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Please Don't Eat The Flowers!

Is the Booroola Gene Unique?

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Since the discovery of the Booroola gene in a flock of Merino sheep on a remote estate in Australia in the forties and fifties and since the determination that the super prolificacy was associated with the presence of a single gene, many scientists have been on the lookout for a similar gene in other sheep breeds. From the information now emerging from different countries it seems that the gene in the Booroola may not be unique, and that other sheep may have the same gene or other genes with similar effects.

The first step, of course, is to have sheep which produce more multiple births than the ordinary. The next step is to find out if this increased prolificacy fits a mathematical model capable of distinguishing between prolificacy as a result of undetermined number of genes such as is the case in Romanov and Finnsheep or as the result of one major gene such as in the Booroola. French scientists are active in developing such models which enable the detection of major genes. The last step is to find out by experimentation if the gene is transmitted according to the genetic theories.

In the last ten years there have been reports that major genes are present in a variety of breeds all over the world. A breed in Java called Javanese Thin Tailed showed considerable prolificacy. Examination of the records of a flock of these sheep indicated that ewes can be classified according to their ovulation rate and litter size into three groups according to three genotypes as determined by the genotype of their parents, sheep homozygous to a prolificacy gene (FF), sheep heterozygous to that gene (F+) or sheep non-carrier of the gene (++). Table 1 presents the results obtained for first and later records.

Another means of finding out if there is a major gene in a population is to examine the repeatabilities. Repeatability is a term used to calculate the association between repeated measurements on the same animal. For example, if animals have more than one lambing record, say two, a correlation can be calculated between the first and second lambing records. Correlation estimates can vary between +1.0 and −1.0. Estimates close to +1.0 indicate that the animals have a tendency to repeat their performance time after time. For example if they produce single, twins, or triplets the first time, they most probably would produce the same the next time. In populations where a major gene is present, the repeatability estimates tend to be high. In the Javanese flock the repeatability of ovulation rate was 0.55 and in a previous analysis 0.65, much higher than the values of 0.20-0.40 for populations where there is no evidence for the presence of a major gene. As a matter of fact, some theories about the origin of the Booroola sheep suggest that the gene may have come from Javanese sheep.

The second breed in which a major gene for prolificacy exists is the Icelandic sheep and the gene is given the name "Thoka." The story of the Thoka gene is similar to that of the Booroola. Two flocks in Southeast Iceland had sheep which gave an unusually high percentage of triplets. Twelve ewe lambs and three ram lambs were purchased by the Skriduklaustur Experimental Station in 1976 to conduct research on these sheep. The first report published in 1985 confirmed the presence of a single major gene responsible for the increased prolificacy. The researchers presented different results to justify their conclusions. They noted that in the normal Icelandic sheep non-carriers of the gene ovulated on the average 1.59 ova whereas the carriers ovulated 2.14; the difference was highly significant statistically. In another group of ewes born in 1984 and examined for ovulation rate between 1985-1989, gene-carrier ewes ovulated on the average 3.4 compared to 2.2 ova for non-carrier ewes. The repeatability of ovulation rate for carriers averaged 0.69 while for the non-carriers it averaged 0.24. As in the case of prolific breeds resulting from a single gene, identifying the carrier sires with one or two copies of the gene is the greatest challenge. So far, most of the results on the Icelandic sheep with the Thoka gene assume heterozygous animals. The scientists calculated that a copy of the gene may be responsible for an increase of 0.64 lambs per ewe lambing, and the effect is higher on ovulation rate (1.21 ova).

The Cambridge breed developed in Britain showed evidence that a major gene was present. However, unlike the other breeds, the exact origin of that gene cannot be determined with certainty. The breed originated by collecting in one place ewes with exceptionally high prolificacy from sheep breeders anywhere in Britain regardless of the breed. Thus, there were eleven breeds represented in this population. These ewes were all bred to Finnsheep rams, and some of the male progeny were used to breed the original ewes, thus reducing the proportion of Finnsheep ancestry to less than 20%. The flock was closed and selected for increased prolificacy and litter weight. Cambridge sheep may be the highest ovulating sheep that exist now. Up to 13 ovulations were counted in some ewes. Because ovulation is so high, ewes ovulating up to 3 are considered non-carriers, those with one copy of the gene ovulate between 4 and 6 while those with two copies ovulate between 7 and 12. Average ovulation rate for the three groups was 2.5, 4.7 and 8.5 for ewes one year old and 2.4, 4.4 and 7.1 for ewes two years old, respectively. Lambs born per ewe average 1.6 for one-year-old and 2.8-3.0 lambs for 3- and 4-year-old ewes. As with the other breeds, repeatability of ovulation rate is very high in the Cambridge breed (0.51 for lambs and 0.87 for older ewes).

The Olkuska sheep of Poland may be the latest addition to the breeds with expected presence of a major gene for prolificacy. These sheep originated from crossing local long-wool Polish sheep with Pomeranian sheep in the thirties. The Olkuska sheep are prolific with fecundity of over 190 lambs per 100 ewes. Triplets and quadruplets are frequent and larger litters of 5 and 6 are not rare. A ewe was reported to have given 31 lambs in 9 lambings. The study conducted to test the presence of a major gene involved a first and a backcross of Olkuska with non-prolific Polish sheep and a population of these sheep as a control. The results on ovulation rate and litter size indicated that suspected carriers of the prolificacy gene had 1.04 more ovulations and 0.60 more lambs than the non-carriers. These esti-

	FF		F+		++	
	first	later	first	later	first	later
Ovulation rate	2.52	2.92	2.02	2.19	1.24	1.27
Litter size	2.37	2.83	1.89	2.11	1.23	1.30

mates are remarkably close to those found for other breeds with confirmed presence of a major gene. The size of the data and duration of the testing are rather small to give a definite conclusion, but there is a great possibility that the Olkuska breed would be shortly included on the list of breeds with a major gene.

Until now, in all the breeds in which a major gene was identified, the inheritance of the gene followed the basic Mendelian theories suggesting that this or these genes (depending if it is the same or different genes), are found on the autosomal chromosomes. There is now some evidence from New Zealand that certain animals of the Romney breed may have a major gene for prolificacy located on the sex chromosome (X). This implies that the transmission of this gene follows the rules of sex-linked inheritance. If this gene is actually on the X chromosome as the pedigree analysis suggested, that would mean a breakthrough, since males would be either carriers when they have the gene or non-carriers when they don't, and the problem of identifying the genotype of the male would be solved.

Is the gene for prolificacy found only in sheep? Probably not; the author was contacted in the early seventies by an Ayrshire cattle breeder who claimed that he had a cow which almost always gave him twins and that her daughters were doing the same thing. We got the cow and two of her daughters at the experimental station and followed their performance over many years. It was true, the cows almost always gave twins and if my memory is good, I think one of the daughters gave triplets. Then, the possibility of one gene theory was completely unthinkable, and the fact that twins in dairy cattle is not a desirable trait if the calves were of different sexes (FreeMartin Syndrome) cooled our enthusiasm about the whole affair, and we let the cows disappear gradually. If the prolificacy in these cows was in fact the result of a major gene, then we surely missed a golden opportunity that nature gave us to improve productivity in beef cattle. We could have crossed and developed beef cattle breeds with high prolificacy. So breeders of every type of livestock should keep their eyes open to animals with extraordinary potential because these animals could be carrying a gift from nature which could serve mankind.

Hard work is often the easy work you did not do at the proper tme.