# OVULATION RATE AS A SELECTION CRITERION FOR FECUNDITY IN SHEEP

## Le rythme d'ovulation comme critère de sélection pour la fecondité chez les brebis

## El ritmo de ovulación como criterio de selección para la fecundidad en las ovejas

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The most important factor affecting the efficiency of meat production by sheep populations is the reproductive rate. This is so because the litter size (fecundity) of the most important meat producing breeds is well below 2.0. There is, therefore, considerable interest in methods of achieving genetic improvement in litter size. While recently many investigations have been initiated into the use of highly prolific breeds (e. g. Finnish Landrace) as a source of genetic material for the improvement of fertility there is still a role for prolific strains of native breeds if they can be developed.

With the development of the technique of laproscopy in sheep (ROBERTS, 1968) it is possible to select for ovulation rate based on a number of measures on each ewe in the one breeding season. This can be done without any adverse effects on the ewe. This technique combined with mild superovulation to ensure rapid generation turnover opens up the prospect of substantial increases in ovulation rate and, hence, litter size, within 10 years. This paper examines the relationship between ovulation rate and litter size and the genetic advantage expected in ovulation rate under various selection schemes.

Genetic variation in litter size may be expected to come from two sources:

1) Ovulation rate.
2) Uterine capacity (includes embryo survival).

Therefore, the correlated response in litter size following selection for ovulation rate can be predicted if the appropriate parameters have been estimated. No estimates are available for ovulation rate or uterine capacity. However, information available from a successful selection experiment for litter size (TURNER, 1968;

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TABLE 1

OVULATION RATE AND LITTER SIZE TO FIRST SERVICE IN GALWAY, FINN AND FINGALWAY EWES *

| Breed | Ovulation rate ($a$) | Litter size ($b$) | Ratio ($b/a$) |
|---|---|---|---|
| Galway | 1.57 ± 0.08 | 1.35 ± 0.12 | 0.86 |
| Fingalway | 2.53 ± 0.11 | 1.83 ± 0.25 | 0.72 |
| Finn | 4.19 ± 0.24 | 2.44 ± 0.31 | 0.58 |

* There were 42, 30 and 41 ewes of the Galway, Fingalway and Finn breeds, respectively.

BINDON et al., 1971; TROUNSON and MOORE, 1972) and from interbreed egg-transfer experiments (LAWSON and ROWSON, 1973; BRADFORD *et al.*, 1974) allows reasonable prediction of the correlated response in litter size to selection for increased ovulation rate. Thus, the response to divergent selection for litter size in Merinos (TURNER, 1968) has been achieved by increased ovulation rate with little or no change in uterine capacity. Similarly, differences between breeds varying from 1.1 to 3.0 in litter size can be attributed mainly to differences in ovulation rate. This is shown by the results of transferring 3 or more eggs to recipient ewes belonging to breeds in this range of littler sizes. However, the results of interbreed egg-transfer experiments have shown a fairly consistent tendency for uterine capacity to increase slightly with natural ovulation rate. It is also clear that as ovulation rate increases embryo survival declines (TROUNSON and MOORE, 1973); LAWSON and ROWSON, 1972). Data presented in Table 1 are in agreement with these findings. Ovulation rate was measured on mature Galway, Finnish Landrace and Fingalway ewes in 1973. The litter size produced to first service by these ewes in the previous three lamb crops was also known. The ratio of average litter size to average ovulation rate declines substantially as ovulation rate increases. It would appear from the comparison of Fingalway and Galway ewes that only 50 percent of the difference in ovulation rate is reflected in litter size at birth. However, it may not be correct to apply a value of 50 percent in evaluating expected change in litter size following selection for ovulation rate since the relationship between litter size and ovulation rate is unlikely to be linear over the range 1.5-2.5. An egg-transfer experiment initiated in 1973 and involving these three breeds as recipients will provide more critical estimates of embryo survival and uterine capacity.

## SELECTION FOR OVULATION RATE

### *Assumptions*

The expected response to selection for increased ovulation rate in the Galway breed has been evaluated. Two basic strategies have been considered:

TABLE 2

EXPECTED PROBABILITY DISTRIBUTION OF AVERAGE OVULATION RATE ($\bar{X}$) FOR VARYING VALUES OF REPEATABILITY AND THEREE AND FOUR OBSERVATIONS PER EWE

| $\bar{X}$ | Repeatability | | | |
|---|---|---|---|---|
| | 0.00 | 0.10 | 0.15 | 0.20 |
| | | 3 records / ewe | | |
| 1.00 | 0.22 | 0.26 | 0.28 | 0.30 |
| 1.33 | 0.43 | 0.38 | 0.35 | 0.33 |
| 1.67 | 0.29 | 0.27 | 0.26 | 0.25 |
| 2.00 | 0.06 | 0.09 | 0.11 | 0.12 |
| | | 4 records / ewe | | |
| 1.00 | 0.13 | 0.18 | 0.21 | 0.23 |
| 1.25 | 0.35 | 0.30 | 0.29 | 0.27 |
| 1.50 | 0.35 | 0.29 | 0.26 | 0.24 |
| 1.75 | 0.15 | 0.17 | 0.17 | 0.17 |
| 2.00 | 0.02 | 0.05 | 0.07 | 0.08 |

1) Selection based on the average of three records of an individuals ovulation rate.

2) Selection based on the average of four records of an individuals ovulation rate.

Ovulation rates were measured on 1 ½ year old ewes only with selected ewes maintained in the flock for the number of lamb crops dictated by the selection intensity. All fertile matings were preceded by mild superovulation so that a weaning percentage of 200 could be achieved. Rams were selected from among the progeny of the best 1 ½ year old ewes and were used as ram lambs only. Both selection schemes were initiated by acquiring the appropriate number of 1 ½ year old ewes from the population at large until such time as a sufficient number of home produced ewes were available for testing. Selected ewes produced three and four lamb crops for strategies «1» and «2» respectively.

*Distribution of average ovulation rate*

Average ovulation rate is a discrete variable and hence there is limited freedom in the choice of selection intensity. The appropriate probability distribution depends on repeatability, average ovulation rate and the number of scores making up the average. Table 2 gives the predicted probability distribution for average ovulation

TABLE 3

EXPECTED TOTAL GENETIC GAIN IN OVULATION RATE FOLLOWING SELECTION BASED ON THE AVERAGE OF THREE OR FOUR RECORDS

| Heritability | Repeatability | | | |
|---|---|---|---|---|
| | 0.10 | 0.15 | 0.20 | 0.25 |
| | | 3 records / ewe | | |
| 0.10 | 0.22 | 0.21 | 0.20 | 0.20 |
| 0.15 | | 0.32 | 0.30 | 0.29 |
| 0.20 | | | 0.41 | 0.39 |
| 0.25 | | | | 0.49 |
| | | 4 records / ewe | | |
| 0.10 | 0.29 | 0.27 | 0.26 | 0.25 |
| 0.15 | | 0.41 | 0.39 | 0.38 |
| 0.20 | | | 0.52 | 0.50 |
| 0.25 | | | | 0.63 |

rate based on 3 and 4 measurements and for varying levels of repeatability. These distributions have been derived using the regression of next performance on the average of previous records. It was assumed that only single and twin ovulations occur, that the covariance among all pairs of records was the same and that mean ovulation rate did not change. It is obvious from an examination of Table 2 that only certain selection intensities are feasible for rams and ewes. Thus, if ewe selection is based on the average of three records the selection intensity will be approximately 36 percent. In the same case rams are selected from the progeny of the top 10 percent of ewes. Similarly, if selection is based on the average of four records the only intensity greater than 50 percent for ewe selection is to select the top 25 percent, approximately. The intensity of ram-dam selection will be of the order of 7-8 percent. Consequently, the generation interval will be 2.5 years as against 2.0 years if selection is based on the average of three records.

*Results*

The expected response to selection after 10 years is shown in Table 3. Varying values of heritability and repeatability have been used. The range of values used is based on an estimate of 0.11 ($d.f. = 67$) for the repeatability of ovulation rate in Galway sheep. The repeatability of litter size in this breed is approximately 0.10 (unpublished data). The values in the table show that selection based on four records per ewe yields a higher expected response after 10 years despite the

increased generation interval. Examination of the values in the table indicates that response may reasonably be expected to equal 0.4 egg per ewe. If, at this level of avulation rate egg survival is reduced to 80 percent then the response in litter size would be expected to equal 0.24. If, however no decline in embryo survival occurs the response would equal 0.34.

Comparable selection schemes based on litter size could be expected to achieve similar genetic gain per generation after the steady state had been reached. However, the generation interval would be 3.5 years at least. Hence, genetic gain per year would be in the region of 50 percent that possible for ovulation rate. In addition it is likely that the heritability of ovulation rate will be higher than the heritability of litter size. It is concluded that selection for fertility should be based on average ovulation rate.


## RESUME

On a fait une étude du taux d'ovulation et capacité utérine chez la brebis. On en a conclu qu'une sélection réussie en vue de l'ovulation devrait résulter en une réponse presque égale quant à la taille de la portée, particulièrement chez les races à basse fertilité. On propose que la critère de sélection soit la moyenne de 3 ou 4 résultats de taux d'ovulation relevés au cours d'une même saison de reproduction. Le taux d'ovulation peut être rapidement mesuré à l'aide d'un laprascope. Les distributions de probabilité que l'on peut attendre pour la moyenne de 3 ou 4 résultats dérivent d'une gamme de valeurs de répétition. Les retours à la sélection que l'on peut attendre s'avèrent être de l'ordre de 0,5 oeuf par brebis après 10 ans. On s'attend à ce que cela résulte en une réponse correspondant d'entre 0,32 et 0,43 agneaux par brebis.

## RESUMEN

Un examen se ha llevado a cabo de los folletos sobre proporción de ovulación y capacidad uterina en corderos. Se saca la consecuencia de que la selección con éxito para la ovulación debería resultar en casi la misma reacción en el número de corderos por parto, especialmente en razas de poca fertilidad. Se ha propuesto que el criterio de selección debería ser el promedio de tres o cuatro promedios de ovulación, tomada en una temporada de cría. La proporción de ovulación puede ser medida rápidamente usando un laparoscopio. La probabilidad esperada con distribuciones para el término medio de tres o cuatro procesos de ovulación es derivada de una clase de valores de repetibilidad. Las respuestas esperadas frente a la selección están confirmadas en alrededor de 0,5 huevo por oveja después de diez años. Ello se espera que conduzca a una respuesta entre 0,32 y 0,43 corderos por oveja.


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