab sample of six bulls included in the analysis. Clearly, there were differences between ejaculates within bulls. Seventeen of the fifty-one (or 33%) collections were beyond the range of the mean ± one standard deviation. Thus, by comparing the interval between collections with the deviation from the overall mean, in general there seems to be a larger difference in % male calves when the interval is 20 to 30 days. If the trend seen in these six bulls is indicative of what happened in the rest of them, then the clue to taking advantage of the natural deviation is to manage the collection schedule to optimize the phenomenon.

The use of artificial insemination in dairy cattle has allowed the AI bull to produce several (sometimes hundreds) of offspring per ejaculate. This simulates reproduction in polytocous (litter bearing) species, in that several offspring result from a single ejaculate in the male. To establish

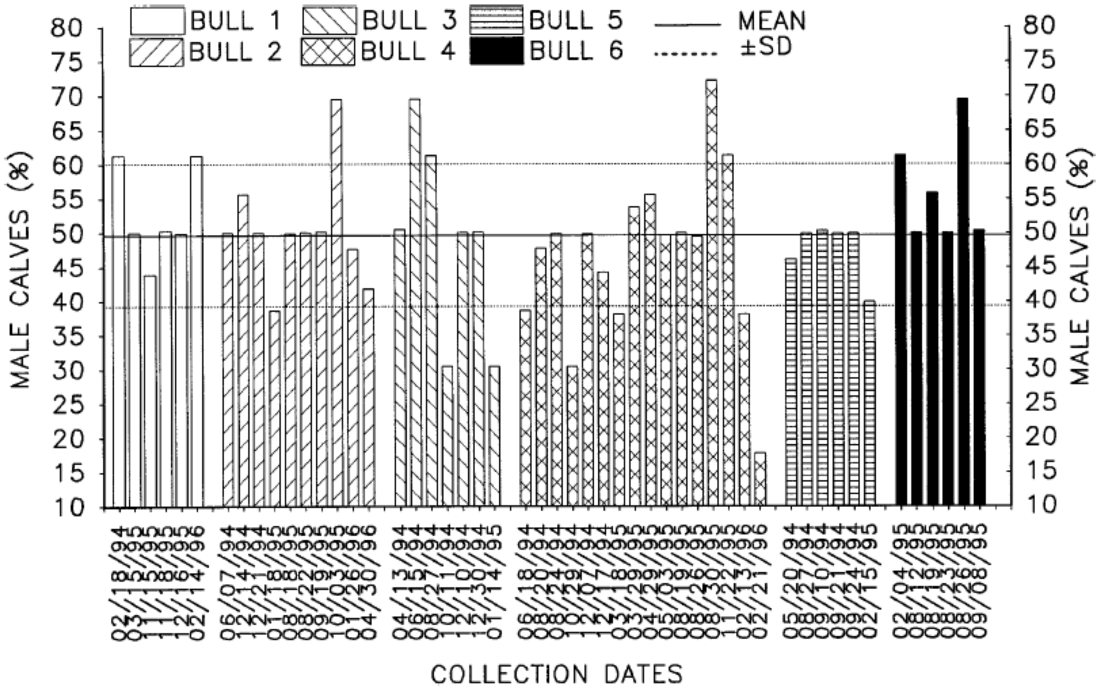

Figure 2. The percentage male calves per ejaculate (collection) for 6 of the bulls used in an AI program.

whether variation in sex ratio between ejaculates occurs in litter bearing animals, we chose to study this phenomenon in the pig, because the breeding schemes are better controlled than those found in other litter bearing species.

Breeding records were obtained from the LSU Agricultural Center Swine Breeding Station and included the total number of pigs born per litter, the sex distribution in the litter, and sire and dam identification. The records covered three years with most sows were farrowed twice yearly. Only records from sires that had produced at least two litters were included and only from litters resulting from a single mating. Records on 1,985 pigs from 127 sows with 196 ejaculates within 24 boars resulted.

Data were analyzed and sex ratio in pigs did not differ between boars. However, the individual ejaculates, or in this case matings, within a boar, did contribute significantly to the variation in sex ratio of pigs born. Both of these findings were consistent with those observed for the calving data indicating that maternal influences on sex ratio may not be a problem, at least in these two species.

Mean percentage of male pigs was 54.6% (Figure 3). The lowest percentage of males per ejaculate was 7.8% and the highest was 94.7%. Although the data represented 196 ejaculates, the distribution was slightly skewed to the left and several classes had lower than expected frequencies. Figure 4 illustrates the variation in percentage male pigs per litter within six of the boars used in this analysis. Remember these litters resulted from a single mating, or one ejaculate. Again there was considerable variation in the percentage of male pigs. Eighteen of the fifty litters represented were beyond the range of the mean ± one standard deviation. Also, far fewer litters approached the theoretical 1:1 ratio. Whether mating frequency impacted the deviation is difficult to discern in this data.

Several researchers have studied variation in secondary sex ratios within polytocous (litter bearing) and monotocous (single offspring) wild species and attributed the variation in ratios to the dam's age and size plus competition for availability of food and space (1, 2, 4, 5). These studies assumed a 1:1 ratio within each ejaculate or breeding and thus at conception. Our previously reported DNA results showed that the sex ratios differed significantly from 1:1 even before conception. It is possible that the sex ratio may be skewed even further by these other sources of variation, potentially resulting in the much wider ranges in secondary sex ratios observed in calving and farrowing data.

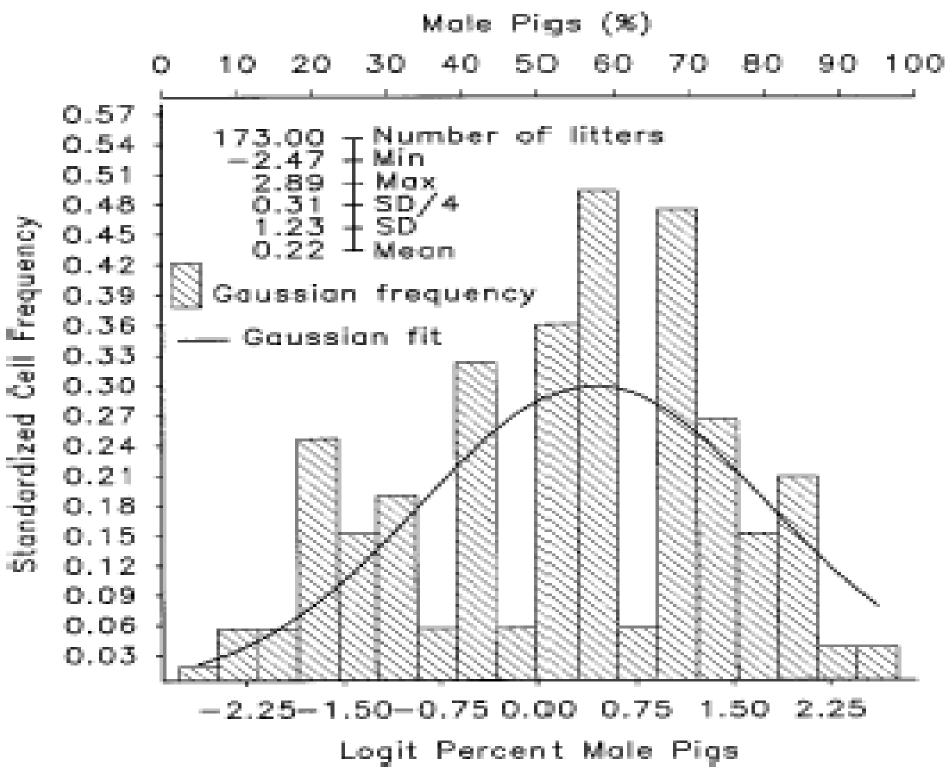

Figure 3. Distribution of litters (ejaculates) within boar per standardized class for the percentage of males (class interval = standard deviation/4).

SUMMARY AND APPLICATIONS

In this study, sex ratio in offspring did not differ between sires, but was different from ejaculate to ejaculate within a sire, for both swine and dairy cattle. These same results had been previously observed in semen providing evidence that the two are related. If variation of this magnitude can be measured accurately, it could have value in production agriculture. If a particular sex was preferred, semen with a sex ratio favoring that sex could be identified and used. On the other hand, if both sexes were desired in equal amounts, current methods may be causing problems. Handling of bull semen is currently designed for tracking and control of inventory and straws from single ejaculates tend to stay together. If straws were grouped randomly according to ejaculate, the producer would be marginally affected by any possible sex ratio discrepancies. Other possible applications are numerous. In addition, this knowledge could lead to a better understanding of fundamental biological processes of sperm production.

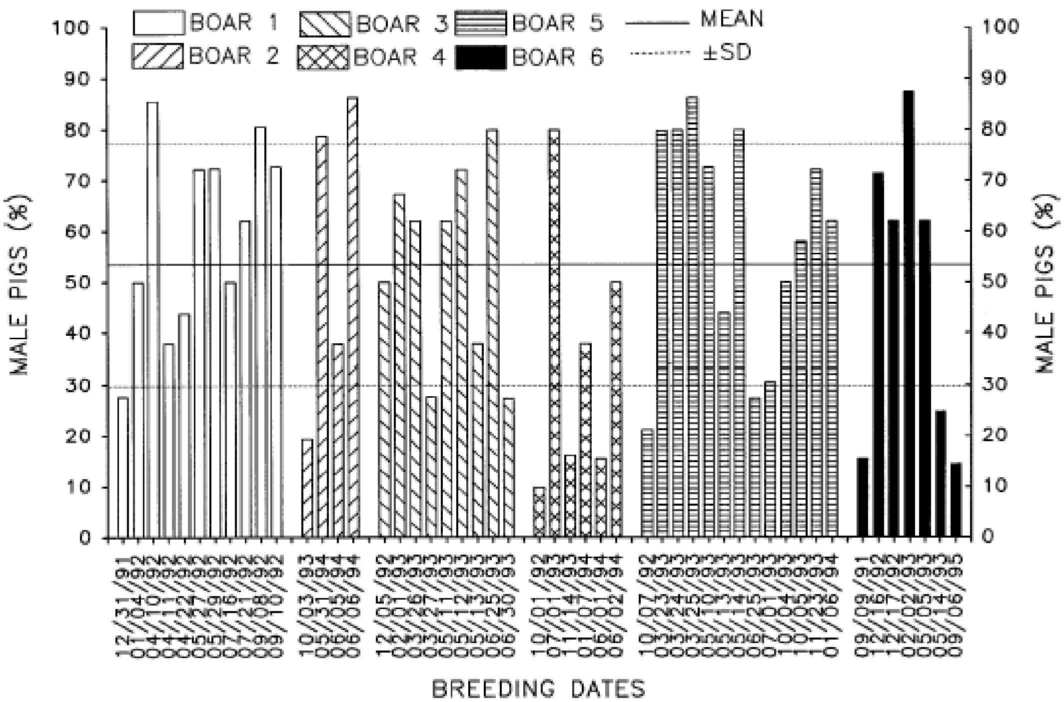

Figure 4. The variation in the percentage of male pigs per litter per boar for six boars used in a controlled mating program.

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