Genet. Res., Camb. (1976), **28**, 277–280
Printed in Great Britain

The combinations of the sexes in twin lambings

BY WILLIAM H. JAMES

The Galton Laboratory, University College London, Wolfson House, 4 Stephenson Way, London NW1 2HE

(*Received* 10 *June* 1976)

SUMMARY

Evidence is presented that the distribution of the combinations of the sexes in twin lambings has subnormal dispersion: there are more opposite-sexed pairs than same-sexed pairs. When adjustment is made for the occasional presence of monozygotic twin pairs, the departure from expectation (on the assumption that the sexes of DZ twins are distributed binomially) is highly significant. Thus sheep litters seem to show a feature characteristic of litters of pigs and (probably) mice and rabbits. This is consistent with the suggestion that p, the probability of a male zygote, varies systematically from one zygote to another within a litter.

1. INTRODUCTION

In a previous paper (James, 1975) I considered the distributions of the combinations of the sexes in the litters of some mammals. I concluded that in one species (the pig) there is good evidence, and in two other species (the mouse and the rabbit) there is fair evidence that these distributions have subnormal dispersion. For instance, consider litters of exactly size 8: as contrasted with binomial expectation, there are too many with exactly 4 males and 4 females, and too few unisexual litters.

In the present note I want to consider the evidence relating to twin lambings.

2. MATERIAL

All the volumes of the Science Citation Index were combed for references to Rae (1956), Rowson & Moor (1964), Barton (1949) and Stansfield (1968) – papers which I knew referred to the topic. I then combed the Index for citations of these references – and so on until all the references had been extracted. Table 1 gives the data thus obtained.

3. RESULTS

These data may be analysed in a number of ways. In the first place, the dispersion of nine of the ten samples is subnormal. The probability that this would occur by chance (on the null hypothesis that all are drawn from binomial distributions) is 0·02. It might be objected that (since some of these samples are so small) chance must have played rather a large part in this result. However, there seems no reason why the data should not be pooled. Using Robertson's (1951) test as described in my earlier paper (James, 1975), the pooled data (omitting Morley's data because they were not presented in sufficient detail) give a z-score of $-2{\cdot}25$, $P < 0{\cdot}025$. It is clear too that if Morley's data were included, they would strengthen this result.

The reader is referred to my earlier note (James, 1975) for detailed interpretation of such a result: it seems that the distributions of the combinations of the sexes in litters of sheep (like those of pigs, mice and rabbits) are subnormal, in spite of a tendency to supernormality which would be expected from the occasional presence of MZ twins. The latter point will now be discussed.

Table 1. *Combinations of the sexes in twin lambings*

Source	♂♂	♀♀	♂♂ + ♀♀	♂♀
Johansson & Hansson (1943)	5885	6191	12076	12359
Stansfield (1968)	50	61	111	142
Barton (1949)	164	173	337	340
Chapman & Lush (1932)	87	90	177	184
Clark (1932)	129	121	250	273
Laplaud & Garnier (1924)	17	16	33	37
Morley (1948)	—	—	1051	1100
Bell	38	34	72	67
Bernardin	87	83	170	187
Henning (1939)	135	134	269	274

(i) *The incidence of MZ twinning in sheep*

The grounds for supposing that MZ twin lambs exist are that observations have been made of

(*a*) same-sexed twins with a single corpus luteum (Henning, 1937) or a common chorion (Cohrs, 1943),

(*b*) blastodermic vesicles with two germinal areas (Assheton, 1898; Rowson & Moor, 1964),

(*c*) conceptuses with double embryos (Rowson & Moor, 1964), and

(*d*) conjoined lamb twins (Anon, 1946; Bru, 1944; Cole & Craft, 1945; Dennis, 1972).

How often, then, does MZ twinning occur in sheep? If, as suggested above, the distribution of the sexes in DZ twin lambings is not binomial, it would be invalid to use Weinberg's Differential Rule for purposes of estimation. Accordingly, there seem to be three methods of estimation: (i) by blood-typing, (ii) by direct examination of large samples of conceptuses, and (iii) by searches for corpora lutea.

(i) Stansfield (1968) noted that among 253 twin pairs, 8 same-sexed pairs had identical blood groups. (It would have been interesting to know the number of opposite-sexed pairs with concordant bloods.) Twenty-seven blood-typing reagents were used, so the probability that each of these eight pairs was MZ would seem to be high. However, it is not easy to derive a minimum estimate of the MZ twinning rate from such data.

(ii) Rowson & Moor (1964) examined a series of 200 blastocysts removed at 7–9 days of pregnancy. Two of them were found to contain double embryonic discs. Rowson & Moor also examined 250 conceptuses removed at 12–14 days of pregnancy, and found that two contained double embryos on a single tube-like trophoblast.

(iii) Henning (1937) examined 675 sheep foetuses and found among them one pair of twins whose dam had an ovary with only one corpus luteum, indicating the MZ origin of her twins.

So, pooling the data of Rowson & Moor (1964) and of Henning (1937), it seems that we might estimate the incidence of MZ twinning in lambings at 5/1125. To get a lower 95 % confidence limit of this estimate, we might assume MZ twinning to be a Poisson variable. Pearson & Hartley (1954, table 40) give the confidence limits for the expectation of a Poisson variable: the lower 95 % limit for an observed value of 5 is 1·62. So the estimated lower confidence limit of the probability is 1·62/1125 = 0·00144. These estimated incidence rates are consistent with the suggestion (Bulmer, 1970, p. 8) that MZ rates in other mammals may be rather similar to those in man (namely about 3–4 per 1000 maternities).

(ii) *The variance of the distribution of the combinations of the sexes when adjustment is made for the presence of MZ twins*

Let us consider the variance of Johansson & Hansson's data if we accept this value of 0·00144. The rates of multiple births in lambings vary greatly with the breed of sheep. In the Swedish breeds (to which the data of Johansson & Hansson relate) these rates are high. These authors estimate that in these breeds the percentage of multiple births (almost all of which are twins) is 47·45. So among 474·5 multiple births there are expected to be 1·44 MZ twin pairs. In other words, among Johansson & Hanson's sample of twin lambs, one would expect $2 \times 1{\cdot}44 \times 100/474{\cdot}5 = 0{\cdot}6069$ % were drawn from MZ pairs. Using the argument of Fisher (1958, p. 68) one would calculate accordingly that the 'expected' variance would be the binomial variance increased by 0·6069 %. Now the binomial variance, nqp, is 0·499922. And this, raised by 0·6069 % is 0·502956. The observed variance is 0·494072. Fisher (1958, p. 67) gives the standard error of such an estimate of variance as

$$\sqrt{\frac{2(nqp)^2}{N-1}+\frac{npq(1-6pq)}{N}}.$$

These values yield a normalized deviate of 2·78, $P \simeq 0{\cdot}005$.

4. DISCUSSION

So when even a minimum estimate of MZ twinning is assumed, the variance of the distribution of the combinations of the sexes of twin lambs is significantly lower than expectation.

For discussion of possible causes of such dispersion, the reader is referred to an earlier paper (James, 1975). It was there noted that it is consistent with the hypothesis that the sex of a zygote is associated with the time within the female cycle that it is formed. Evidence for that hypothesis has been summarized (James, 1976).

I am grateful to Dr A. R. Jonckheere (University College London) for help and encouragement.

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