IDRC
CRDI
CIID

CANADA

SMALL RUMINANTS RESEARCH AND DEVELOPMENT IN THE NEAR EAST

PROCEEDINGS OF A WORKSHOP

HELD IN CAIRO, EGYPT,

2–4 NOVEMBER 1988

The International Development Research Centre is a public corporation created by the Parliament of Canada in 1970 to support research designed to adapt science and technology to the needs of developing countries. The Centre's activity is concentrated in six sectors: agriculture, food and nutrition sciences; health sciences; information sciences; social sciences; earth and engineering sciences; and communications. IDRC is financed solely by the Parliament of Canada; its policies, however, are set by an international Board of Governors. The Centre's headquarters are in Ottawa, Canada. Regional offices are located in Africa, Asia, Latin America, and the Middle East.

Le Centre de recherches pour le développement international, société publique créée en 1970 par une loi du Parlement canadien, a pour mission d'appuyer des recherches visant à adapter la science et la technologie aux besoins des pays en développement; il concentre son activité dans six secteurs : agriculture, alimentation et nutrition; information; santé; sciences sociales; sciences de la terre et du génie et communications. Le CRDI est financé entièrement par le Parlement canadien, mais c'est un Conseil des gouverneurs international qui en détermine l'orientation et les politiques. Établi à Ottawa (Canada), il a des bureaux régionaux en Afrique, en Asie, en Amérique latine et au Moyen-Orient.

El Centro Internacional de Investigaciones para el Desarrollo es una corporación pública creada en 1970 por el Parlamento de Canadá con el objeto de apoyar la investigación destinada a adaptar la ciencia y la tecnología a las necesidades de los países en desarrollo. Su actividad se concentra en seis sectores: ciencias agrícolas, alimentos y nutrición; ciencias de la salud; ciencias de la información; ciencias sociales; ciencias de la tierra e ingeniería; y comunicaciones. El Centro es financiado exclusivamente por el Parlamento de Canadá; sin embargo, sus políticas son trazadas por un Consejo de Gobernadores de carácter internacional. La sede del Centro está en Ottawa, Canadá, y sus oficinas regionales en América Latina, Africa, Asia y el Medio Oriente.

This series includes meeting documents, internal reports, and preliminary technical documents that may later form the basis of a formal publication. A Manuscript Report is given a small distribution to a highly specialized audience.

La présente série est réservée aux documents issus de colloques, aux rapports internes et aux documents techniques susceptibles d'être publiés plus tard dans une série de publications plus soignées. D'un tirage restreint, le rapport manuscrit est destiné à un public très spécialisé.

Esta serie incluye ponencias de reuniones, informes internos y documentos técnicos que pueden posteriormente conformar la base de una publicación formal. El informe recibe distribución limitada entre una audiencia altamente especializada.

IDRC-MR237e
April 1990

SMALL RUMINANTS RESEARCH AND DEVELOPMENT IN THE NEAR EAST

**Proceedings of a workshop
held in Cairo, Egypt, 2-4 November 1988**

Editor: A.M. Aboul-Naga

SPONSORING ORGANIZATIONS

* **Ministry of Agriculture** (MOA), Egypt.

* **International Development Research Centre** (IDRC), Canada.

* In cooperation with:

  - **FAO**, Near East Regional Office

  - **European Association of Animal Production** (EAAP)

  - **International Centre for Advanced Mediterranean Agronomic Studies** (ICAMAS)

ORGANIZING AND SCIENTIFIC COMMITTEE

A.M. Aboul-Naga,	Animal Production Research Institute (APRI), MOA, Egypt.
E.S.E. Galal,	Ain Shams, University, Egypt.
M.B. Aboul-Ela,	Mansoura University, Egypt.
Ferial Hassan,	APRI, MOA, Egypt.
M. El-Serafy,	Ain Shams, University, Egypt.
Eglal Rashed,	IDRC, Cairo.

CONTENTS

SELECTION FOR IMPROVED REPRODUCTIVE PERFORMANCE OF NATIVE SHEEP

J. P. HANRAHAN

The Agricultural Institute, Belclare, Tuam, Co. Galway, Ireland

ABSTRACT

The annual reproductive rate is determined by prolificacy and the frequency of lambing. Information on the extent of genetic variation in these traits is briefly summarized. Results of selection for increased litter size in the native Galway breed show that the response is attributable to changes in ovulation rate. The merits of starting selection lines by screening large populations are briefly reviewed and results from such a selection study are presented. These again confirm the central contribution of ovulation rate. Selection for extreme reproductive performance in a foreign breed may facilitate the use of such genetic sources for the improvement of native populations with minimum impact on adaptedness. Results from selection for high ovulation rate in Finn sheep are considered from this view point. Selection for litter size or ovulation rate has significant effects on components of the breeding season but these are not consistent among breeds.

INTRODUCTION

The annual reproductive rate of sheep is a major determinant of production efficiency. The principal sources of variation in the rate of reproduction are prolificacy and frequency of lambing. The former trait has been the subject of a large number of studies under many different production conditions and it is clear that there is a wealth of genetic variation both within and among populations (Hanrahan, 1982). In the case of frequency of lambing the amount of information on genetic variation within populations is rather limited. Studies of breed differences in length of the breeding season, and hence the possibility of frequent breeding, have shown that considerable differences exist among breeds developed and maintained in temperate latitudes (Hanrahan and Quirke, 1986). It is well known that breeds native to tropical and subtropical regions do not exhibit a distinct anoestrus season although the incidence of oestrus is usually depressed in Spring (Aboul-Naga, 1985; Aboul-Naga, Aboul-Ela and Mansour, 1987).

The large differences among breeds in prolificacy have led to widespread investigation of the use of prolific breeds as a source of genetic material to raise the reproductive rate of native breeds by increasing prolificacy. In recent years the discovery of the Booroola gene, which dramatically increases litter size (Piper and Bindon, 1982), has led to a new phase of research related to increasing reproductive rate by introducing this gene into populations with low prolificacy levels. The exploitation of this type of genetic material for increasing the reproductive rate of native populations has the advantage that the desirable characteristics of adapted native breeds can be preserved when such major genes are incorporated by a system of repeated backcrossing to the native population combined with selection for the gene in question. Such a backcrossing programme will involve a considerable period of time depending on the desired level of native breed ancestry and methods available for determining the genotype of individual animals. Evidence for the existence of genes with large effects on reproductive rate in other sheep populations, such as Icelandic sheep (Jonmundsson and Adalsteinsson, 1985), the Cambridge breed (Hanrahan and Owen, 1985), Indonesian sheep (Bradford et al., 1986) and possibly the D'Man breed in Morocco (Lahlou Kassi and Marie, 1985) suggests that by using the most appropriate breed as a source for a major gene the amount of backcrossing required to maintain other traits at the desired level can be reduced. This would minimize the time and effort involved in exploiting such genetic variation. However, one difficulty with such genetic effects would remain, namely, the fact that the effects of these genes are so large that the increased reproductive rate would be such that prevailing production systems may be inadequate to ensure real production benefits. This would be especially true for homozygous individuals and consequently, accurate information would be required on the genotype of individual animals, especially males, for effective exploitation of such genes in many situations. In the absence of biochemical criteria for determining individual genotypes this will require progeny testing of males which may be difficult to organize in many circumstances. Consequently, increasing prolificacy by within population selection may be the only realistic approach in some cases.

Consideration of the problem of increasing the frequency of lambing raises the same questions as those connected with approaches to increasing prolificacy. Information on available genetic variation is however much more limited.

While large breed differences exist the expression of these differences is likely to be much more dependent on environment, especially latitude, than is the case for prolificacy. While single gene effects on length of the breeding season have been found (Drymundsson and Adalsteinsson, 1980) they appear to be much less dramatic than in the case of prolificacy.

In the present paper results of selection for increased prolificacy in Irish sheep are reviewed together with results on the exploitation of the large amount of genetic variation for ovulation rate in Finn sheep to provide an exceptionally high ovulation rate line of Finn sheep. Such a line could be used to provide a genetic lift in the reproductive rate of target populations with a smaller fraction of Finn ancestry than was possible heretofore.

SELECTION FOR INCREASED PROLIFICACY IN GALWAY SHEEP

The Galway is a native Irish breed with a modest level of prolificacy and a clearly defined breeding season (Hanrahan and Quirke, 1985, Quirke et al., 1986). Selection for increased litter size was initiated in 1963 and a control line was also maintained. The details of the selection programme and the observed responses were reported by Hanrahan (1984). The main features of the responses observed are summarized in Table 1. These show a significant response in litter size which is attributable to a correlated change in ovulation rate. An estimate of the annual rate of improvement in litter size was 0.023±0.009 (Hanrahan, 1984) which is equivalent to 1.5% of the control line mean. Mean ovulation rate in 1985 and 1986 together with the resulting litter size is summarized in Table 2. The data on 4- and 5-year old ewes in this table refer to a random sample of 1982 born ewes. The effect of selection on ovulation rate and litter size for 2-year old ewes is consistent with the earlier results (Table 1). However, the agreement between results for mature ewes is not quite as good. The evidence suggests that the divergence between the lines for litter size is reduced at older ages and based on the results in Table 2 this is attributable to a reduced divergence in ovulation rate. However, this interpretation is not supported by the earlier results (Table 1). Further evidence needs to be acquired on this point.

The results in Table 2 were averaged over years and the observed and expected litter sizes were compared using the expression given by Hanrahan (1982). The results of these calculations are presented in Table 3. The agreement between observed and predicted mean litter size is quite good indicating that the response to selection for increased litter size is attributable to changes in ovulation rate. This is consistent with the conclusion that variation in embryo survival is a minor source of genetic variation in litter size in sheep (Hanrahan and Quirke, 1986).

TABLE 1

Response to selection for increased litter size in Galway sheep*

Ewe age	Line	Fertility (%)	Litter size	Ovulation rate
2	Control	78	1.21	1.34
	Selection	81	1.47	1.62
3	Control	90	1.44	1.39
	Selection	91	1.70	1.65
4	Control	79	1.61	1.56
	Selection	95	1.71	1.99

* Adapted from Hanrahan (1984).

TABLE 2

Ovulation rate and litter size in Galway sheep.

Ewe age	Year	Line	Ovulation rate	Litter size
2	1985/86	Control	1.62±0.11	1.40±0.11
		Selection	1.94±0.10	1.65±0.08
2	1986/87	Control	1.55±0.14	1.37±0.11
		Selection	1.94±0.07	1.73±0.09
4	1985/86	Control	2.00±0.09	1.71±0.16
		Selection	2.13±0.13	1.77±0.13
5	1986/87	Control	1.78±0.19	1.62±0.14
		Selection	1.95±0.09	1.74±0.10

TABLE 3

Comparison of observed and predicted litter size for Galway ewes.

Ewe age	Line	Ovulation rate	Litter size Observed	Litter size Predicted *
2	Control	1.58	1.38	1.42
	Selection	1.94	1.69	1.66
4*	Control	1.89	1.66	1.63
	Selection	2.04	1.75	1.72

* Using the equation of Hanrahan (1982).

INCREASING PROLIFICACY BY SCREENING COMMERCIAL FLOCKS

The response to selection is the product of selection differential and heritability which together with the generation interval determine the annual rate of genetic improvement. Usually increasing the selection differential will automatically extend the generation interval unless reproductive rate per selected individual is increased as, for example, in systems based on superovulation of selected females followed by collection of embryos and their transfer to recipient females (Hanrahan and Quirke 1982). The potential for such MOET schemes in sheep have been examined by Smith (1986). Another situation which allows a substantial increase in selection differential without any consequences for generation interval is the initiation of selection programmes by applying extreme selection in a sufficiently large population to provide adequate foundation animals. Continued selection among the progeny of these foundation stock will of course be subject to the usual constraints connecting selection intensity and generation interval. The obvious benefits of such intensive screening is that an immediate significant genetic improvement should be obtained. A further benefit is that the likelihood of favorable genes at low frequencies contributing to response to further selection is enhanced because the frequency of such genes in the foundation group will be increased. A final point is that for traits such as litter size, which have a discrete distribution, the selection pressure which can be applied depends upon the relative frequency of the different levels of the trait (e.g. singles or twins). Screening of foundation animals will increase the mean of their progeny and in breeds of low prolificacy this increase can substantially increase the possible rate of further progress - especially in the initial generations.

Selection for increased litter size was initiated in Ireland in 1963 by using the screening approach. The criteria for choosing foundation animals were: (a) any ewe which gave birth to four or more lambs in any year, (b) a ewe which gave birth to nine or more lambs over three consecutive lambings, (c) foundation rams were from ewes which would qualify under (a) or (b). Details on the foundation animals and other aspects of this study have been given by Hanrahan (1984). After the assembly of foundation animals the flock was closed and selection was continued, based on litter size. However, some ewes were crossed with Finnish Landrace rams and not all of the resulting progeny were culled so that some Finn ancestry was incorporated (5.3%, Hanrahan, 1984). No breed restrictions were imposed on the foundation stock so that the initial selection pressure operated on genetic differences among and within breeds and crossbreeds. Unfortunately there was no attempt to form a control flock to facilitate the estimation of genetic improvement but based on various lines of circumstantial evidence genetic improvement of litter size was achieved (Hanrahan, 1984). Thus, information on the reproductive performance in lowland sheep flocks in Ireland about the time when the foundation animals were born indicates a litter size of 1.5 to 1.6 at most. Even allowing for breed differences in prolificacy it seems unrealistic to assume that the average litter size of unselected foundation ewes of the same average composition as the selected individuals could have been higher than 1.7. This value is consistent with a repeatability of 0.2 and the observed decline in litter size between on-farm and post-purchase records. The litter size of this flock increased significantly over time when measured as unadjusted phenotepic trend or as a deviation from the Galway Control line. The deviation of litter size from the Galway Control line increased by 0.029 ± 0.007 per year between 1970 and 1982 inclusive.

Data on ovulation rate and litter size of mature ewes from this High Fertility line for the years 1982 to 1985 are summarised in Table 4. The litter size data do not refer in all cases to those ewes which provided ovulation rate information. The predicted litter size, using the mean ovulation rate, is 2.02 using the formula of Hanrahan (1982). While the observed litter size is somewhat higher than this prediction the difference does not approach significance which suggests that the intense selection for litter size involved in developing this line of sheep has had no major impact on embryo survival.

TABLE 4

Ovulation rate and litter size of mature High Fertility ewes*

	No.	Mean	Range	CV %
Ovulation rate	78	2.55±0.10	1-6	33
Litter size	91	2.13±0.08	1-4	35

* Data for 1982 to 1985.

SELECTION ON OVULATION RATE IN FINN SHEEP

The heritability of ovulation rate in Finn sheep is about 0.5 (Hanrahan and Quirke 1985) and divergent selection on ovulation rate at 18-months of age was initiated in 1976. Mean ovulation rate data for the three lines involved in this study were given by Hanrahan (1987) and showed a divergence of about 2 ova between the High and Low lines. High line ewes have an ovulation rate which is 1.44±0.07 times the mean of the control line. The possibilities for exploiting this high ovulation rate line to increase the prolificacy of local breeds were considered by Hanrahan (1987) where it was indicated that using 25% Finn ancestry would generate the same prolificacy as that attainable by using 50% ancestry from the unselected Finn line. Results for ovulation rate and litter size of 1/4 Finn x 3/4 Galway ewes generated by using rams from the High ovulation rate line are given in Table 5 together with values for contemporary Galway ewes.

TABLE 5

Ovulation rate and litter size of 1/4 Finn x 3/4 Galway ewes and contemporary Galway ewes.

	Ovulation rate	Litter size
1/4 Finn x 3/4 Galway	2.80	2.05
Galway control	1.75	1.35

These results are consistent with the expectation that the use of genetic material from the high ovulation rate line can reduce the proportion of Finn ancestry required to increase prolificacy of a target population. Work is currently underway on the use of the high ovulation rate Finn line in combination with the Texel sheep to develop a high prolificacy composite breed with improved carcass merit. Finn sheep and Texels are being crossed to produce 1/4 Finn x 3/4 Texel animals. The ovulation rates of F1 ewe lambs born in 1988 are given in Table 6. The High-line cross has an ovulation rate which is significantly greater than F1 animals from the other two lines and the superiority of the High line cross over the control cross (+28%) is consistent with the divergence between the purebred Finn lines.

TABLE 6

Ovulation rate of Finn x Texel (F1) ewe lambs.

Crossbred type	No. of lambs	Ovulation rate
Finn High line x Texel	27	1.78±0.08
Finn Control line x Texel	14	1.39±0.12
Finn Low line x Texel	18	1.32±0.10

CORRELATED CHANGES IN BREEDING SEASON

The effects of selection for litter size and ovulation rate on components of the breeding season have been examined in the Galway and Finnsheep populations at our Institute. In the case of the Galway selection line the date of first oestrus of the breeding season was established for random samples of mature ewes in 1986 and again in 1987. Ovulation rate at the first oestrus of the season was also recorded in 1986. The results are given in Table 7. Ewes from the selection line had a slightly later onset of cyclicity in both years but these differences were not significant. However, when the line differences were pooled across years the mean difference of 6.5 days was significant ($t = 2.26$, $P < 0.05$).

In 1986 the difference between the lines for ovulation rate at first oestrus was consistent with differences between these lines during the breeding season (Table 2).

In the case of the Finn breed selection for increased ovulation rate was associated with a significant increase in the duration of the breeding season which was largely attributable to later cessation of cyclicity in the Spring although the High line ewes starting cycling slightly earlier in the Autumn (Table 8).

TABLE 7

Correlated response in date of onset of the breeding season in Galway ewes.

Ewe age	Line	No. of ewes	Date of First oestrus	Ovulation rate*
4.5	Control	14	14.9.86±3.5	1.64±0.15
	Selection	19	19.9.86±3.0	2.00±0.12
2.5	Control	19	6.10.87±3.1	-
	Selection	35	14.10.87±1.5	-

* At first oestrus of the breeding season.

TABLE 8

Correlated changes in the duration of the anoestrus in Finn ewes selected for ovulation rate.

Trait	Line		
	High	Low	Control
Duration of the anoestrus (days)			
- 1985	124±4.6	157±5.2	132±4.9
- 1986	126±5.9	146±5.6	143±5.3
- average	125±3.7	152±3.8	138±3.6
Date of onset of the breeding season	Oct.2±3.1	Oct.9±2.8	Oct.9±2.8
Date of onset of the anoestrus	May 30±3.6	May 8±3.3	May 23±3.3

The results from these two selection experiments yield opposite trends in relation to the genetic association between reproductive rate and date of onset the breeding season. These conflicting results are not inconsistent with literature on this topic reviewed by Hanrahan and Quirke (1986).

CONCLUSIONS

It is clear from the results reviewed that within breed selection for increased prolificacy is successful and especially when initial selection is based on screening of individuals with extreme performance from native populations. The additional option of exploiting genes with a large effect on ovulation rate to enhance the reproductive rate of a target population allows the preservation of the genetic background of adapted local breeds. An alternative procedure is to select for increased ovulation rate in a prolific breed to be used for upgrading a target population.

Results from selection for increased prolificacy show that responses are mediated via changes in ovulation rate. The advantages of using ovulation rate as the selection criterion for increasing prolificacy have been discussed elsewhere (Hanrahan, 1987). These advantages should be exploited in selection programmes aimed at increasing litter size in native populations.

Information on the genetic association between seasonality of breeding and prolificacy appears equivocal with conflicting evidence between populations.

REFERENCES

Aboul-Naga, A.M. 1985. Crossbreeding for fecundity in subtropical sheep. In: R. B. Land and D.W. Robinson (Editors), Genetics of Reproduction in Sheep. Butterworths, London, pp. 55-62.

Aboul-Naga, A.M., Aboul-Ela, M.B. and Mansour, H. 1987. Seasonality of breeding activity in subtropical Egyptian sheep breeds. 38th Annual Meeting of the European Association for Animal Production, Lisbon. (Mim.) 13 pp.

Bradford, G.E., Quirke, J.F., Sitorus, R., Inouni, I., Tiesnamurti, B., Bell, F.L., Fletcher, I.C. and Torell, D.T. 1986. Reproduction in Javanese sheep: evidence for a gene with large effect on ovulaltion rate and litter size. J. Anim. Sci., 63: 418-431.

Dyrmundsson, O. R., and Adalsteinsson, S. 1980. Coat color gene suppresses sexual activity in Icelandic sheep. Journal of Heredity, 71: 363-364.

Hanrahan, J.P. 1982. Selection for increased ovulation rate, litter size and embryo survival. In: Second World Congress on Genetics Applied to Livestock Production, 5: 294-309.

Hanrahan, J.P. 1984. Results on selection for increased litter size and ovulation rate in sheep. In: J.H. Hofmeyer and E.H.H, Meyer (Editors), Proceedings of the 2nd World Congress on Sheep and Beef Cattle Breeding. South African Stud Book and Livestock Improvement Association, Bloemfontein, pp. 483-493.

Hanrahan, J.P. 1987. Genetic variation in ovulation rate in sheep. In: I. Fayez M. Marai and J.B. Owen, (Editors), New Techniques in Sheep Production. Butterworths, London, pp. 37-46.

Hanrahan, J.P. and Quirke, J.F. 1982. Selection on ovulation rate in sheep aided by the use of superovulation and egg transfer. In: R.A. Barton and W.C. Smith (Editors), Proceedings of the World Congress on Sheep and Beef Cattle Breeding. The Dunmore Press Ltd. Palmerstown North, New Zealand, 2 : 329-335.

Hanrahan, J.P. and Owen, J.B. 1985. Variation and repeatability of ovulation rate in Cambridge ewes. Animal Production, 40: 529.

Hanrahan, J.P. and Quirke, J.F. 1985. Contribution of variation in ovulation rate and embryo survival to within breed variation in litter size. In: R.B. Land and D.W. Robinson (Editors), Genetics of Reproduction in Sheep. Butterworths, London, pp. 193-201.

Hanrahan, J.P. and Quirke, J.P. 1986. Breeding season and multiple births in small ruminants. In: 3rd World Congress on Genetics Applied to Livestock Production, Lincoln, Nebraska, pp. 30-45.

Jonmundsson, J.B. and Adalsteinsson, S. 1985. Single genes for fecundity in Icelandic sheep. In: R.B. Land and D.W. Robinson (Editors), Genetics of Reproduction in Sheep. Butterworths, London, pp. 159-168.

Lahlou-Kassi, A. and Marie, M. 1985. Sexual and ovarian function of the D'Man ewes. In: R.B. Land and D.W. Robinson (Editors), Genetics of Reproduction in Sheep. Butterworths, London, pp. 245-260.

Piper, L.R. and Bindon, B.M. 1982. Genetic segregation for fecundity in Booroola Merino sheep. In: R.A. Barton and W.C. Smith (Editors), Proceedings of the World Congress on Sheep and Beef Cattle Breeding. The Dunmore Press Ltd., Palmerstown North, New Zealand, 1 : 395-400.

Quirke, J.P., Hanrahan, J.P., Loughnane, W. and Triggs, R. 1986. Components of the breeding and non-breeding seasons in sheep: breed effects and repeatability. Irish of Agric. Res., 25: 167-172.

Smith, C. 1986. Use of embryo transfer in genetic improvement of sheep. Animal Production 42: 81-88.