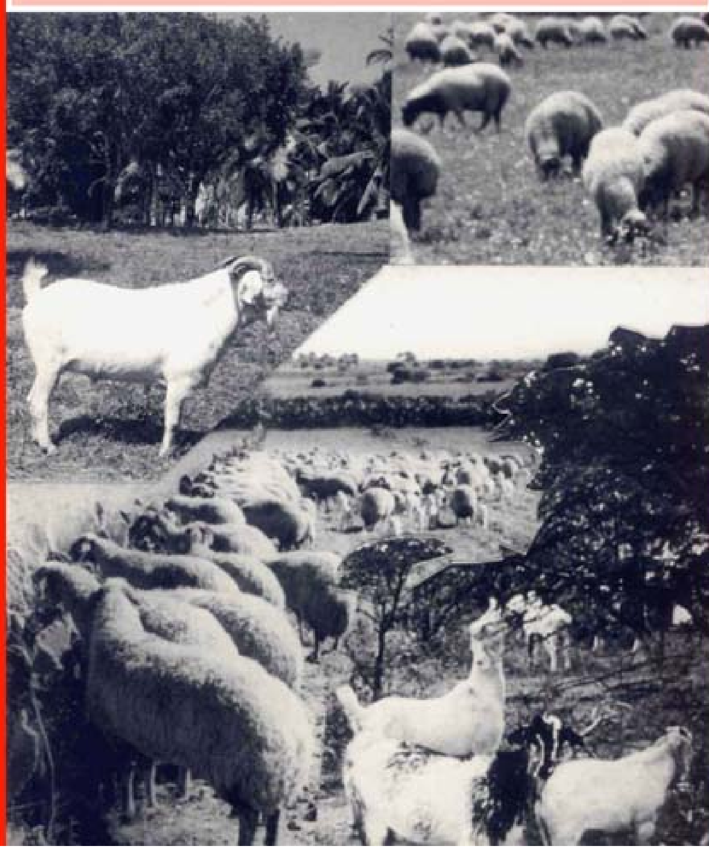
Small ruminant production in the developing countries

FAO ANIMAL PRODUCTION AND HEALTH PAPER

58



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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Small ruminant production in the developing countries

Proceedings of an Expert Consultation
held in Sofia, Bulgaria, 8–12 July 1985

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ABSTRACT

This publication on the development of small ruminant production in the developing countries is based on an FAO Expert Consultation, held in Sofia, Bulgaria in July 1985. Twenty papers were presented and discussed in the consultation and are reproduced in these proceedings. Strategies in breeding and breed development, nutrition and management, the development and utilization of indigenous grasses, shrubs and forest feeds for the production of sheep and goats, in arid, semi-arid and tropical conditions, are presented in the papers. A synthesis of the discussions is presented in the final chapter of the proceedings.

KEY WORDS

Sheep, goats, breeding, nutrition, management, feeds, arid, semi-arid, tropical.

INTRODUCTION

World wide sheep and goat numbers have been increasing steadily over the past twenty years unlike most other livestock species used by man. Sheep numbers are now in excess of one billion and goat numbers are steadily approaching half that level. Of particular significance is the fact that sheep and goat numbers are increasing much more rapidly in the developing countries than in the more developed regions. This may well reflect the particular ability of small ruminants to survive and produce on low cost feed, their adaptability to difficult and in particular arid environments but perhaps more than anything else it reflects their suitability to the small low-capital family farms in the developing countries that so badly need extra food and additional income.

However population growth, albeit an encouraging trend, is not enough. We must achieve greater production efficiency in small ruminant production in the developing countries; eg., meat output per ewe is much lower and less efficient per unit of body weight in Africa and Asia than in North America or Europe. Levels of flock/herd management, of breed improvement and of disease control are lagging far behind those practiced in the more developed countries.

These are the challenges which motivated FAO to organize a consultation of experts in small ruminant production to assess the progress and development to date and in particular to identify and chart the strategies of development for the years ahead.

The consultation was held in Sofia, Bulgaria, July 8/12,1985 and was attended by 21 invited participants from all of major sheep and goat producing areas of the world. Following the presentation and discussion of the individual contributions the consultation then addressed the main purpose of the meeting, viz., to identify strategies and recommendations as to how best small ruminant production may be advanced in the developing countries. These recommendations are presented as the summary and outcome of the consultation. A complete report of the consultation and its recommendations has been published by FAO.

H.A. Jasiorowski
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CONTENTS

TRENDS IN SHEEP AND GOAT PRODUCTION OVER THE PAST 20 YEARS

C. E. Terrili

INTRODUCTION

Sheep and goat industries are healthy and growing in the world but we cannot be satisfied that all is well. Total meat production per capita seems on the verge of a continued decline. Food production is barely keeping up with population growth. Per capita cereal production is levelling off and will likely decline until farm prices increase drastically. Then less and less meat will be produced from grain and less meat will be consumed at higher cost. Can sheep and goats, the most efficient convertors of low quality feed materials to high quality food, increase in numbers, productivity and efficiency to provide an adequate supply of low cost meat for everyone in the world ? Are research and development efforts in the past 25 years and at present sufficient to lead to a rapid upward trend in numbers, productivity and efficiency of sheep and goats ? Data from FAO since 1961 have been examined for answers to the above questions (FAO Production Yearbook, V.30, 1976; V.35, 1981; V.36, 1982).

SHEEP AND GOAT NUMBERS

Worldwide upward trends in sheep and goat numbers are shown in Table 1 but progress is at a rate of only about one percent per year. The hopeful sign is that the rate of increase is higher in the late 70's than earlier. Sheep and goat numbers have increased from 1 billion sheep and 0.4 billion goats to 1.1 billion sheep and 0.5 billion goats in about 20 years. Further increases are not only likely but probable. Generally over the world there are untapped forage resources either natural or by-products and wastes which could support much larger populations of sheep and goats. This is especially true of most developed and of some developing countries. These resources are fully used only in desert areas and probably in the USSR and in China. I have estimated that in the United States there are 300 million acres of practically unused potential pasture land which would support about one sheep to the acre as it is and several per acre if improved.

The rate of increase in numbers could be much greater. In the United States over the last century when sheep numbers have increased the rate has been about 5 percent per year and goat numbers have increased as rapidly as 10 percent per year. A slow steady increase in numbers of animals, through more producers using more resources is preferable to a more rapid but temporary increase. Three to five percent per year would not seem too rapid providing each new producer starts with a small number. Numbers have increased more rapidly in developing than in developed countries although developed countries are now showing increases. The decline in North America is entirely due to predator losses which have increased due to Government restrictions on control. Africa and Asia have shown larger and more consistent increases in the last 20 years than the remainder of the world. More rapid increases in numbers of sheep and goats are feasible and probably desirable over most of the world.

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MEAT PRODUCTION

Meat is the most important product of farm animals and is probably essential for human well being and productivity as well as for enjoyment of life. Thus meat production of sheep and goats is more important than their numbers. Trends for all meat production as well as for sheep and goats are given in Table 2. Meat production from all species has generally increased rapidly over the last 20 years. Exceptions for sheep and goats due to predator losses in North America, economics of wool in South America and possibly competition with cattle in the Soviet Union all may be temporary. In South America production of wool seems to be competing with meat production from sheep so that meat production may not increase until it is more important economically than wool. Somewhat the same situation may occur in the Soviet Union where priority seems to be given to cattle for meat production and to sheep for wool and pelt production. Increases are somewhat more rapid in developing than in developed countries although the level of production and consumption are far lower in the developing than in developed countries. People in developed countries produce and consume far more meat than in the remainder of the world. This is not just a result of wealth but it was true also with the first settlers, most of whom were livestock farmers.

Meat from all species, however, has probably reached its peak in the rate of production. The decline which is evident this year will probably be more rapid in the future as a-result of the economic downward pressure on beef production because of rising production costs and declining prices. Grain and soybeans are generally available for less than the real cost of production. Sooner or later their farm price will probably increase and then less grain and soybeans will be used to produce beef, pork, milk, poultry and farm fish. In the future rising prices will probably not result in increased production because of high capital costs and high risk of expansion. Sheep and goats with their very low needs for capital input, grain and concentrates would be able to increase under these conditions and may slow the decline in total high quality food available.

Sheep and goats, unlike all species, are producing meat at an increasing rate but far below their potential. Again increases are more rapid in developing countries. Meat production does tend to decline as numbers increase, as more replacement animals mean fewer slaughter animals. But genetic improvement in weight of meat produced per female kept, improvement of forage resources and increases in land surfaces utilized could result in providing almost unbelievable increases in meat marketed from sheep and goats into the almost indefinite future. The challenge we face is how do we bring it all about without producing surpluses and without competing with other food production. The opportunity is real and great.

Trends in per capita meat production (all) are given in Table 3 and are not as favourable as for numbers or for total meat production. In fact recent rates of increase were often negative although all were positive for the world and for developing countries. Gains in per capita production in developing countries were generally higher than for the remainder of the world although average per capita production was much lower in developing countries except for goats.

Meat Production Efficiency

Average meat produced per head of sheep and goats is probably the best measure of efficiency that can be obtained from world statistics for these species. The number of sheep maintained provides an estimate of biological costs, and weight of meat produced and marketed gives an estimate of biological returns. Upward trends indicate increased net returns to producers. An upward trend in meat produced per head along with an increase in numbers indicates that the greater amount of meat produced is not due to liquidation of numbers but rather that increased replacements have been more than offset by increased meat production. Further, an upward trend in both numbers and meat production per head indicates that the greater numbers are not leading to over-grazing. Over-grazing would be revealed by decreased production per head over the long-term. High emphasis on wool production may lead to a reduction in average meat produced per head as both ewes and wethers that would otherwise be sent to slaughter may be kept for wool production.

Average meat produced per head of sheep world-wide is increasing but at only about 1/3 percent per year while for goats the rate of increase is more than twice as fast (Table 4). Both species were increasing more rapidly in the late 70's than earlier. Use of high prolificacy breeds, crossbreeding, breeding more than once per year and control of reproduction may all have contributed to the increase. Much of the gain may have resulted from research supported by FAO and other international agencies. Likely very little of the gain was due to selection. Far greater gain is possible from selection which would be additive rather than an alternative to other methods. The upward trends in Asia, Africa and developing countries are encouraging (Table 4). The higher efficiency in developed countries is obvious. Trends in countries with high efficiency of sheep meat production, (Figure 1) are also encouraging. These show that efficiency can be increased to far higher levels than are now common in many countries. Furthermore continued increases in countries such as Iceland, Albania, France, Ireland and Greece show that upward trends can be sustained for long periods.

Trends in efficiency of goat meat production (Table 4) indicate that upwards trends may be more definite both in developed and developing countries than with sheep. The individual countries with high efficiency (Figure 2) indicate with goats that some developing countries rank higher than developed countries as seven of the top countries had developing market economies. The general upward trend was most encouraging but it could be much more rapid.

FIBRE PRODUCTION

Wool Production

Wool production is increasing along with sheep numbers although increases are generally in Centrally Planned Market Economies and in developing countries (Table 5). Wool clothing is almost essential in the USSR while wool products are exported from China probably to obtain hard currency. Wool production is declining however on a world basis as the population is increasing more rapidly than wool production. The population is generally increasing more rapidly in the tropics where demand for wool is low. In the temperate zone where there is good demand for wool the farm price has not been sufficiently high to stimulate increased production.

Mohair Production

Trends in mohair production are not available from FAO statistics as it is a very minor textile fibre. Van Der Westhuysen (1982) has provided some information for 1980 (Table 6). Production declined from the mid 1960's to the mid 1970's because of the low world price. Prices have been relatively high since and production is increasing. Predator losses in the United States have prevented much increase there. The price seems to have stabilized at a profitable level. The future of mohair use as a speciality fibre seems good as it produces a very high quality, attractive textile product. Even in biblical times it was known as a high quality fibre used to make curtains for the Tabernacle. No doubt that reputation will persist.

REFERENCES

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TABLE 1. Trends in numbers of sheep and goats

AREA	Species	Average number of head (,000) 1961–65	1980–82	Annual change (%) 61–65 to 69–71	69–71 to 74–76	74–76 to 80–82	61–65 to 80–82
World	Sheep	1 015 863	1 134 834	0,91	-0.43	1.21	0.65
	Goats	377 500	467 416	0,98	0.73	1.97	1.32
Africa	Sheep	140 328	184 235	2.42	0.06	1,99	1.74
	Goats	111 315	146 945	3.03	0.15	1.67	1.91
North and Central America	Sheep	37 128	22 560	-2.35	-4.25	-1.27	-2.18
	Goats	15 124	10 871	-1.07	-2.31	-2.03	-1.56
South America	Sheep	121 212	106 432	-0,71	-2.35	0.78	-0.68
	Goats	26 554	19 383	-4.41	1.11	0	-1.50
Asia	Sheep	237 887	333 499	1.92	1.80	2.22	2.23
	Goats	203 471	269 418	1.03	1.33	2.63	1.80
Europe	Sheep	133973	138 035	-0.72	-0.33	1.67	0.17
	Goats	14 437	11 859	-2.04	-1.24	0.37	-0.99
Oceania	Sheep	211 468	207 568	1.72	-2.75	0.26	-0.10
	Goats	176	380	1.46	-0.41	16.67	6.44
USSR	Sheep	133 867	142 507	0.27	0.98	-0.07	0.36
	Goats	6 442	5 957	-2.37	1.76	0.37	-0.40
Centrally Planned	Sheep	243 242	301 577	1.27	1.52	0.97	1.33
	Goats	68 571	92 689	1.17	1.24	2.94	1.95
Developed M.E.[+]	Sheep	382 519	352 787	0.18	-2.29	0.47	-0.43
	Goats	21 059	17 400	-1.72	-1.74	0.48	-0.96
Developing M.E.	Sheep	390 103	480 470	1.40	0.06	1.97	1.29
	Goats	287 870	351 145	1.13	0,75	1.81	1.34

M.E. = market economy

TABLE 2. Trends in meat production

AREA	Species	Average meat production (1000 MT) 1961–65	1980–82	Annual change (%) 61–65 to 69–71	69–71 to 74–76	74–76 to 80–82	61–65 to 80–82
World	All	83 626	143 052	3.52	3.96	2.92	3.95
	Sheep	5 151	6 095	1.43	-0.74	1.95	1.02
	Goats	1 428	2 046	1.76	1.23	3,36	2.40
Africa	All	3 963	6 793	4.40	1.45	3.69	3.97
	Sheep	483	730	4.17	-0.67	3.51	2.84
	Goats	362	568	4.82	-0.37	3.26	3.16
North and and Central America	All	21 609	30 036	2.34	1.48	1.87	2.17
	Sheep	377	183	-3.71	-4,66	-2.41	-2.86
	Goats	17	30	5.04	0	5.07	4.25
South America	All	6 885	11 735	3.58	2.16	3.84	3.91
	Sheep	312	264	2.56	-4.73	-1.01	-0.86
	Goats	65	65	-0.22	-0.62	0.81	0
Asia	All	17 612	36 115	3.36	5.21	5.28	5.84
	Sheep	1 020	1 801	2.74	2.60	5.18	4.25
	Goats	849	1 259	1.03	2.44	3.88	2.68
Europe	All	21 724	39 307	4.11	4.45	2.49	4.50
	Sheep	892	1 154	0.85	2.18	1.69	1.63
	Goats	84	85	0	0.24	0	0,07
Oceania	All	2 513	3 882	3.35	3.46	1.12	3.03
	Sheep	1 066	1 146	3.00	-4.06	1.91	0.42
	Goats	1	1	0	20.00	-8.33	0
USSR	All	9 320	15 182	4.78	3.09	0.96	3.49
	Sheep	1 001	814	-0.80	-0.80	-1.36	-0.93
	Goats	49	38	-3.21	-1.58	1.43	-1.25

AREA	Species	Average meat production (1000 MT)		Annual change (%)			
		1961–65	1980–82	61–65 to 69–71	69–71 to 74–76	74–76 to 80–82	61–65 to 80–82
Centrally Planned	All	27 411	49 556	3.43	4.83	2.90	4.49
	Sheep	1 526	1 537	0.34	0.17	-0.40	0.04
	Goats	336	446	0.21	2.23	2.95	1.82
Developed M.E.	All	40 489	64 816	2.98	2.74	2.28	3.34
	Sheep	2 251	2 340	1.37	-2.20	1.45	0.34
	Goats	83	99	1.38	1.54	0.17	1.07
Developing M.E.	All	15 727	28 679	3.94	2.45	4.56	4.58
	Sheep	1 375	2 172	2.74	0.59	4.79	3.22
	Goats	1 010	1 501	2,29	0.92	3.74	2.70

TABLE 3. Trends in meat produced per head of human population (kg)

AREA	Species	Average meat production per capita 1961–65	1980–82	Annual change (%) 61–65 to 69–71	69–71 to 74–76	74–76 to 80–82	61–65 to 80–82
World	All	26.46	31.69	0.93	1.22	0.99	1.10
	Sheep	1.63	1.35	-0.85	-2.50	0.11	-0.95
	Goats	0.45	0.45	-0.57	-0.74	1.40	0.01
Africa	All	13.71	13.96	0.94	-1.28	0.35	0.10
	Sheep	1.67	1.50	0.75	-3.15	0,21	-0.56
	Goats	1.25	1.17	1.28	-2.93	-0.01	-0.38
North and and Central America	Sheep	76.25	78.89	0.45	-0.17	0.20	0.19
	Sheep	1.33	0.48	-4.92	-5.83	-3.75	-3.56
	Goats	0.06	0.08	2.86	-1.67	3.54	1.85
South America	All	43.84	47.68	0.46	-0.32	1.18	0.49
	Sheep	1.99	1.07	-0.37	-6.44	-3.02	-2.55
	Goats	0.41	0.27	-2.66	-2.85	-1.50	-2.03
Asia	All	10.05	13.75	0.36	2.62	2.99	2.05
	Sheep	0.58	0.69	-0.15	0.28	2.91	0.99
	Goats	0.48	0.48	-1.59	0.14	1.73	-0.07
Europe	All	49.77	81.29	3.20	3.68	2.01	3.46
	Sheep	2.04	2.37	0.10	1.49	1.22	0.90
	Goats	0.19	0.18	-0.67	-0.44	-0.28	-0.46
Oceania	ALL	149.57	168.98	1.05	1.39	-0.27	0.72
	Sheep	63.45	48.91	0.75	-5.47	0.59	-1.16
	Goats	0.06	0.06	-1.90	16.15	-6.38	-0.18
USSR	All	41.41	56.71	3.39	2.02	0.08	2.05
	Sheep	4.45	3.11	-1.78	-1.69	-2.11	-1.67
	Goats	0.22	0.14	-4.00	-2.42	-0.36	-1.96

AREA	Species	Average meat production per capita		Annual change (%)			
		1961–65	1980–82	61–65 to 69–71	69–71 to 74–76	74–76 to 80–82	61–65 to 80–82
Centrally Planned	All	26.40	33.71	0.41	2.80	1.48	1.54
	Sheep	1.47	1.04	-2.16	-1.45	-1.59	-1.61
	Goats	0.32	0.30	-2.29	0.44	1.50	-0.36
Developed M.E.	All	60.08	81.31	2.15	1.67	1.43	1.96
	Sheep	3.34	2.99	0.26	-3.05	0.64	-0.58
	Goats	0.12	0.12	0.23	0.64	-0.65	0.04
Developing M.E.	All	10.86	12.66	1.06	-0.16	1.71	0.97
	Sheep	0.95	0.97	0.06	-1.80	1.92	0.10
	Goats	0.70	0.67	-3.46	-1.40	1.26	-1.35

TABLE 4. Trends in meat per head from sheep and goats

AREA	Species	Average meat per head (kg)		Annual change (%)			
		1961–65	1980–82	61–65 to 69–71	69–71 to 74–76	74–76 to 80–82	61–65 to 80–82
World	Sheep	5.07	5.37	0.49	-0.32	0.68	0.33
	Goats	3.78	4.38	0.73	0.49	1.24	0.87
Africa	Sheep	3.44	3.96	1.50	-0.73	1.36	0.84
	Goats	3,25	3.80	1.47	-0.52	1.44	0.93
North and Central America	Sheep	10.15	8.09	-1.63	-0.51	-1.27	-1.13
	Goats	1.12	2.79	6.60	2.60	8.36	8.24
South America	Sheep	2.57	2.48	3.44	-2.70	-1.68	-0.19
	Goats	2.45	3.34	6.06	-8.23	-0.72	2.02
Asia	Sheep	4.29	5.40	0.72	0.73	2.60	1.44
	Goats	4.17	4.67	0	1.04	1.08	0.66
Europe	Sheep	6.66	8.36	1.66	2.48	0.02	1.42
	Goats	5.82	7.21	2.38	1.58	-0.27	1.32
Oceania	Sheep	5.04	5.52	1.14	-1.52	1.64	0.53
	Goats	5.68	3.58	-1.32	20.84	-11.00	-2.05
USSR	Sheep	7.48	5.84	-1.06	-1.70	-1.29	-1.21
	Goats	7.63	6.31	-1.00	-3.07	0.85	-0.96
Centrally Planned	Sheep	6.27	5.10	-0.86	-1.26	-1.30	-1.04
	Goats	4.90	4.82	-0.88	0.93	0.21	-0.09
Developed M.E.[+]	Sheep	5.89	6.77	1.17	0.09	0.96	0.83
	Goats	3.94	5.69	3.52	3.59	-0.29	2.47
Developing M.E.	Sheep	3.52	4.52	1.22	0.53	2.52	1.57
	Goats	3.51	4.20	1.08	0.16	1.73	1.09

TABLE 5. Trends in scoured wool production from sheep in world

AREA	Item	Average total scoured wool (1000 MT) and per capita Production (kg) 1961–65	1980–82	Annual change (%) 61–65 to 69–71	69–71 to 74–76	74–76 to 80–82	61–65 to 80–82
World	Total	1 503	1 696	1.55	-1.18	1.37	0.72
	per cap.	0.48	0.38	-0.75	-2.90	-0.40	-1.16
Africa	Total	96	100	2.59	-0.78	-1.36	0.24
	per cap.	0.33	0.21	-0.54	-3.23	-3.86	-2.11
North and Central America	Total	63	33	-4.14	-5.62	0.69	-2.60
	per cap.	0.22	0.09	-5.29	-6.73	-0.88	-3.36
South America	Total	188	176	-0.24	-2.59	1.59	-0.35
	per cap.	1.20	0.73	-2.69	-4.54	-0.77	-2.23
Asia	Total	144	261	4.44	1.71	4.61	4 54
	per cap.	0.08	1.0	1.26	-0.53	2.39	1.18
Europe	Total	147	161	-0.73	0.95	1.63	0.51
	per cap.	0.34	0.33	-1.40	0.30	1.17	-0.11
Oceania	Total	648	691	2.19	-2.80	1.25	0.37
	per cap.	38.58	30.08	0.04	-4.31	-0.15	-1.22
USSR	Total	217	274	2,01	2.00	0.13	1.47
	per cap.	0.96	1.02	0.82	0.99	-6.70	0.35
Centrally Planned	Tota	307	462	3.39	2.06	1.72	2.81
	per cap.	0.30	0.31	0.38	0.25	0.38	0.35
Developed M.E.	Total	881	869	1.24	-2.74	0.86	-0.08
	per cap.	1.31	1.09	0.14	-3.56	0.06	-0.92
Developing M.E.	Total	315	366	0.62	-0.36	2.24	0 90
	per cap.	0.22	0.16	-1.73	-2.64	-0.29	-1.39

TABLE 6. Production of mohair in 1980

Country	Number of goats millions	Total Production (10^6)	Production/Goat (kg)
Republic of South Africa	1.4	6.1	4.35
Texas, USA	1.2	4.1	3.70
Turkey	2.0	4.5	2.25
Argentina	1.0	1.0	1.00
Lesotho	0.8	0.6	0.75
Total	6.4	16.3	2.55

Source: Van Der Westhuysen (1982)

Fig 1. COUNTRIES HIGH IN EFFICIENCY OF SHEEP MEAT PRODUCTION

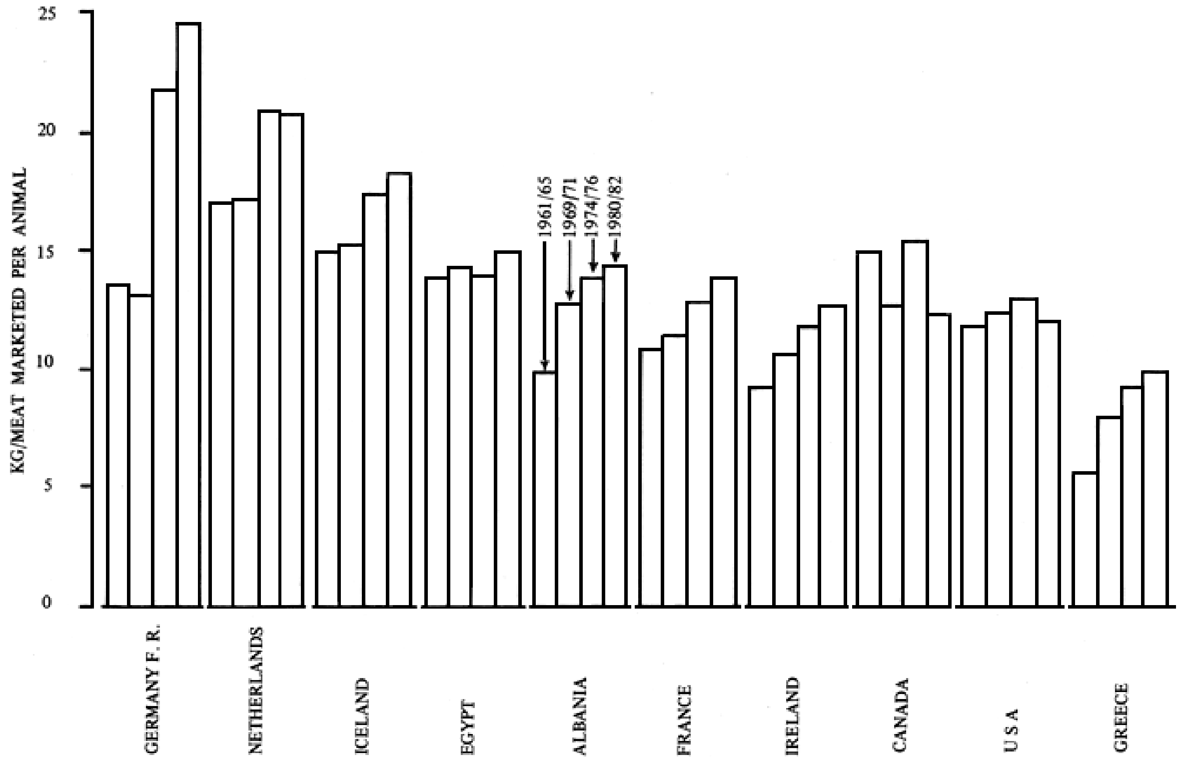
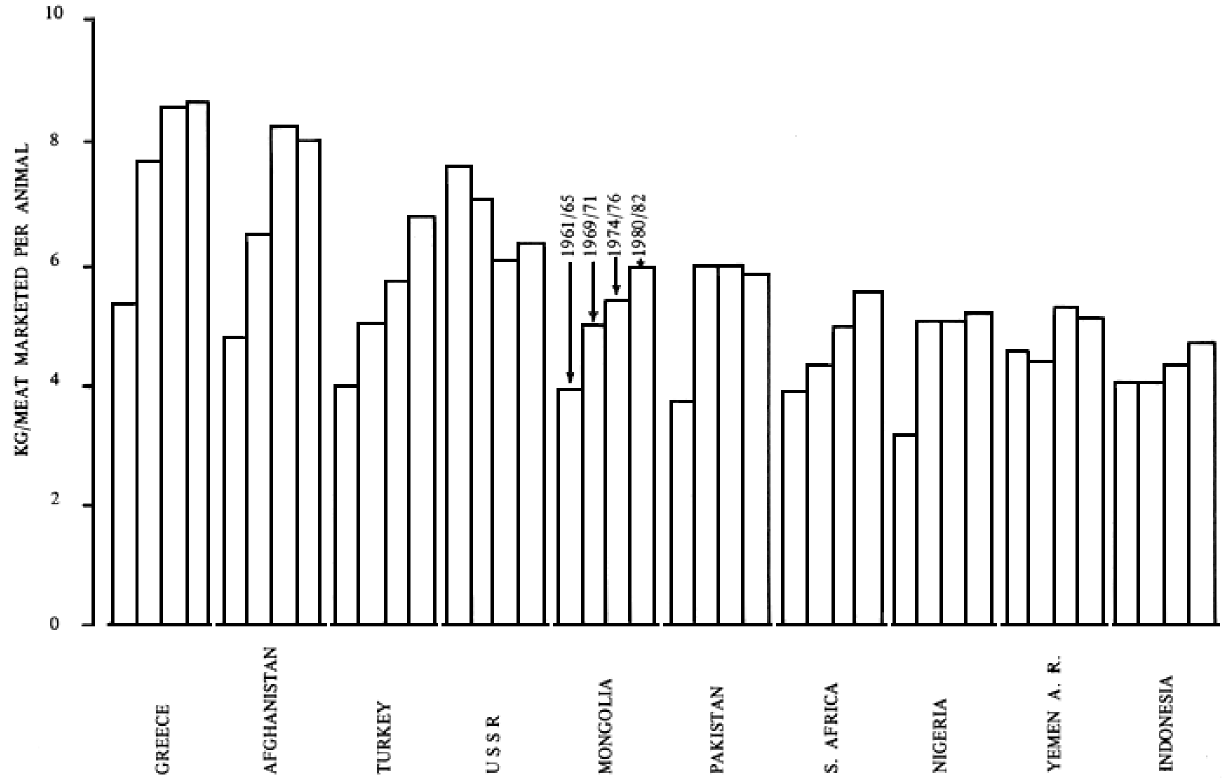


Fig 2: COUNTRIES HIGH IN EFFICIENCY OF GOAT MEAT PRODUCTION.



SELECTION FOR INCREASED EFFICIENCY IN SMALL RUMINANTS

Helen Newton Turner

INTRODUCTION

This paper deals with the role of selection in increasing the efficiency of production from small ruminants. Increasing the efficiency of output from the animals, as discussed, will fail unless attention is also paid to problems of marketing and distribution of the product. Australia is renowned for its wool production per head, but over the last 10 years the wool marketing system has been revised to increase the efficiency of the whole system. And currently, Australia is in trouble over milk marketing.

In developing countries also there may be no encouragement for owners of small flocks and herds to increase production of wool, meat or milk because they will receive no benefit without a revision of the ways in which their product is presented for sale, marketed and distributed. Further, it may not be possible to implement production improvements without access to credit.

Genetic improvement is a simple, relatively cheap and permanent way of increasing animal production, but disease control and better nutrition also make major contributions. And improvement relating to the animal is only part of a whole system. Remembering this, discussion of genetic techniques for animal improvement becomes profitable, and selection is a major tool among those techniques.

This paper makes no Claim to be a complete literature review - examples are chosen to illustrate points.

Selection may involve the choice of:

- Species,
- Breed within a species, or strain within a breed,
- Selection, or cross-breeding followed by selection, as the major tool,
- Individuals within a flock.

The small ruminants under discussion are sheep and goats, while increased efficiency is defined as an increased ratio of output (lifetime production) to input (labour, feed, management costs). The main products for sheep are meat, wool and milk, and for goats, meat and milk, plus fibre in the case of some special breeds. Basic to efficiency of production for either species is a high reproduction rate, which means more surplus animals for sale as meat, and a higher selection differential, leading to a faster response to selection.

There has been considerable discussion as to whether selection should be based on production per head, or per unit of input. A general conclusion has been (Turner and Young 1969) that production per head is preferable for grazing animals because:

- Production costs are on a per head basis,
- Production per head and per unit of feed are highly correlated.
- Feed intake for grazing animals is costly to measure.

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If milking animals are artificially fed and production recorded, or if meat animals are lot-fed, then selection on output per unit of feed may be justified, while production per hectare may be needed in selecting species or breeds.

In this paper, increased production per head is taken as the criterion of increased efficiency for selection of individuals within a flock or for choosing between cross-breeding and selection, while the need for considering other factors is discussed in relation to choosing species, breed or strain.

CHOICE OF SPECIES

Influencing Factors

Discussion in this section will merely draw attention to the need for considering the best species for the environment, without detailed analysis. Some of the important factors are:

- Adaptation,
- Impact on the environment,
- Markets,
- Management costs.

Adaptation

Some questions of adaptation have clear-cut answers, while others require further research. Heavily-woolled sheep, for example, do not thrive in warm, humid environments, where the choice must lie between hair sheep, sheep with coarser, lighter fleeces, goats (other than fibre-producing) or cattle.

The browsing habits of goats makes them useful in shrubby or partly-degraded semi-arid areas compared with grazing sheep (Harrington 1982, Wilson 1984), but the comparative digestive efficiency of the species for various feedstuffs may vary with breeds and circumstances. (Devendra 1978 and 1983, Brown and Johnson, 1984, el Hag et al. 1984).

Impact on the Environment

Goats or cattle may damage collection cups if run under rubber trees, whereas sheep are less likely to do so. Goats are alleged to cause erosion on steep, treeless hillsides because they form playgrounds; would sheep be any better ? Goats can be used to control shrubs, but will they cause erosion when the shrubs are gone ?

Markets

Markets dictate the product required. If this is clothing, the sheep, with its wool, may be chosen. If meat is the product, does the consumer prefer mutton, beef or goat meat ? Is there a high incidence of children who can tolerate goat milk but not cow's milk? When markets are distant, as in inland temperate Australia, sheep are favoured because wool can readily be stored and transported, whereas meat and milk require special facilities.

Management Costs

Woolled sheep require shearing, and in some areas regular inspection for flystrike. Goats and cattle require less oversight; cattle may also be less susceptible to disease.

CHOICE OF BREED OR STRAIN

Many genetically different breeds exist, and often genetically different strains within a breed. The problem in each case is to choose between groups, as distinct from selecting individuals within a group, so the two will be considered together.

Influencing Factors

Most factors apply as for choosing species, though details may differ.

Adaptation : Adaptation is again of primary importance. The many breeds of sheep and goats vary in physical appearance and production levels, and are grown over a wide range of environments. These environments differ in:

- Climate (tropic to arctic, dry to humid),
- Altitude (sea level to 6000 m.a.s.l.),
- Topography (treeless flat plains to rocky mountains),
- Management (small shepherded groups to flocks of thousands in fenced paddocks; groups grazing in the open year-round, day and night, to those housed for part of each day or for months at a time; groups which are stationary, or move between summer and winter pastures, or are completely nomadic),
- Nutritional level (in Australia alone from improved pastures carrying 10 sheep/ha to semi-arid areas requiring 18–25 ha/sheep),
- Exposure to disease (including internal and external parasites), and to predators.

Sheep and goat breeds differ in their products; woolled sheep give either apparel wool or coarse, carpet-type wool, as well as meat, skins and sometimes hair. Angora and cashmere goats give fibre and meat, while other goats give meat and sometimes milk, as well as hair and skins. There are some broad adaptations among these classifications; hair sheep and many goats are adapted to hot, humid climates, while apparel-woolled sheep and Angora goats are not.

The FAO Production Yearbook divides countries into three main categories- centrally planned economies, developed and developing market economies. In general the developed countries have a better environment for sheep and goats than the developing; many of the latter lie in the tropics, with the animals exposed to harsh climate, poor nutrition and a range of diseases. Production per head in the developed countries is higher than in the developing (e.g. 4–5 kg. of wool for sheep in Australia, compared with 1–2 kg, in India).

An often occurring mistake in the past has been to assume that animals can be transferred from temperate areas to raise production in harsh environments. Local breeds are adapted to their harsh conditions; exotic imports often fail to survive or even reproduce.

In recent years the importance of adaptation has been recognised; FAO is now in the process of establishing data banks of production records for livestock breeds in various countries, together with details of their environments. These should assist choice of breed (FAO 1985).

Impact on the Environment

This has received less attention in breed than species comparisons; its possible importance is stressed by Brooke and Ryder (1978).

Markets

These are important for choice of breed, strain or individual animal. There are broadly three types - world market, local market, and home use. The world market for wool pays higher prices for white apparel wool of fine diameter, with a low percentage of medullated fibre, or white carpet-type wool with some medullation. A local market may consume carpet-type wool, tolerate a higher level of medullation, and even seek some pigmented wool. If the wool is for home use in handcraft, coarser wools may be preferred for hand processing and pigmented wools may be sought. Similarly a home market may not pay attention to distribution of meat over the body as all is cut into small pieces for cooking, whereas a world (or developed country) market may give different prices for different cuts.

The whole marketing infrastructure, including distance from market, may also influence choice of product and breed.

Management Costs

These are related to adaptation. Inputs for animals in a harsh environment are likely to be lower for adapted local breeds than for imports.

Performance Data

Need

Performance data are essential for a final choice of breed. There have been movements to collect such data for decades, but the traits recorded in various places are not always the same. FAO is currently involved in a major project aimed at bringing available information together in data bases, standardizing the traits recorded, and describing the environment as well. One deficiency at present is that many of the records are made on experiment farms and not under field conditions, where the environment may be different.

Examples of summaries of available data for sheep and goat breeds will be found in Mason (1967, 1980), SABRAO (1980 and 1982), PARC (1982), Wahid (1982), Acharya (1982), Yalcin (1979).

These summaries are nearly all in what SABRAO has termed the documentation stage of recording, where animals have been run in different places. Critical breed selection should be based on evaluation, when breeds (or strains) under comparison have been run together, or in different places with a reference breed included. Collection of such information is long-term and expensive but a few experiments can be quoted. For example, Dunlop (1962, 1963) and Dun *et al.* (1966) compared Australian Merino strains, Atkins (1980) Australian sheep breeds, and Farid *et al.* (1977) Iranian sheep breeds.

Because of the paucity of such evaluations, breed (or strain) choices will often have to be made without them. Available data must then be used, seeking information from as many sources as possible, and on adequate numbers. Breeds from areas with similar environments should be sought.

Important Criteria

Characteristics to be considered depend on species and main product, and should describe also the ability of the animals to survive and reproduce. They are:

For all:	Number of offspring weaned/year/female exposed to the male, Annual death rates (each sex), Length of productive life (each sex), Incidence of major defects.
For meat production:	Total weight of offspring weaned/year/female exposed to the male, 12–15 month body weight (each sex).

For Fibre Production:	Annual clean fleece weight (sheep and Angora goats), Annual down weight (cashmere goats), Average fibre diameter, Percent medullated fibres (sheep), Percent kemp (sheep and Angoras), Length, Strength.
For milk production:	Production per lactation, Lactation length, Fat percent. Protein percent.

Lifetime production is important, and can be obtained only approximately from the above figures, but actual data are rare.

Many performance records include birth weight and body measurements. These may be useful in research programmes, but are less useful in estimating the productive value of a breed.

Products not mentioned above include skins (for both species) and hair (goats and hair sheep), which are not usually objectives for selection. Fur skins from certain sheep breeds, obtained from day-old lambs, are a very specialized product; much research has gone into their production, but they are not discussed here.

Possible Gains

Sheep

Indian data can be used as an example to examine possible benefits of breed selection. Acharya (1982) noted four environmental regions-Northwestern arid and semi-arid, Southern Peninsular, Eastern and Northern temperate. Taking the Northwestern region as an example, he listed 11 sheep breeds, of which 5 are used for milk and 6 are not. Among those 6, Chokla and Nali have greasy fleece weights well above any others (1.37 and 1.46 kg. for 6 months, compared with 0.8 -1.09) finer fleeces (28 and 35 μm, compared with 32–39 μm) lower percent medullation (24 and 31 percent, compared with 48–65), but lighter 12-month body weights (18 kg. compared with 19–28) and comparable mortality rates. Figures for reproduction rates are very variable.

These figures indicate that replacement of other breeds by Chokla or Nali in the N.W. Region would lead to increased wool production, and in fact Nali rams have been used to a limited extent for wool improvement in two of the breeds normally milked (Muzzarfarnagri and Jalauni, with fleece weights of only 0.65 and 0.90 kg. respectively).

Goats

Acharya (1982) also listed 11 goat breeds in the N.W. region, the Beetal and Jamnapari being outstanding for body weight (12-month weight 22 and 30 kg, compared with 15–21 kg.) and milk production (201 and 177 kg/ lactation, compared with 122 or less) and are being used for upgrading other regional breeds.

Hair is harvested from some goat breeds, though production is not mentioned for Beetal or Jamnapari, and quantity of hair does not seem to merit consideration in selection.

CHOICE OF SELECTION OR CROSSING

When data on breeds and environments have been assembled, a choice has to be made between selection or cross-breeding. The latter may be used to exploit hybrid vigour, or to change the genotype by complete replacement or development of an intermediate. If change of genotype is involved, selection will be combined with crossing.

Exploiting hybrid vigour means maintaining pure breeds so that crosses can be continually made. Gains with small ruminants are slight except for reproduction rate; the Australian prime lamb industry is based on first cross Merino × Border Leicester or Merino × Dorset ewes. The technique has a place in developed economies, but is more difficult to exploit in developing ones, where most flocks and herds are small.

Too often in the past crossing to change the genotype has been automatically chosen for developing economies; the low performance of local breeds in their usually harsh environments has been compared with the far superior record of exotic breeds in temperate environments, and the exotics have been imported in the hope of improving the local breeds. All too often the result has been disastrous. No large-scale imports should be considered without pilot trials evaluating the proposed imports (or their crosses with local breeds) against the local breeds <u>when run in the local environment.</u> Usually the environment will have to be modified for the imports (or their crosses) to perform; the effect of such modification on the local breed should be recorded, as well as the inputs required for the modification.

Not all introductions of exotic breeds have failed; temperate sheep breeds such as the Corriedale have been introduced to the Peruvian Andes and to the lowlands of Patagonia as purebreds, and to the Himalayas in Kashmir for crossing with local breeds. The Australian Merino has been developed from the first imports of coarse-woolled and hair sheep from Bengal and the Cape of Good Hope, crossed with a variety of European breeds (Turner 1982, Garran and White, 1985). The failures have come from taking temperate sheep breeds into very harsh environments, with environmental stress from heat, humidity, poor nutrition and unaccumstomed diseases.

Crossing to change the genotype, using breeds from similar environments, is being practised in a number of places, particularly in relation to raising specific characteristics such as reproduction rate. A few sheep breeds in the world have outstanding lambing percentages, and are being used in this way; the Finn has been taken into a number of countries, the Romanov is used in France, and the Booroola Merino (whose high fecundity is due to a single gene) in Australia (Bindon et al., 1985).

Unfortunately failed imports, or failed crosses, have often not been recorded; it is hoped the planned FAO data bases will record both successes and failures for future guidance.

SELECTION OF INDIVIDUALS WITHIN A FLOCK

<u>Background</u>

Selection of individuals improves production in the current flock for the lifetime of the selected animals, these usually being females and castrates, with males in smaller numbers. Of more importance are genetic gains in the next generation, part of which come from the selected females and part from the selected males; these gains are permanent and cumulative.

The classic formulae related to selection are:

$$\Delta C = iR\sigma \quad (1)$$

$$\Delta G = \bar{i}h^2\sigma \quad (2)$$

where

ΔC	=	gain in current flock
ΔG	=	genetic gain per generation
i	=	selection differential of selected animals, in standard units
$\bar{i}$	=	average selection differential of parents, in standard units
R	=	repeatability
h^2	=	heritability
σ	=	phenotypic standard deviation

The controlling elements are <u>permanent environmental variation</u> ($R\sigma$) in (1), <u>genetic variation</u> ($h^2\sigma$) in (2) and in both <u>selection differential</u>, dependent on <u>proportion saved.</u> A high reproduction rate raises the number of animals available for selection, and in a flock of fixed size lowers the proportion saved, increasing the selection differential. Artificial insemination increases the male selection differential still further (Table 1). So far frozen semen is not as successful with sheep and goats as with cattle, and use of fresh semen sometimes causes problems with small, scattered flocks or herds. Improvements in the techniques for using frozen semen will be a great advantage; laparoscopic insemination is giving better results than previous techniques, but may not always be feasible.

A distinction must be drawn between characteristics under selection which can be measured in both sexes (e.g. fibre weight and liveweight) and those which are sex-limited (e.g. reproduction rate, milk production). For the latter, a male's female relatives must be measured; attempts to find measurable indicators in males have so far failed.

Genetic gain per generation can be converted to annual genetic gain (Δ_{Ga}) through dividing by the average age of the parents when the offspring are Born.

$$\Delta_{Ga} = \frac{\Delta_G}{\text{average age of parents}} \quad \text{-- (3)}$$

Here the average age of the parents becomes important in choosing which female relatives should be measured for sex-limited characters.

Formulae (1 and 2) apply to single characteristics, or to indices combining a number of traits, using economic weights, heritabilities and genetic correlations. Many such indices have been developed, and computers have simplified their calculation and use. If computers are not readily available or if measurement costs are high, there is still merit in independent culling levels, which in some circumstances are no less efficient, in terms of genetic gain, than the indices.

Table 2 gives available estimates of heritability for the most important performance criteria.

Selection should be made as early as possible in an animal's life. First matings for sheep are usually at 1–1/2 years, though with some breeds earlier matings are possible. Selection can be based on measurements at 12–18 months for characters not sex-limited. Heritabilities for these are sufficiently high for selection to be based on an animal's own performance unless artificial insemination is being used; it would be wise to progeny test sires before wide use with AI. The advantages of earlier matings are discussed below.

For reproduction rate and milk production, no measurements are available till after a female's first parturition. Lifetime performance of the dam is then a useful selection criterion for both sexes. Again, if AI is to be used, progeny-testing of the sire is desirable.

If full records on the dam are not available, then for the female production of multiple births at her first parturition, or her first lactation record, may be used. The advantage of using dams' records is that the female can be selected before she enters the breeding flock.

Vital Statistics

These include reproduction rate (number of offspring born and weaned per year per female exposed), death rates, length of productive life, and defects.

The length of the breeding season varies for both sheep and goats; near the equator, all-year-round breeding can occur, though there may be seasonal differences in ovulation rate. Obst et al. (1980) in Indonesia found an average ovulation rate of 1.2 in Priangan sheep in September -October, compared with 1.7 -1.9 in other months. Lawson and Shelton (1982) in Texas found no Spanish does ovulating in March and April, with rates ranging from 1.17 in May to 1.86 in November. In higher latitudes, the breeding season is more restricted.

Increasing the frequency of parturitions is a technique for higher reproduction rates which has received more attention in recent years, three parturitions in two years being a common aim. The number of offspring born (or weaned) per female per year then is:

$$\frac{\text{(Mean no. of offspring born at one parturition)} \times 365}{\text{Interval between parturitions}}$$

Reproduction rate - One parturition per year

The components of reproduction for yearly parturitions are:

- Proportion of females failing to produce offspring,
- Litter size,
- Survival rate of offspring to weaning.

Simple arithmetic indicates that increased litter size will give more rapid progress in raising the number of offspring born than reducing the proportion of barren females. The upper limit through the latter route is 100% ; if all females produced twins, the limit would be 200%, and so on. Survival rates are usually lower for offspring from multiple births, but only on rare occasions are they sufficiently lower to offset the increased number born (Turner and Young 1969, Hanrahan 1982b). For twin births, the survival rate must be less than half that of singles, for triplets, less than one-third, for quadruplets less than one-quarter, and so on. Decreases in survival rate of this order have seldom been reported.

Although advantages in numbers from multiple births are not eliminated, higher death rates and slower growth rates lower productivity from their potential, and French workers have developed systems of early removal and artificial feeding of lambs which increase productivity, though with some financial cost (Thimonier et al. 1975). The risk of high mortalities has led some workers (e.g. Peacock 1982) to recommend against selection for twins in sheep in severe environments; she nevertheless recommended such selection in goats.

Sheep : Successful selection for increased average litter size at birth is evident in the few highly prolific sheep breeds of the world, such as the Finn (Finland), the Chios (Greece), the Dahman (Morocco) and Hu (China), the Barbados Blackbelly (Caribbean) and the Booroola Merino (Australia). All have been developed originally in small, carefully managed flocks. The length of time required to reach the current high average litter size is not known, except for the Booroola Merino (Turner 1978, 1982). When CSIRO acquired its sample in 1958, the Seears brothers had been selecting their flock (on the ewe side only) for 10–15 years, and had reached an average litter size of around 1.9; by 1984, following selection in both sexes, the average litter size in the CSIRO flock was 2.5, with an average ovulation rate of 4.2 (Piper et al. 1985). Selection has been based on lifetime performance of the dam, adjusted for age, for rams, and this plus the ewe's own performance for ewes.

Losses among multiple-born lambs increase with litter size but, as stated before, the increases in death rate are seldom enough to eliminate the raised numbers. Ewe progeny of Booroola rams by two other strains of Merino ewes weaned 16% (Piper and Bindon 1982) and 28% (McGuirk et al. 1984) more lambs than the progeny from rams of the respective strains.

Since lambs from multiple births are smaller than those from single births, economic returns from weight of lamb weaned have also been studied. A comparison of crossbred dams from Booroola and random Merinos by two meat breeds has shown that the Booroola ewe crosses produced annually 27% more lambs and returned 24% more dollars per head than the control crosses (Bindon et al. 1985).

The fast rate of selection response with the Booroola has been explained by the presence of a single gene (Piper and Bindon, 1981; Piper et al. 1985), and this discovery has stimulated a search for single-gene control of litter size in other prolific sheep breeds. Selection response has also been obtained where no single gene has been suspected. Turner (1978) reported an initial gain of 35 in the percentage of peppin Merino ewes with at least one multiple birth in their first 3 lambings through selection of twice-twinning base ewes, and an annual increase of 2.4 over the next 14 years. The annual gain in lambs born per 100 ewes exposed was 2. Rzepecki (1979) reported that lambing percentages increased from 114 to 160 over 15 years (= 3 lambs/100 ewes/year) in a closed flock of Polish Merinos. Other successful responses have been reported by Wallace (1958) and Clarke (1975) with the N.Z. Romney, and Owen et al. (1980) with British breeds.

In most of these reports selection was on litter size at birth, in the case of the Australian experiments using lifetime records of the dam. Hanrahan (1982a) reported selection on the ewe's own ovulation rate and body weight in Galway ewes, with increases over unselected ewes of 0.35 in ovulation rate, 0.37 in litter size and 2.4 kg. in body weight. The aim is earlier selection of the ewe on her own performance.

A fitting conclusion to this section is Mason's statement (1980, p.97) after reviewing prolific sheep breeds: “It is therefore tentatively concluded that almost any breed of sheep could be selected for prolificacy and the principal requirement is that the owner should conceive the idea".

Goats: Many authors have reported high average litter sizes for some goat breeds e.g., Hoist and Pym (1977, Australia), Acharya (1982, India) Devendra (1983, Malaysia), Wilson (1984, Africa), Cheng (1985, China). There seem to be no reports, however, of results of selection to increase reproduction rate.

Reproduction Rate - More than one parturition per year

The components are the same as for one parturition per year, plus the interval between parturitions, which mainly depends on the length of postpartum anoestrus.

Sheep : Although many successes have been reported for more frequent lambings, there have also been failures, and I have been unable to find any references to the results of selection to increase lambing frequency. Hunter (1968) gave a very comprehensive review of information up to that time, while the possibility of selecting ewes more capable of sustaining frequent lambings has been discussed by Bernard and Fahmy (1974) and Lindahl and Terrill (1975).

For sheep which can come into oestrus all the year round, matings could occur twice a year if postpartum anoestrus lasted no longer than approximately 30 days. Mason (1980, Table 24) gives lambing intervals with ranges from 6 to 8–9 months for the hair sheep of the Americas, 6 to 7–9 months for the Asian and African and 6–7 to 10–12 for the European prolific breeds. These ranges would indicate the possibility of selecting towards twice-a-year lambing, but Mason reports only Spurlock (personal communication) as using this selection, with the Barbados Blackbelly, and he settled on 3 lambings in two years. Management requirements and the desired product dictate the appropriate frequency; if milk is a main product, more frequent lambing will interfere with lactation.

Goode et al. (1980) tried 4 lambings in 26 months with 3 crosses (Barbados × Borset, Finn × Dorset, Finn × Rambouillet) and pure Suffolk; only the Barbados cross produced any lambs at all at the fourth lambing.

Systems of lambing 3 times in 2 years have been more often successful, though not universally so. Lax et al. (1979) suggested it was not feasible for breeds in Wisconsin. Notter and Copenhaver (1980) used Finn × Rambouillet and Suffolk × Rambouillet crosses in an 8-monthly lambing programme over 5 years. The half-Finn ewes of different ages bore from 10–19 lambs over the period, compared with 7–10 for the quarter-Finn and 7 for the Suffolk cross, but both conception rate and litter size declined with successive lambings.

Fogarty, Dickerson and Young (1984, 1985) presented an extensive analysis of an accelerated lambing trial (3 in 2 years) with 5 breeds and 2 crosses over 4 years. They concluded that "the major limitation for accelerated lambing was fertility and litter size born. These limitations might be overcome by genetic changes in length and level of breeding season fertility, and in lambing rate".

The possibility of selecting for ability to lamb every 8 months, however, remains unanswered, more work on long term selection is needed, including an assessment of the effect on lifetime performance.

Goats : Not as much work on "accelerated" parturitions has been done with goats as with sheep, possibly because bucks often run continuously with does. Wilson (1984) quoted mean kidding intervals of 200–310 days (depending on parity) for African breeds, Devendra (1983), 259–360 days for Malaysian breeds and Acharya (1982), 229–376 days for Indian breeds. There is therefore scope for 3 kiddings in 2 years with controlled matings, but assessment of the effect on lifetime performance is desirable.

Annual death rates and length of productive life

Though these are important aspects of efficiency of production, there is no work on genetic aspects for either species.

Major defects

Nicholas (1985) has prepared a bibliography of papers reporting genetically controlled defects in domestic animals.

Meat Production

Number of surplus animals is the main component of meat production; the others are the quantity and quality of meat per animal, the latter depending mainly on the absence of excessive fat. Liveweight has been taken as the best single measurement in selection for increased lean meat production in sheep (Tallis, Turner and Brown, 1964, Bradford and Spurlock, 1972), but with consciousness of the association of fat with health problems there is now an increased demand for fat estimation in selection for meat production. Since goats produce leaner meat, the need with them is not so great.

Weaning Weight

Sheep: Weaning weight has a lower heritability than later liveweights (Table 2), but selection responses have been obtained, with gains of approximately 2% per annum over a random control (Pattie 1965) for a period of 10 years.

Goats : No selection reports have been found, but a heritability estimate of 0.35 for 5-month weight in Australian feral goats indicates that there should be response to selection.

Total weight of offspring weaned

This is a useful selection measure for ewes, which has been adopted in the New Zealand Sheep Performance Recording Scheme, Sheeplan. It combines number of lambs born, lambs' survival rate and lambs' weaning weight.

Other body weights

Responses to selection for yearling or 15-month weight in sheep have been obtained, e.g. in the Australian Merino (Turner et al. 1970). Initial selection of base animals gave a gain of 10% over a random control: during the next 14 years the gain increased by 1.5% per annum.

Fibre Production

For both species, weight per head per annum is the criterion for quantity-clean weight for preference, but the correlation with greasy weight is high, and this can often be used. Where animals are shorn more than once a year, weights of part-time shearings are added.

Sheep

Wool can be divided broadly into two categories, apparel and carpet-type. The main quality characteristic is average fibre diameter, required to be low for apparel wool and higher for carpet-type. Apparel wool requires absence or a low percentage of medullated fibre, whereas for carpet-type a certain percentage of heterotypes (with interrupted medulla) is desirable. Kemp (shed medullated fibre) is undesirable for both categories.

Other important quality traits are length (not falling below a minimum) strength (showing no tenderness, or point of reduced diameter) and pigmentation. White wool is preferred for both categories on the world market, but for some local markets pigmented wool is desirable.

Table 2 shows that the heritability levels for wool weight and quality traits are high. (Pigment of the whole or part of the fleece is genetically controlled and can be manipulated, though the presence of individual pigmented fibres in a white fleece is causing concern, and the inheritance of these is under investigation in Australia). Long-term selection for wool weight, with and without control of quality, has been reported from several experiments in Australia (Turner 1977), with gains of 2% per annum when quality was controlled through diameter. Attempts to control quality by maintaining high crimp frequency leads to lower rates of increase in wool weight, because of the high negative genetic correlation between the two.

Goats

The quality characteristics for mohair and cashmere are similar to those for wool. Although no selection experiments have been reported, Shelton (1979) concluded that selection for fleece weight had been effective as average weight per head in Texas had increased from 1.4 kg. in 1910 to 3.4 kg. in 1975 (= 0.03 kg/year).

Work on increasing cashmere production is in progress in Australia (Restall, personal communication), India (Bhat in SABRAO 1980) and China (Cheng 1985).

Milk Production

Milk production is measurable only in the female, and also requires more frequent recording than other characteristics considered. For this reason genetic progress will be made mainly through distribution of males (or semen) from a central necleus in which measurement and recording are possible, and in association with which progeny - testing of males can be done.

Sheep

One of the countries best-organized for achieving genetic progress in milk production from ewes is France. Flamant (1970), Flamant and Barillet (1982) and Flamant et al. (1982) have reviewed the work; milk-recording now involves over 80,000 ewes served by progeny - tested rams, and over 130,000 subject to a simplified recording scheme and within-flock mass selection.

Goats

Both Norway and France have reported herd recording schemes for goats. The Norwegian records show an increase in lactation milk yield from 574 kg. in 1967 to 592 kg. in 1978, the correspondingly fat percentages being 3.4% and 3.2%. The highest record is given as 1960 kg.

Steine (1976, 1980) gave estimates of genetic parameters and described the Norwegian recording and progeny testing system; he predicted annual gains of 1.0 - 1.5% in milk yield using natural mating, with the Norwegian system of “buck circles”. He considered that AI for goats was at that time not suitable for wide use.

Using genetic parameters estimated in Norway, Ronningen (1967, 1980) made theoretical predictions of possible increases under Swedish conditions of 1.6% (11 kg. milk) per annum with natural mating, or 1.9–2.8% (13–19 kg.) using AI.

Bouillon and Ricordeau (1975) made estimates of direct and indirect responses to selection for milk production in goats in France. Selection for milk yield would increase yields of milk and milk protein and fat, but would decrease percentages of protein or fat. If cheese-making were the aim, they suggested selection for yields of protein or fat.

Singh and Acharya (1980) suggested that selection on first lactation yield would give large responses in lifetime performance for the Beetal goat in India.

Correlations between Characteristics

Turner (1972) reviewed estimates of genetic correlations between sheep production traits, and concluded there are no important genetic antagonisms, provided wool quality is based on average fibre diameter and not, as formerly, on crimp frequency. A high negative genetic correlation between wool weight and crimp number/unit length of staple will hinder genetic gains in wool weight if there is simultaneous selection to maintain high crimp frequency. The genetic correlation between wool weight and fibre diameter, though positive, is low, and diameter can be kept from increasing without serious loss to gains in wool weight (Turner et al. 1968).

Some negative estimates of the genetic correlation between wool weight and reproduction rate led to concern at one time, but other estimates have been negligible, and reciprocal selections for wool weight and reproduction rate in the Australian Merino have led to no changes in the other character. (Turner et al. 1972 and Turner, unpublished)

Estimates of genetic correlations for goats are not as numerous as for sheep.

Ways of increasing selection response

Establishing a Nucleus

The previous discussions have related to selection within one flock. Greater genetic progress can be made if a large population can be screened and the top animals placed in a central sire-breeding nucleus. Suppose 4 percent of rams and ewes can be drawn off in this way, taking the most superior animals from a number of flocks or herds; the average standardized selection differential of the parents is then 2.154. With a heritability of 0.4 and a standard deviation of 12%, the offspring of these parents would on average be $2.154 \times 0.4 \times 12 = 10\%$ superior to the average of the population from which they came. If males from this necleus are then distributed in the original population, they will give an initial production boost due to the superiority of the nucleus. Thereafter genetic progress in the main population due to selection will be at the same rate as in the nucleus. Apart from its initial advantage of including the most superior animals, a necleus has the additional advantage of being a centre in which new techniques can be concentrated.

Increasing the selection differential

The importance of a high selection differential has already been stressed, together with two avenues of increase - raising reproduction rate and using artificial insemination. Recent techniques involving multiple ovulation and embryo transfer (MOET) make it possible to increase the selection differential for females as well as males. Such techniques require a high level of facilities and technical skills; they could be applied in a central nucleus, but costs would need to be balanced against advantages, and the dangers of inbreeding would need to be watched.

Decreasing the generation interval

Reduction of average parent age from 4 years to 2 would double Δ_{Ga}, while reduction of 4 to 1 would quadruple it.

Average parent age depends on age at first parturition for both sexes, and for females on reproduction rate as well; for example, if only 25 females reached mating age per 100 mated, 5 age-groups of dams would be required to allow for annual death rates, compared with only 3 if the reproduction rate were high enough to lead to 40 replacements per 100 females mated.

Both age at first parturition and reproduction rate depend on species, breed and environment, and both can be changed by selection. Multiple ovulation techniques can be used to increase the reproduction rate; combined with embryo transfer they can be used to ensure that replacements come from young dams, so providing another avenue for decreasing generation interval. As previously stated, the techniques are not yet likely to widely applicable.

CONCLUSIONS

Selection of species and selection of breeds or strains within species can both increase efficiency of production.

Selection of individuals within a flock has led to genetic gains of 1.5 -2.0% per annum in the character under selection. These may at first sight seem small increases, but they are permanent and cumulative. The total genetic gain after 10 years would be 10 ΔGa, and the total extra product over the 10 year period would be -

$$\text{Total gain} = \Delta_{Ga} + 2\ \Delta_{Ga} + \text{--} + 10\ \Delta_{Ga}$$
$$= 55\ \Delta_{Ga}$$

In other words, a flock with an initial wool weight of 4 kg. of wool, with a Δ_{Ga} of 2% (=.08 kg.) would after 10 years return an extra amount of 55 X 0.08 = 4.4 kg. per head.

These are minimum rates of gain; various techniques exist which can increase them.

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TABLE 1. Average selection differentials for different ratios males : females

Male : female ratio	No. males required	Proportion saved (males)	Standardized Selection differential (males)	Average selection differential	Percent change over 1 : 50
1 : 25	40	0.08	1.858	1.104	- 12
1 : 50	20	0.04	2.154	1.252	0
1 : 100	10	0.02	2.421	1.386	+ 11
1 : 500	2	0.004	2.962	1.656	+ 32
1 : 1000	1	0.002	3.170	1.760	+ 41

Assumptions:	No. of females to be mated	1,000
	Males available for selection	500
	Proportion females saved	0.80
	Standardized selection differential for females	0.350

TABLE 2. Heritability estimates

Characteristic	Species		Range of estimates
Number of offspring/parturition:			
Born (other than 1st parturition)	Sheep		0.1 -0.4
	Goat		0.1 -0.2
Weaned (" " " ")	Sheep		0.1 -0.2
Kidding interval	Goat		0.2
Weaning weight	Sheep		0.2 -0.3
	Goat		0.3 -0.5
Weight of lamb weaned/ewe exposed 12–16 month liveweight	Sheep		0 -0.2
	Sheep		0.4 -0.6
	Goat		0.5
Annual fibre weight (clean or greasy)	Sheep	-Wool	0.3 -0.5
	Goat	-Mohair	0.2 -0.4
		-Cashmere	0.6
Average fibre diameter	Sheep	-Wool	0.4 -0.6
	Goat	-Mohair	<0.2
		-Cashmere	0.5
Percent medullation	Sheep	-Wool	0,4 -0.6
Kemp score	Goat	-Mohair	>0.3
Staple length	Sheep	-Wool	0.3 -0.6
	Goat	-Mohair	>0.3
		-Cashmere	0.7
Milk yield per lactation	Sheep		0.2 - 0.6
	Goat		0.3 -0.7
Milk - Fat %	Sheep		0.2 -0,6
	Goat		0.3 -0.5

Sources: Sheep: Gjedrem (1969), Turner (1977), Rae (1982).
Goats: Shelton and Bassett (1970), Steine (1976), Rae (1982) Restall and Pattie (1985).

RECENT DEVELOPMENTS IN REPRODUCTIVE TECHNIOUES OF SHEEP AND GOATS

H.W. Vivanco

INTRODUCTION

Reproduction is directly affected by various management related factors. Manipulation of these factors can cause changes in reproductive performance. The control and manipulation of the sheep reproduction has been the objective of scientists around the world for many years and more recently the goat is also being studied, because some reproductive characteristics which appeared similar with sheep, after more detailed studies, were found to be quite different.

High levels of reproductive performance can only be achieved under optimum management conditions (including nutrition). This is one factor that determines the dramatic differences in reproductive efficiency between the developed and the developing countries (where the nutrition and general management of the flocks are not quite good). In developed countries of the western hemisphere most of the sheep or goat populations are maintained in small or medium size flocks with more or less intensive systems of production whereas in developing countries (like Peru for instance) the sheep population is exploited in extremely large flocks (80,000 to 200,000 ewes per flock) in extensive systems or in very small flocks (20 to 50 ewes) in the hands of Indian communities with very poor levels of education. The structure of goat production is also quite different in developing countries where the goat flocks are in the hands of nomads and poor goat keepers.

The structural aspects of land (pasture or natural resources) distribution are important factors that determine the possibility of using different systems of production and technology in the small ruminant production. This coupled with the educational level of the farmers and the potential of the available resources (cultivated or natural pastures, rain distribution, water avaiability, ecological environment, etc.) finally decides which practices or technologies can be applied economically to improve the productivity. In addition the “cost of the technology” is an additional factor that has to be considered and can explain partially why in developing countries the use of modern reproductive techniques that are in practice in developed countries (e.g. controlled breeding) are not applied in developing countries on a commercial scale. The big differences in the economic and financial situation between the north and the south are reflected also in the application of technology. Most of the recent developments in reproductive techniques have to use some hormones or imported products that are expensive for producers in the developing countries.

Apartado 456, Lima, Peru

The preceding considerations explain why existing technology in small ruminant reproduction is not being used in developing countries. On the other hand, the objectives in terms of reproductive aspects can be quite different depending on the type of resources that the small ruminant population is using (e.g. twin lambs are difficult to maintain in natural pastures in the Peruvian highlands).

MAIN AREAS OF DEVELOPMENT IN REPRODUCTIVE TECHNIQUES

Sheep and goats because of their gestation period of about five months and the possibility to produce more than one offspring per pregnancy are species whose production methods can still be greatly intensified. In order to maximize the production potential of a small ruminant flock (sheep or goats) it is essential to increase the reproductive rate. There are a group of factors which limit reproductive efficiency namely those which influence the fertility, the fecundity, the lamb survival and the interlambing period. The development of reproductive techniques are directed to solve or minimize the effects of these limiting factors as well as to make possible the application of more intensive systems of production and to facilitate the genetic improvement of the productive characteristics of the flock.

Reproductive techniques in sheep

The main areas of research activity on advanced techniques in sheep reproduction can be summarized as follows:

a) Manipulation of the breeding cycle:

- Synchronization of oestrus during the breeding season
- Out of season breeding - more frequent lambings

b) Breeding at younger ages

c) Increasing fecundity

d) Control of lambing - induction of parturition

e) Pregnancy testing

f) Artificial insemination

g) Embryo transfer

Manipulation of the breeding cycle

Attempts to control oestrus and ovulation in sheep during the breeding season and anoestrus are based on simulating the activity of the corpus luteum, producing progesterone in quantity for about 2 weeks and in shutting off production sharply at the end of the oestrus cycle. Progestagen administration was made commercially feasible by the work of Robinson (1964) using the progestagen impregnated sponge inserted intravaginally. The technique of vaginal sponges for the control of the oestrus cycle in the ewe is now well developed in France and this system is spreading in Spain, Italy, Holland, Germany, Isreal and in some East European countries.

Synchronization of oestrus during the breeding season: One application of the progestagen technique is the synchronization of the ewe's oestrus during the breeding season, so that all ewes will show oestrus simultaneously during a 3-day period. Different procedures are in use for this purpose:

(i) Vaginal progestagen pessaries

Only compounds with characteristics identical to progesterone, especially in having short duration of activity, are suitable (Robinson, 1976). These compounds, according to studies in Australia (Robinson et al., 1968), Ireland (Gordon,1971) and France (Colas, 1975) are flurogesterone acetate (FGA) and medroxyprogesterone acetate (MAP). When FGA (30 mg) and MAP (60 mg) have been compared in ewes by artificial insemination, a small but significant advantage in favour of FGA was found (Smith et al., 1981). As well as the question of the particular progestagens which are regarded as acceptable for intravaginal applications there are two other important considerations; dose level of compound and method of impregnation employed in the preparation of sponges (Gordon, 1983). Robinson (1968) mentioned that a progestagen dose which will inhibit ovulation in the cyclic ewe is lower than that required for full fertility. The rate of absorption of FGA from intravaginal sponges can be significantly affected by the impregnation procedure and by the initial dose of compound (Robinson et al., 1968). Absorption rate significantly affected the percentage of ewes in oestrus and the number of sheep lambing to service at the controlled heats. Gordon (1971) reported that a significantly higher mating response and lambing outcome resulted from thorough dispersion of a 30 mg dose of FGA in the sponge matrix. The dose of FGA which can be regarded as optimal, lies in the range of 20–40 mg. With MAP, the 60 mg dose appears to be the standard currently (Gordon, 1983). The procedure currently used for oestrus synchronization during the breeding season is to insert the vaginal progestagen pessaries (MAP or FGA) in the vagina for 14 days, creating an artificial cycle for all ewes. When the pessary is removed ewes will show oestrus 2 to 4 days later (Bindon, 1982).

(ii) Progesterone implants

An alternative approach to the intravaginal sponge in sheep is the subcutaneous implant containing the natural hormone, progesterone. Leman et al., (1970) used implants impregnated with 375 mg of progesterone, others have reported the same technique (Doane, 1971; Zenoulis et al., 1972; Gordon, 1975). The implant is inserted under the skin in the brisket region and removed 14 days later. Ewes show oestrus 2 to 3 days after implant removal. According to Gordon (1983) using the progesterone implants in Ireland it has not been possible to match the speed and simplicity of the intra-vaginal sponge technique.

(iii) Prostaglandin injection

The prostaglandin $F_2\alpha$ works by inhibiting the production of progesterone from the ewe's ovary. During the normal oestrus cycle in the ewe prostaglandin $F_2\alpha$ is synthesized and released from the uterus, causing the regression of the corpus luteum (McCracken et al., 1970; Goding, 1974). In comparison with the oestrus response after progestagen treatment in ewes, the incidence of oestrus that follows the prostaglandin method may be much lower (Gordon, 1983); also the fertility rate is depressed (Bindon, 1982). If the natural prostaglandin $F_2\alpha$ agent is employed, the accepted luteolytic dose of 15 mg is about 60% of that required in the bovine; using the cloprostenol analogue, 100 µg has been employed as a luteolytic dose, which is only 20% that employed in the cow (Gordon, 1983). In comparison with the progestagen or progesterone treatment the prostaglandin (PG) treatment is more expensive. In order to use PG the ewe must be in the 5th-13th day of her cycle, so that to synchronize, all ewes in the flock, 2 injections are given 9 days apart. Ewes show oestrus on 2–3 days after the second injection. Table 1 shows a comparison made by Bindon (1982) between the synchronization methods.

Synchronization methods can be useful in A.I. programs or in hand service in some smaller studs wanting to reduce spread of lambing to allow maximum supervision. In Peru we used the intravaginal sponges with MAP in 40 ewes syncrhonized during the breeding season this March 1985 to perform embryo transfer using frozem embryos from Montana (USA) to introduce Finn sheep in Peru. The use of synchronization methods in developing countries can have justification in genetic improvement programs in selected studs from which the genetic material then can be distributed in other flocks.

Some disadvantages of the use of synchronization of oestrus during the breeding season are the necessity of a higher ram: ewe ratio than in natural mating for maximum fertility. Also lambing figures will not be improved and may be slightly reduced.

Out of season breeding: Progesterone implants and progestagen intravaginal sponges also can be used for out of season oestrus induction in sheep. In most out of season applications it is also considered essential to augment the supply of exogenous gonadotrophin by administering a follicle-stimulating agent on completion of the progestagen treatment. The cheapest, most readily available and consistently effective gonadotrophin for this purpose is PMSG. So ewes may be induced to breed outside their normal sexual season by the combined use of a 12 day progestagen phase to simulate the oestrus cycle and an injection of a gonadotrophic hormone, usually PMSG, to cause ovulation. With this method the ewe shows oestrus 48–60 hr after PMSG (400–700 i.u.) which is injected at the time of sponge or implant removal. Fertility should be 60 to 70% (Bindon, 1982; Vivanco et al., 1985). Table 2 shows a summary of results in different locations in the world. This procedure is now used on 1 million ewes per year in France and about 20,000 per year in the U.K. and Ireland (Bindon, 1982). The objective in almost all cases is to advance breeding season with a view to producing early lambs to catch a market premium. This method also could be used to create 2 lambings per year (Cognie et al.,1980).

Unfortunately, in developing countries, the lamb market is not organized and the commercialization and prices fluctuate at ramdom, sometimes the government fixes or regulates the prices so the lambs born out of season have no premium. In addition lambs born out of season, if there are no cultivated pastures available, cannot be grown successfully. So the use of out of season breeding to advance the lambing season or to produce 2 lambings per year is only feasible in flocks with very good management and with good feed supply; this type of farm is very scarce in developing countries This implies the necessity to combine reproduction improvement programs with pasture improvement and technical assistance.

Table 3 shows the results from one experiment in Peru using progesterone implants and FGA sponges for out of season breeding in ewes in the Peruvian highlands under natural pasture conditions at 3,800 m above sea level. Fertility was less than in the breeding season but fecundity was higher because of the effect of PMSG.

Recent research shows that the “Ram Effect” (the ability of the odour of the ram to induce oestrus) in anoestrus ewes may be used to replace injection of PMSG; ewes must have been isolated from rams for at least 4 weeks. The ram is introduced on the day the vaginal sponge is removed.

The manipulation of the breeding cycle in ewes can be done also by artificial day length control (Gordon, 1983). It can be a matter of providing a gradual decrease or increase in artificial day length, similar to what occurs under natural day length conditions or it may be done by subjecting the ewes to an abrupt decrease on one day and thereafter maintaining them at that day length until a response is shown (Fraser and Laing, 1969). One partial disadvantage in using day length control is the fact that individual ewes show oestrus after varying intervals; several weeks may elapse between the time and the first and the last sheep in the flock comes on heat. Obviously this system requires electrification of the rural areas.

Breeding at younger ages

The age at first parturition is critically dependent on the growth rate of the ewe lamb, so if the feed availability is short or the genetic characteristic of the sheep is not for fast growth, the age at the first parturition will be delayed. But in some circumstances the intensification of the production systems allows a reduction of the interval from birth to first mating and this can have obvious benefits: reducing maintenance costs, shortening the generation interval, increasing the genetic gain and increasing lifetime production. In Peru for example, young ewes maintained extensively in natural highland pastures are currently mated at 18 months of age, whereas in other parts of the world most sheep farmers breed ewes for the first time at the yearling stage. For the Peruvian farmers that are introducing cultivated pastures, it is of interest to start breeding the ewe at one year of age because at that age they reach the same body weight as the 18 months old ewes in natural pastures. For ewes that are one year in November (anoestrus period or very poor oestrus activity) some technique of oestrus induction has to be apllied. In other locations of the world the objective is to mate at 7–8 months of age to have first lambing at one year of age.

In France where controlled breeding is now used on some scale in ewelambs, it is recommended that ewe lambs should be 60–65% of their mature weight and older than 7 months before being induced to cycle using the FGAPMSG technique (Thimonier et al., 1968).

Increasing fecundity

In farming situations where the full genetic potential of the particular breed is being achieved and a further improvement in litter-size is considered desirable, then the introduction of a more prolific breed, selection of ewes within a breed or the artificial control of litter-size are among several of the options available (Gordon, 1983).

In Peru, the sheep breeds (Corriedale, Junin and Criollo) have very low ovulation rates and the incidence of twins under natural pasture conditions is extremely low. Under cultivated pastures the Junin breed increases slightly in twinning percentage (about 2% of twinning); so in cultivated pastures it is necessary to increase the fecundity of ewes in order to have more profit per hectare. The genetic approach requires more time to introduce and or select the characteristic. Physiological methods, like the use of exogenous gonadotrophin or the immunization against sexual steroids, are interesting alternatives that have the advantage that they can be applied under the decision and control of the farmer according to the feed availability.

(i) Use of PMSG to increase the fecundity

Lambing figures may be increased by treating ewes with PMSG applied on day 14 of the oestrus cycle. This is somewhat similar to the out of season breeding technique. An injection of approximately 400 i.u. of PMSG should increase the number of lambs weaned by about 20% (Bindon, 1982). Ewes must be synchronized so that day 14 can be easily identified. The schedule recommended is: insert MAP sponges day 1, remove MAP sponges day 14, inject PMSG day 30, days 33–36 expect ewes on heat with normal fertility. A disadvantage of the use of PMSG is the long half life of this hormone so the response of the ewes is variable; in our experiment we found ewes with five corpora lutea after 700 i.u. of PMSG treatment and some triplets at lambing.

(ii) Immunization against steroid hormones to increase lambing percentages

Immunization of the ewes against their own oestrogenic steroid hormones is a new method of increasing lambing percentages of sheep due to the increase in the ovulation rate. The procedure was developed by the CSIRO Division of Animal Production (Cox et al., 1976; Scaramuzzi et al., 1977). This technique offers the potential of an immediate gain in ovulation rate and lambing percentages, the flexibility of a decision each season and the possibility of a simple treatment (Cox, 1983). Active immunization is considered likely to be more practical than a passive system. Ewes are vaccinated against their own oestrogneic steroid hormones and this has the effect of upsetting the system which regulates the number of eggs shed.

From the results obtained by the CSIRO team up to mid-1982, a basic protocol was defined giving optimal results with an androstenedione -7-HSA immunization. In this, 1.2 mg androstenedione -7-HSA in 5% DEAE-Dextran/0.9% sodium chloride solution, is administered in 2 ml at a single site subcutaneously in the upper third of the neck. Spacing between first and second treatment is 3–5 weeks. Synchronization of oestrus is not required. Rams are joined 2–3 weeks after the second injection or after the booster injection in subsequent years. If rams are joined earlier than 2 weeks, poor results are likely (Cox, 1983). Table 6 shows some results from New Zealand quoted by Bindon (1982). The immunization method is now commercially available in Australia, New Zealand and U.K. Table 7 shows the results obtained by the commercial applications.

The application of immunization increases lambing percentage by between 20 to 30% in breeds like Corriedales that have currently a low twinning percentage.

Obviously the increase in fecundity requires good management and food availability, so the application of these methods are limited to farms in which this requirement can be achieved. In developing countries farming is generally carried out in harsh environments. This condition determines that the reproductive rates are poor compared with the standards of the temperate countries. Efforts are in progress to improve the pastures and farming conditions; for instance in Peru some large co-operatives are irrigating lands in the highlands to cultivate ryegrass and clover. On cultivated pastures the ewes have to achieve a higher reproductive performance in order to utilize the better resources. In those cases the use of techniques to increase lambing percentage can be justified.

Control of lambing - induction of parturition

The main objective for the use of techniques for control of lambing is to reduce labour, to supervise more closely the lambing of stud ewes, or to induce premature lambing in pelt producing sheep (Karakul). These techniques are used in highly sophisticated intensive sheep systems. French research has led to a successful technique for reducing the spread of lambing. It is based on the injection of a hormone (Dexamethasone) which mimics the action of the signal normally produced by the foetus to initiate parturition. Ewes are injected on the evening of day 144; it is thus essential to know the date of conception. Lambings will normally be confined to a 48 hr period and about 75% will occur during daylight hours (Bindon, 1982).

Part of the reason for interest in compact lambing is in being able to reduce lamb mortality by the application of well-proven management techniques for ensuring survival of the lambs (Gordon, 1983). In the Peruvian highlands, lamb mortality reaches about 25% due to the negative effects of climatic factors (frost, limited food availability, etc.).

Closer observation of the flocks during lambing can help, especially in the stud flocks, to reduce the lamb mortality.

Pregnancy testing

The interest in sheep farming of early pregnancy detection is based on the necessity to select the pregnant ewes to give them better feeding and attention and culling barren ewes. In some farms in which twinning is expected there is an additional interest to determine whether the pregnant sheep is carrying multiple foetuses so that special management can be applied before and at the time of lambing to eliminate lamb mortality.

Several methods have been developed: radiographic techniques, progesterone and oestrogen tests, ovine placental lactogen, immunological tests, vaginal biopsy, laparotomy, ultrasonic techniques, rectal-abdominal palpation, manual examinations (Gordon, 1983). From these very few can be used practically and economically at farm level; perhaps the most practical one for simple early diagnosis is the detection of the fluid filled uterus by A-mode sound. The ewe is usually dealt with in the standing position, the transducer is smeared with oil and placed on the bare skin of the belly about 50 mm in front of the udder on the ewe's right side. When the narrow beam of ultrasound meets tissue which has a different acoustic value (like the fluid filled, pregnant uterus), it is reflected at the boundary of the object; the echoes are received by the transducer and converted into signals which are amplified and displayed on a cathode ray screen or in some other visual form (Gordon, 1983). In Peru we are applying this method since 1980, the ultrasound was introduced by the Small Ruminants Collaborative Research Program US-AID (CRSP-US-AID). The diagnosis is done between 40 to 50 days with 96% of accuracy.

To diagnose multiple births during pregnancy, Bindon (1982) refers to techniques potentially available such as the real time ultrasound scanning and the plasma-glucose measurement (ewes carrying twins or large singles have significantly lower blood glucose from about day 90 of gestation).

Artificial insemination in sheep

Artificial insemination (A.I.) is a reproductive method of great influence in the improvement of productivity. The advantage of A.I. has to be coupled, however, with an appropriate reproductive rate. That means that the A.I. must not have a detrimental effect on conception and lambing rates. The effort of the research centres has been focused on increasing the viability of the semen doses, especially testing different diluents. The most distinctive characteristics of A.I. in sheep are probably:

(i) the necessity to have large quantities of sperm cells in the insemination doses in comparison with the concentration of spermatozoa in bovine insemination (100 to 500 million sperm in sheep vs. 10 to 30 million sperm per A.I. dose in bovine).

(ii) The relatively short effective life of the refrigerated diluted semen (24 hours vs. 3 days in bovine).

(iii) The anatomical obstacle of the ovine cervix, not permitting the access of the insemination pipette deeply in the cervix (Bunch and Ellsworth, 1981).

(iv) The extensive practice of insemination with raw semen.

(v) The limited use of frozen semen due to the low fertility rates obtained.

(vi) The non-existence of commercial A.I. organisations for the sheep industry; most of the inseminations are done with semen collected on the farm.

These characteristics are in some way determining that A.I. is not in sheep the main reproductive method and genetic improvement tool whereas in bovine the importance of A.I. is enormous. The use of A.I. in sheep in Western Europe and United States of America is very limited; France is one of the countries in Western Europe in which A.I. is developed. In the Soviet Union and some Eastern European countries A.I. is more widely used. In Peru, the total number of ewes inseminated per year is about 300,000 compared to 40,000 cows inseminated per year, so in terms of total numbers we are inseminating more ewes than cows. The organization of the sheep industry in each country determines the relative importance of the use of the A.I. The genetic improvement systems, selection pressure and availability of rams are some of the determining factors.

In Peru, the sheep population consists mainly of “Criollo” animals introduced by the Spanish 400 years ago; those animals became naturalized to the harsh environment of the highlands, but sacrificing their productive characteristics because of the lack of genetic improvement programs. Thirty to fifty years ago the introduction of improved breeds like Corriedale led to crossing with the Criollo sheep. Since that time there have been periodic imports of rams from Australia, New Zealand and other countries. These rams are intensively used through artificial insemination using either raw semen or fresh diluted semen; the fertility rates fluctuate between 60 to 70%.

It is probable that by increasing the viability of refrigerated and frozen semen A.I. in sheep can be greatly improved; because semen is deposited only in the entrance of the cervix then semen with low viability cannot reach the fertilization site with enough capacity to fertilize the ova. Experiments with intra-uterine insemination have demonstrated higher conception rates using frozen semen compared with cervical insemination; this demonstrated that if the sperm cells can avoid passing through the cervical canal they can be much more fertile (Fukui and Roberts, 1976; Maxwell etal.,1983).

In Australia the use of the endoscope for intra-uterine insemination with frozen semen has given very good fertility (Maxwell et al., 1983). The results are shown in Table 8. According to these results, successful A.I. with frozen semen can be done at 60 hours after FGA sponge removal, inseminating 40×10^6 sperms per uterine horn by endoscopy.

In Peru, we have been interested in developing A.I. in sheep with frozen semen; so we started, in 1978, comparing different diluents and freezing methods. In 1980, we inseminated 34 ewes with frozen semen using tris-egg yolk diluent. The semen was stored in ampoules in liquid nitrogen. The insemination was carried out by the cervical method with doses containing 80 million sperms. The lambing rate was 57.9%. The semen was processed at the National Agrarian University in Lima and the inseminations were done in the highlands (Table 7).

Due to the help of the International Atomic Energy Agency in our research activities in Peru, we have the advice of CSIRO Scientists from Australia. This has led to the importation of semen from proven Corriedale rams. The semen was frozen in pellets at the University of Sydney and imported into Peru in October 1984. We inseminated 1,000 ewes (in commercial scale) in November 1984 (out of season breeding), synchronizing the oestrus with FGA vaginal sponges and PMSG (500 i.u.); we inseminated an average of 150 ewes per day using two endoscopes, applying the semen by intra-uterine insemination 54 to 60 hours after sponge removal. Each pellet served for two ewes and each ewe received 40×10^6 spermatozoa in each uterine horn. In February 1985 pregnancy diagnosis by ultrasound showed that 65% of the ewes were pregnant. The expectation of the Peruvian farmers in this trial is high because they could in the future replace the importation of rams by frozen semen from proven rams and have the benefit of the selection work of Australian breeders. Apparently the use of the endoscope is considered to be complicated but with some practice it is relatively easy. For the large Peruvian co-operatives it is justified to invest in one endoscope for A.I. with imported frozen semen. Of course the utilization of A.I. and especially imported frozen semen has to be a decision made having regard to all the factors (genetic, ecological, economic, etc.)

Embryo transfer in sheep

The A.I. must have an important role in the genetic improvement of the sheep population; through A.I. selection, genetic improvement through cross-breeding can be done gradually and economically. In some circumstances, when it is decided to introduce a new breed, or to boost the population of a particular breed, the use of the embryo transfer (ET) can be an interesting alternative. The ET technology requires the superovulation of donors, breeding of the donors, recovery of eggs, evaluation of the embryos, handling and preservation of embryos, synchronization of recipients, transfer of the embryos. Each of these phases has its own characteristics and problems; research activities have been focused to solve the difficulties in each step and to define an economical and practical methodology.

To some extent, the superovulation of sheep can be considered satisfactory either using PMSG (Lawson et al. 1972) or HAP (horse anterior pituitary) (Moore and Shelton, 1964a). The fertilization rates obtained in superovulated ewes are also considered appropriate (Moore, 1974). The technique applied for the recovery of eggs due to the anatomical limitations of the ewe, is a surgical method (laparotomy) that involves flushing the eggs from the reproductive tract (Holstand Braden, 1972; Moore and Shelton, 1962a, b, 1964; Trounson and Moore, 1984a-c; Tervit and Havik, 1976). Using the surgical approach more than 80% recovery has been achieved, but perhaps the necessity to perform surgery is the main limitation in the development of ET as a practical field method. The embryo evaluation of sheep eggs can be done by stereoscopic microscopy with a high degree of precision (Moore, 1970) and the short or long-term storage of embryos has also been developed for sheep (Adams et al., 1961; Lawson et al., 1972; Moore and Bilton, 1976). Most of the ET was performed under experimental conditions, however, some commercial organizations are now in progress.

The laparoscopic embryo transfer is an interesting alternative. Shiewe et al., (1984) describe a very practical method of embryo transfer using the laparoscope, comparing laparotomy vs. laparoscopy. They realised 16.6 and 50.0% of pregnancy rate, respectively. The laparoscopic approach is probably one of the most promising aspects in the future development of ET as a practical method in the field. Through the CRSP - US-AID Program, Finn sheep will be introduced to Peru in order to perform some genetic trials to increase reproductive rate. For this purpose, 40 embryos will be transferred to recipient ewes in Peru; the embryos were frozen in Montana State University (USA). The embryo transfer will be done by laparoscopic technique on 17th of April 1985. This is an example of how genetic material can be introduced at lower cost into developing countries.

Reproductive techniques in goats

As was mentioned before, goats differ from sheep in some reproductive characteristics; for instance the length of the oestrus cycle in goats is on average 20 days, in sheep 17 days; the length of oestrus is 34–38 hours in goats, 24–36 hours in sheep. Ovulation occurs in sheep 24 hours after onset of oestrus (Bearden and Fuquay, 1980) whereas in the goat ovulation occurs 34.5 ± 6.6 hours after the onset of oestrus (Gonzales Stagnaro, 1984). In addition there are some anatomical differences; the cervix in goats is approximately 3–4 cm in length with 3–6 folds (Simplicio et al, cited by Riera, 1984). In sheep the cervix is 6 cm in length with 5–8 folds (Wond 1958, cited by Riera, 1984). But perhaps the most important anatomical difference is that in goats all the folds of the cervix have a straight alignment whereas in the ewe the second posterior or caudal fold is not aligned with the other folds conferring a tortuous lumen of the cervix (Bunch and Ellsworth, 1981). The anatomy of goats enables deep intra-cervical or intra-uterine insemination through the cervix and may affect approaches for non-surgical recovery and transfer of embryos.

Other differences between sheep and goats were found in the number of placentones, being higher in goats; in the endocrinology of gestation and parturition, the corpus luteum remains active throughout the gestation in the goat; males influence differently the initiation of the oestrus cycle in goats; better responses are found in goats to superovulation than in sheep and also in embryo yields and embryo survival which are higher in does than in ewes (Riera, 1984).

There are some similarities between the species. Sheep and goats are “short day” breeders, can have multiple births, the gestation length is similar as is the postpartum anoestrus.

The seminal characteristics however are different; buck semen has to be handled and processed in a different way (Nelson, 1981; Corteel, 1975). The actual insemination procedures for goats are essentially similar to those in sheep (Salamon, 1976).

Initially, work on reproductive techniques in goats using procedures successful for cattle and sheep were disappointing. French workers started to study goat reproduction more closely contributing greatly to the application of specific reproductive techniques for goats. Today methods of control of the breeding cycle, artificial insemination and embryo transfer in goats are effective.

Control of the breeding cycle in goats

The control of the oestrus cycle can be done in the mating season to synchronize the cyclic does, or for fixed time A.I.(Cortell, 1975; Moore, 1974; Hearnshow et al.,1974).

In the non-breeding season, the induction of oestrus and ovulation in does is also possible (Corteel, 1975).

Control of oestrus during the mating season

During the mating season oestrus can be synchronized by either intra-vaginal progestagen pessaries, progesterone implants or prostaglandin. Does show oestrus 36–48 hours after the removal of pessaries or implants (Moore and Eppleston, 1979). Moore (1980) applied 30 mg FGA in pessaries inserted for around 18 days. A small dose (about 300 i.u.) of PMSG was applied at the time of removal. Corteel (1975) used 45 mg FGA for 18–21 days.

When a single injection of 100 µg of a prostaglandin analogue "Estrumate" (I.C.I.) is used, oestrus occurs one day later and with somewhat less precision than after pessaries (Moore and Eppleston, 1979). In the doe, corpora lutea during the first 4–5 days after oestrus are not sensitive to the luteolytic action of prostaglandin. This problem may be overcome by two injections spaced 10–12 days apart (Moore, 1980).

Control of breeding cycle in the non-breeding season

The goat in most temperate areas of the world is a short-day breeder with peak breeding activity occuring during late summer, autumn and early winter (Moore, 1980). In tropical regions close to the Equator there is some evidence of polyoestric activity throughout the year (Gonzales Stagnaro, 1984) but still more observations are required in these regions. To induce oestrus and ovulation in the anoestrus does progestagen pessaries with PMSG can be used but fertility is dependent upon stage of anoestrus and time of treatment postpartum. In dairy breeds conception rates at induced oestrus are not high until around one month before the start of full breeding activity and during lactation full fertility is not restored until some three months after kidding (Corteel, 1975).

Most recently (Corteel et al., 1984) described two different treatments to induce oestrus and ovulation in the anoestrus dairy goat; a Long Lasting Progestagen Treatment (LLPT) (45 mg of FGA administered by vaginal sponges for 21 days) associated with PMSG (500–700 i.u.) injected intramuscularly 48 hours before sponge removal. The Short Lasting Progestagen Treatment (SLPT) (45 mg of FGA administered by vaginal sponges but for 11 days) associated with two intramuscular injections, one of PMSG (500–700 i.u.) and one of cloprostenol (PGF_2 analogue - 200 ug) both given 48 hours before sponge removal. Fertility based on blood plasma progesterone levels was slightly higher after Short Lasting Progestagen Treatment than after Long Lasting Progestagen Treatment (72.5% vs. 68.2%); kidding percentages were significantly higher, favouring the Short Lasting Progestagen Treatment (62.4% vs. 54.9%). The results are shown in Table 8; the month of A.I. also had an influence. Based on the results reported by Corteel et al., (1984) we applied the Short Lasting Progestagen Treatment on 90 does (Anglo Nubian) in the Peruvian central coast; all of the does showed oestrus after treatment (average 36 hours), then we inseminated with frozen semen donated by FAO through the CRSP; the semen was from the USA. The insemination was performed 18 hours after onset of oestrus. The fertility was poor (less than 40%); the experiment is still in progress, The inseminations were carried out in November–December (spring); these results are in concordance with the explanation made by Corteel (1975) describing low fertility rates in dairy goats at induced oestrus in out-of-season breeding, until one month before the start of full breeding activity.

Artificial insemination in goats

The development of intensive dairy goat farming in some European countries, North America and New Zealand has motivated the use of A.I. in order to prove bucks through progeny testing for milk production. This factor coupled with the accessibility of the doe cervix for intra-cervical or intra-uterine insemination have facilitated the use of frozen semen and the development of commercial organizations for A.I. in goats.

Compared with sheep the A.I. in goats is more accepted by the farmers, some are using A.I. as the main reproductive technique in their flocks. Semen can be collected, either by artificial vagina or by electro ejaculation. When the semen is used fresh, it can be diluted with heat-treated cow's milk. Conception rates higher than 60% have been achieved with semen diluted 2:1(milk: semen) and using a volume of 0.1 ml (Moore and Eppleston, 1979). Diluents containing egg yolk have given rise to very irregular fertility results; kidding rates after a single insemination ranged from 5% to 85% and the improved fertility results reported were never repeated (Corteel 1973). The very poor fertility results obtained by inseminating goat semen preserved in media containing egg yolk may be attributed to high concentrations of lysolecithins in the environment of the sperm cells (Corteel, 1981). These high concentrations are toxic to spermatozoa (Corteel, 1980). Lysolecithins result from the hydrolysis of egg yolk lecithins to lysolecithins and fatty acids; the hydrolysis being triggered by an enzyme secreted in large quantities by the bulbourethral glands of the male goat (Corteel, 1981). So up to now dilutions using cow's skim milk give fairly steady fertility results when semen is maintained at 6°C. But, as a general rule, when extended semen is stored at temperatures above 0°C sperm cell survival is of short duration (a few days) and sperm fertilizing ability cannot be preserved at a high level for more than a few hours (Dauzier,1966).

Insemination with undiluted fresh semen or with liquid stored semen can be used when bucks and recipients are in the same location. With the liquid stored semen short distance shipping of semen is possible; this can be a good tool for Regional Programs of genetic improvement.

Long term storage of goat semen by freezing has been reported by different workers (Bonfert, 1956; Corteel, 1974, 1975; Fougner, 1974; Nelson, 1981) using various diluents and freezing methods. Spermatozoa frozen together with the seminal plasma did not stand storage for more than 2 months (Corteel, 1975); fertility rates better than 50% were obtained only after removal of most of the seminal plasma from the environment of the sperm cells by washing them through dilution and centrifugation before cooling, freezing and thawing, but when ejaculates of high volume are produced the improvement of sperm cell freezability is not substantial (Corteel, 1981). Although non-breeding season seminal plasma is more detrimental to sperm motility than breeding season seminal plasma (Numes, 1980) it is more readily and efficiently removed by the washing procedure because the volumes of the ejaculates are low (Corteel, 1981).

These difficulties in freezing goat sperm is one limiting factor for the development of the A.I. in goats using frozen semen, but some commercial organization are operating using sophisticated methods for freezing. The fertility results after insemination with deep frozen goat semen are variable and are dependent on the freezing method, time of insemination from onset of oestrus, number of inseminations per heat period, concentration of sperms per dose of insemination and site of semen deposition. There are different recommendations in relation to these aspects. Corteel (1981) reported better fertility and kidding percentage following insemination between 0–12 hours after the detection of oestrus. We obtained a better kidding percentage by inseminating at 24 hours after the onset of oestrus and reinseminating at 30 hours after onset of oestrus (Vivanco et al., 1982) with frozen semen donated by “Caritas-Suiza”. Tables 9 and 10 show the results obtained by Corteel and our results. One advantage of goats in relation to sheep is the possibility to introduce the insemination pipette deeply into the cervix; this allows placement of the semen in the uterus without surgery.

The use of A.I. in developing countries can be a very important tool for genetic improvement programs, introduction of specialized breeds, development of selection programs and progeny testing. It is necessary to continue research in freezing methods to find more simple, less sophisticated methods and with better fertility results.

Embryo transfer in the goat

There are very few reports on embryo transfer in the goat, but the results are encouraging and demonstrate that procedures used for transfer in sheep might be successfully applied to the goat. In brief, embryo transfer involves superovulation of donor females with PMSG or HAP, mating, collection of embryos and their transfer to recipient females. Moore and Eppleston (1979) have demonstrated the value of embryo transfer in the Angora Goat. They obtained 393 Angora kids from 121 Angora does, a kidding percentage of 325%. When the best procedures are used it seems possible to obtain 5–6 kids from each donor doe (Moore, 1980).

Embryo transfer with frozen embryos has also been used in goats. The techniques used for freezing cattle, goat and sheep embryos are basically similar (Tervit et al., 1972). This requires gradual and stepwise addition of a cryoprotectant at room temperature; the usual cryoprotectants are dimethyl sulphoxide (DMSO) and glycerol but ethylene glycol and propanediol have also been used; the embryos are placed in glass ampoules or straws which are then sealed, placing the ampoule or straw into a programmable freezer which usually cools at -1°C/min to -7°C. At this temperature ice formation is induced in the freezing solution. Cooling them usually proceeds at -0.3°C/min to around -35°C and finally at -0.1°C/min to about -38°C; plunging the containers into liquid nitrogen and storing for varying lengths of time (Tervit, 1983). Thawing usually involves placing the containers into a 37°C water bath until all ice has melted. The embryos are then recovered and subjected to room temperature cryoprotectant removal, either through a gradual decrease in the concentration of cryoprotectant or a sucrose gradient (Niemann et al., 1982; Tervit, 1983).

According to Tervit (1983), in most studies the number of offspring born from 100 embryos transferred is satisfactory. However, embryos found to be degenerate after thawing are usually not transferred (19% rejection rate) and when embryo survival is expressed relative to the number of embryos frozen around 30 to 40% survival appears to be the norm. Only the best embryos are usually frozen (15% rejection rate) and so the extensive culling of embryos pre- and post-freezing means that considerably fewer pregnancies are obtained per embryo collected compared to unfrozen) embryos.

There are different advantages in using embryo transfer in goats: export of genetic material especially where quarantine restrictions prohibit the importation of live animals, or for better adaptation of introduced breeds in new environments, increase in purebred animals and up-grading (Moore, 1980).

Other reproductive techniques

Other reproductive techniques like induction of parturition, early pregnancy diagnosis, breeding at younger ages and induction of multiple births also can be applied in goats, using the same methods described for sheep, but very little work has been done in these areas perhaps because of lack of interest by the goat industry.

SUMMARY AND CONCLUSIONS

Research work around the world has generated a very important technological package of reproductive methods that can be applied to. increase the reproductive efficiency in sheep and goats as a tool for genetic improvement programs. It is possible to synchronize oestrus and/ or manipulate the breeding cycle, increase ovulation rate, control lambing, make early pregnancy diagnosis, breed animals with top quality males by A.I. or build up of stocks rapidly by embryo transfer, etc. But still some of these techniques have to be improved in order to increase the results in terms of lambing or kidding rates The applicability of such techniques are dependent on the structure or system of production in a particular environment and especially on the ecological or environmental restrictions.

Modern reproductive techniques are applied mainly in developed countries but they constitute a very important tool for the genetic improvement of the non-specialized animals in developing countries using the genetic advances made in developed countries. The applicability of advanced reproductive methods in developing countries requires first the improvement of the actual management practices especially those concerned with the animal nutrition, range management and reproductive management. For this it is essential to have a vigorous educational progam including not only technical aspects but also integral education, especially in poor communities like the Indian communities in Peru which own more tha 40% of the total sheep population of the country.

The main research activities for the future that can be identified to increase the reproduction rates in sheep and goats could be the following:

a) Describe the reproductive potential of the different genotypes of sheep and goats in the different environments in which they are maintained in developing countries (i.e. seasonality of reproduction, ovulation rates, semen characteristics, fertility rates under their current management, etc.);

b) Evaluate the potentiality of the resources available for sheep and goat production in developing countries;

c) Introduce modern practices to manage the resources (natural pastures, cultivated pastures, agricultural by-products, etc.) coupled with reproductive methods to increase fertility, fecundity and total productivity of the flocks;

d) Validate the introduced technology.

In order to improve the actual technology available it will be necessary to;

a) Continue the research activities to increase the viability and fertilizing capacity of frozen sheep and goat semen;

b) Development of practical intra-uterine inseminations in sheep;

c) Optimize the great potential of the immunization methodology for increasing fecundity in sheep flocks;

d) Improve the fertility rates in out-of-season breeding, especially in goats;

e) Find a parameter that can be utilized to predict the fertility rate that can be obtained following A.I.

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TABLE 1. Comparison between synchronization methods

Technique	Approx* cost/ewe (US$)	Ease of Application	Fertility**
Vaginal sponges	0.66	+ + +	61
Progesterone implants	1.09	+	61
PG injection	1.29	+ +	51

* Excluding labour
** Percentage of ewes conceiving to the synchronized oestrus

Source: Bindon (1982)

TABLE 2. Spring/summer breeding of ewes with progestagens + PMSG

Location	Month	Technique	n	% ewes lambed	Litter size	Cost/ewe* treated (US$)
Ireland	Spring	MAP + PMSG	590	72	1.82	6.00
Australia	November	MAP + PMSG	97	60	1.35	2.00
	December	MAP + PMSG	97	53	1.09	2.0

Source: Bindon (1982)
* Excluding labour

TABLE 3. Oestrus induction for out of season breeding in Criollo and Junin ewes in the Peruvian highlands using progesterone implants, FGA vaginal sponges and PMSG (400 and 700 i.u.)

	Progesterone Implants		FGA Vaginal Sponges	
Level of PMSG (i.u.)	400	700	400	700
Total ewes treated	9	11	11	11
No. of ewes mated (%)	8 (89)	9 (82)	6 (54)	7 (64)
No. of ewes ovulating (%)	7 (78)	9 (82)	9 (82)	8 (73)
No. of ewes that lambed (%)	5 (56)	6 (54)	4 (36)	6 (54)
Lambs born per ewe mated	0.75	1.11	0.83	1.14
Lambs born per ewe treated	0.67	0.91	0.45	0.73
Lambs born per ewe lambing	1.2	1.67	1.25	1.33

Source: Vivanco et al. (1985b)

TABLE 4. Results of the immunization against steroids hormones to increase fecundity in New Zealand

Group	n	Ovulation rate	Dry ewes	No. lambs	
				Dead	Weaned
Control	100	1.68	14	28	98
Immunized	100	1.99	13	31	120

Source: Bindon (1982)

TABLE 5. Results of immunization using the commercial treatment field trials 1982/83 season (Australia)

Breed	Group	% lambs born	Increse % lambs born due to treatment
Merino	treated	118	16
	untreated	102	
Border Leicester	treated	140	28
x Merino	untreated	112	
Corriedale	treated	132	20
	untreated	112	
Romney and	treated	141	29
Romney cross	untreated	112	

Source: Fecundin* technical bulletin. Wellcome Australia Ltd. (*Trademark)

TABLE 6. Fertilization and pregnancy after insemination with fresh and frozen - thawed semen

Type of semen (insemination technique)	Insemination time after sponge removal (hr)	Number of ewes			
		fertilized/ laparotomized (%)		pregnant/ slaughtered (*)	
Fresh (cervical)	55	24/30	(80)	33/46	(71)
Frozen (intra-uterine by endoscopy)	24	7/27	(26)	3/34	(9)
	36	12/22	(54)	6/34	(18)
	48	17/25	(68)	17/34	(50)
	60	19/25	(76)	1(/35	(54)

Source: Maxwell et al. (1983)

TABLE 7. A.I. with frozen semen - Peru

Semen from Ram №	No. of ewes inseminated by cervical method	Ewes that lambed	
		№	%
1	15	10	67
2	12	6	50
3	7	4	57
TOTAL	34	20	58

Source: Vivanco and Alarcon (1984)

TABLE 8. Effect of month of A.I. and method of oestrus induction or post A.I. kidding percentages

Method+	June	July	August -September
After SLPT	63.1%	67.5%	66.1%
PMSG + Clo-prostenol	(471)‡	(292)	(330)
After LLPT	49.0% **	57.2%	58.3%
+ PMSG	(259)	(311)	(417)

+ SLPT = Progestaten sponge for 11 days; LLPT = Progestagen sponge for 21 days
‡ No. of does
** = P 0.01
Source: Corteel, J.M., Baril, G., Leboeuf, E. and Boue, P. (1984)

TABLE 9. Fertility of untreated goats inseminated with liquid stored semen at different intervals from onset of oestrus

Hours from first detection of oestrus to insemination	Percentage of does kidding
0 -12	70
12 -24	63
24	47

Source: Corteel, (1981)

TABLE 10. Fertility of untreated goats inseminated with frozen semen in the North Coast of Peru

Treatment	Percentage of does kidding
Inseminated 24 hours after onset of oestrus	67
Inseminated 24 and 30 hours after onset of oestrus	72
Natural mating	61

Source: Vivanco et al., (1982)

INCREASED PRODUCTION AND UTILIZATION OF PASTURE AND FORAGE

I. E. Coop

INTRODUCTION

In such a wide field as pastures and crops it is impossible in the time and space available, to do more than summarise the main lines of research and development of recent years having special reference to underdeveloped countries. In the long-term the greatest advances have been made in fundamental knowledge, such as - the basic physiology and biochemistry of plant growth, the significance of the C4 pathway in tropical plants, genetic engineering, embryo transfer in animals, remote sensing photography, the ecology of the world's grasslands. The pressing problems of rangeland degeneration, and social and economic change in human societies, are also better understood.

The immediate problem and the task of this paper is to descend to a lower practical level of what has been learned about the possibilities of increasing pasture and forage production, and of utilising feed grown in the most efficient manner.

Approximately one half of the sheep and three quarters of the goats in developing countries are within the tropics, the remainder being in a band from North Africa through the Near East to China. It is useful to have some classification of climatic zones governing plant growth, and for the tropics it is given below:

Zone	Rainfall [1] (mm)	Rainfall [2] (mm)	Growing Period (days)	Dry Season (months)
Arid	< 400	< 500	< 90	> 8
Semi-arid	400 -750	500 -1000	90 -180	6 -8
Sub humid	750 -1200	1000 -1500	180 -270	4–6
Humid	> 1200	> 1500	> 270	< 4

[1] From Unesco (1979)

[2] From Jahnke (1982) for Africa

A feature of research and development work in the tropics, with the exception of the arid zone, is that cattle rather than sheep and goats have been used, so that in the absence of good data on small ruminants one has unfortunately to interpret from cattle data. It is proposed to discuss briefly the recent pasture utilisation studies with sheep in the temperate zone and then move to the arid and semi-arid pastoral zones, followed by the cropping/livestock situation in the semi-arid and subhumid zones and finally to the subhumid and humid zones.

4 RD, Christchurch, New Zealand.

PASTURE UTILISATION IN THE TEMPERATE ZONE

Research activities, and the methods derived therefrom, for increasing ruminant production in developed countries follow fairly standarised lines - breeding and selection for improved cultivars, determination of plant nutrient (fertiliser) requirements, determination of animal feed requirements, grazing management studies aimed at integrating pasture growth and animal requirements with maximum efficiency on a year round basis. In the temperate zone under favourable conditions grass-legume pastures are capable of yielding 10–20t DM/ha/ annum on cultivatable land and 5–10t DM/ha/annum on hill land oversown with clovers especially (Trifolium repens).

While these studies have progressed on a broad front, in recent years special attention has been devoted to the most difficult and complex area - the efficient use of pasture under-grazing (Morley, 1981; Parsons et al., 1983). Techniques have been developed for measuring herbage mass, ratio of green to dead leaf, net DM growth of green material under various grazing pressures, the intake of the grazing sheep (or goat) at various levels of pasture availability, the pasture availability needed to promote given levels of production, and the residual pasture (DM/ha) at which production falls below critical levels. Concurrently research has determined the critical and non-critical nutritional periods in the annual cycle of the ewe, and the extent to which the resilience of the ewe to gain and lose body fat may be used to buffer seasonal peaks and troughs of pasture growth (Coop, 1982; Milligan, 1983).

Finally to put this into practice requires control of pasture growth and control or rationing of intake of the grazing sheep. This can only be achieved by adequate subdivision with fencing. This has been greatly facilitated by the development of electric fencing and in really intensive systems by the additional use of cheap portable electric fencing. Such fencing is also used for strip grazing of forage crops, in order to get maximum utilization of the forage.

The efficient conversion of pasture to animal production is a highly complex matter because of the interactions between the grazing animal and the pasture, interactions which vary with season. At low stocking rates percentage utilisation is low and continuous grazing is as good as, or better than, rotational grazing. However to obtain high animal production per hectare intensive grazing at high stocking rates is required in order to give a high percentage utilisation. In this case rotational grazing is superior. In practice compromises become necessary because pasture growth is seasonal, there are periods when utilisation is sacrificed in the interests of achieving high individual animal growth rates and others, such as in winter, when utilisation is much more important than liveweight gain.

The efficiency of utilisation of native pasture in extensive grazing systems running less than 2 sheep/ha is estimated in recent research to be below 30%. When such pasture is improved by oversowing, fertilisation and fencing, utilisation can be increased to 60–70%. On really intensively grazed cultivated pastures efficiencies of 70–85% are possible on a year-round basis. Some appreciation of intensive grazing and utilisation may be gauged from the current practice of wintering pregnant ewes in New Zealand, where the ewes are rotated, at a density of 1000 ewes per hectare, on a daily shift behind electric fences.

In the Northern Hemisphere where winters are colder, greater reliance on hay and silage is made for winter feed. It is estimated that the percentage utilisation of metabolisable energy (ME) of the original pasture, when consumed as hay, is below 50%. For this, and for reasons of cost, the Southern Hemisphere grazing countries place emphasis on utilisation of pasture by the grazing animal with minimal use of conserved fodder.

Advances in grazing management and utilisation have nevertheless been made in northern countries. One example of this is the “two pasture” system developed for the wet cold hill country of Britain, whereby a smaller area of improved pasture is integrated with the larger area of unimproved hill land and utilised at strategic points in the annual cycle of the ewes. Another is the “three pasture” system aimed at minimising worm parasite problems. Finally in all the major grazing countries there is increasing evidence that cattle, sheep and goats can all be beneficial to one another, the special grazing characteristics of each being complimentary to the other. With coats this is seen especially in their preferences for weeds and pasture species not relished by sheep.

If proof is needed that modern pasture/sheep technology can lead to increased animal production the case of New Zealand may be quoted, where from approximately the same area of grazing land, sheep numbers have increased from 33 millions in 1950 to 53 millions in 1965, to 70 millions in 1982 with proportionate increases in meat and wool output. While only some of this temperate zone technology is immediately transferrable to developing countries, the objectives and the principles certainly are.

ARID AND SEMI-ARID ZONE RANGELANDS

The extensive rangelands of the arid and semi-arid zones of developing countries and the peoples they support are in varying degrees of crisis as a result of rangeland degradation, brought about by overstocking. The area is traditionally used solely by pastoralists under nomadic and transhumant systems, but the pressure of human population has led to the incursion of agriculturalists with their livestock into marginal areas, so putting an unbearable pressure on the rangeland vegetation.

Much has been written about the current state of rangeland vegetation, the social and economic impediments as well as the technical difficulties in reversing the deterioration (e.g. Unesco, 1979; Jahnke, 1982; Harrington, 1982 and Malechek, 1982). While there are cases or instances of potential improvements or improvements actually made, the concensus of opinion of authors is that the only solution short and midterm is to reduce grazing pressure. It is recommended that this be achieved by destocking, or by deferred grazing or some other form of grazing management which would permit a more even grazing and reduce severe overgrazing on critical areas. A recent FAO review (FAO 1984) commented that there is need for rehabilitation by the introduction of good management, that forage cultivation is not yet generally accepted and conservation of hay and silage rarely practised. There is a need to introduce forage trees and browze shrubs, but there was little likelihood of increasing forage availability in the near future due to pressure of livestock combined with the persistence of drought.

The productivity of the arid and semi-arid zone rangelands is low. Jahnke (1982), quoting other authorities, gives a figure of 2.5 kg DM/ha/annum per mm rainfall, or It DM/ha/annum at 400 mm which is likely to be inefficiently utilised. Such yields cannot hope to generate enough income to provide incentive to introduce improved species even if this were technologically feasible.

While acceptance by the inhabitants and by Governments that reduction in grazing pressure is the only short term solution, one must not be entirely negative. Observation and development project results indicate that there are avenues for improvement and some specific examples of these are listed below.

(i) Grain yields and sheep production were twice as great in South Australia through replacing fallow with subterranean clover and medic pasture, compared with Algeria having a similar Mediterranean climate but not integrating crop and sheep grazing (Allden, 1982, quoting Carter).

(ii) In the Drought Prone Areas Programme in Western India the introduction of _Cenchrus ciliaris_ and _Lasiurus sindicus_ increased DM yield from 0.4 t to 3t/ha/annum (Jain, 1983).

(iii) Depleted rangeland in China has been shown to be capable of yielding 3t DM/ha/annum by oversowing with milk vetch and fertiliser (Chinzagco project, pers. comm). In another site having 300 mm rainfall, all in summer, the yields of native grassland have been doubled with fertiliser alone, while in cultivated areas the use of newer cultivars of sorghums, maize, and annual grasses for silage, and native grass for hay has also doubled the number of stock carried as well as improving them greatly (FAO 1983).

(iv) The Syrian Arab Republic Rangeland Conservation and Development Project is one of the best known, reviving the ancient "Hema" system of grazing control, introducing Atriplex spp. planting fodder trees and creating lamb fattening cooperatives (Draz 1978).

(v) The wide ranging development project in Morocco where Agropyron elongatum has been introduced into a Stipa-Artemisia ecosystem in a 300 mm rainfall area (El Gharbaoui, 1984).

(vi) The introduction of Atriplex and Kochia spp. in Saudia Arabia (Hassan 1984),

(vii) The legumes Stylosanthes humilis and to a lesser degree S. guyanensis have been shown to be capable of being oversown or direct drilled on sites in the semi-arid zone.

There are also arid or semi-arid rangelands in the temperate zone (U.S.A., South America, South Africa, Australia) which have also degenerated under overstocking during the last 100 years and it is significant that in all of these stock numbers have declined. The most intensively studied are those in the U.S.A. and in a recent review of rangeland management and reseeding results, it is commented that "a considerable portion of western rangelands currently support vegetation assemblages greatly below their potential" (Herbel, 1984; Young et. a!., 1984). Wilson, A.D. (1982) in another review concludes that "there are no technological improvements in the pipeline that will lead to major productivity gains. The basic restrictions of sparse vegetation, low rainfall and a harsh climate are not subject to technological innovation". Nevertheless there are instances that in all of these countries improvements are technically possible. To take but one example, Stevens and Villalta (1983) at high altitudes in Peru were able to establish ryegrass-clover pastures and to direct-seed lucerne into rangeland with large increases in sheep numbers carried.

The problem is that research and development projects in both developed and developing countries on which the possibilities if improvement have been shown, have high inputs of technical and economic aid. Whether they can survive in a straight commercial sense and whether it is economic to attempt to increase production is highly dubious. In the more favourable sites it may be so, but for most of it, the problem is to halt further deterioration. The poor income-generating power of the extensive rangelands dictates that any improvements must be ecologically sound and low cost, and should act in a catalytic role to permit better utilisation of the much larger area of unimproved land.

Research priorities suggested should include grazing management studies to provide more even grazing pressure, forage conservation, selection of species and cultivars extending growth into the dry period, integration with cropping systems. (Unesco, 1979; Malechek, 1982; Butterworth et.al,1984).

CROP - LIVESTOCK INTEGRATION

Crop production is an occupation of agriculturalists living in villages mostly in the semi-arid and subhumid zones. Traditionally some nomads have included the grazing of crop stubbles in their annual movement, while transhumant pastoralists have also made use of stubbles and crop residues during the dry period. The increasing sedentarisation or semi-sedentarisation of nomads and transhumants, together with movement of agriculturalists with their own livestock in the opposite direction into drier areas, is reducing the areas available for grazing and also increasing the risks of crop failure. The integration of cropping with sheep and goats is primarily in the semi-arid zone but extends into the subhumid zone. Although the cropping regime yields more DM/ha in the form of stubbles, straws and byproducts available for stock the increases in stock numbers more than offsets this. Nevertheless cropping systems and the more intensive and settled human existence in villages or permanent abodes, offers an environment much more amenable to technological change and improvement than does the rangeland. The following research developments in recent years are some of the more promising.

(i) The breeding of improved cultivars of human feed crops - wheat, maize, sorghum, groundnuts etc. and research on fertiliser responses, together with an appreciation that in subsistence agriculture, fertilizer put on crops increases yield sufficiently to release land for planting in animal forage crops.

(ii) Research and demonstration has shown that forage production can be expanded considerably by inter-row sowing of legumes with the cereal, using improved cultivars of forage species, and especially replacing the traditional fallow with sown perennial or annual forage crops. Legumes such as Stylosanthes and vetches, and other tropical legumes in higher rainfall areas, are much preferred since their nitrogen level and nutritive value are high and they increase soil nitrogen for the next cereal crop. High yields have been obtained in Cyprus from barley and barley/vetch forage made into hay (Osman and Nersoyan, 1984; Unesco, 1979; FAO, 1983). If a move to greater use of forage crops and more efficient use of grazing stubbles is to be made then control of the sheep and goats becomes important. Attempts should therefore be made to gain acceptance of the electric fence by herders and cultivators.

(iii) Intensive fattening of lambs and kids, on locally grown roughage plus concentrates and byproducts, has a double advantage of controlled marketing with a superior product and more importantly of removing young animals to be fattened from the overgrazed rangeland, thereby reducing the grazing pressure. Lamb fattening trials have been reported from several countries showing typically that weaned lambs make gains of 100 -250 g/day with feed conversion ratios of 6 to 10 according to the energy content of the diet. There is a need to examine what effect this has on the total system.

(iv) Some arid and semi-arid areas have water available for irrigation, which is used mainly for cereal or cash crops (cotton) but some is available for forage. Water from the Nile is used in Egypt and Sudan, underground water in Libya and Saudi Arabia. Extremely high yields of lucerne (Medicago sativa) and Egyptian clover (Trifolium alexandrinum) are obtained and provide a high protein source for cattle, sheep and goats.

(v) Improving the utilisation of low quality roughages is also possible. Low protein levels characteristic of tropical forages during the long dry period are a limiting factor in animal intake and performance. (Minson, 1982). A considerable amount of research work has been done over the last 20 -25 years on the use of urea to improve the voluntary intake of straws and other

> low quality roughages by cattle, sheep and goats. Trials conducted in pens have almost universally given good results but selective grazing by animals in the field has caused some doubts about its application in a grazing context (Coombe 1981). A more recent discovery is that alkali or ammonia treatment of straw can increase digestibility by 10–15 units, e.g. from 45% to 55–60%. Encouraging results are being obtained from the technique at both the village level (Dolberg et.al., 1981), and the factory level (Creek et.al., 1984).

A much better understanding of protein requirements of sheep and goats has been developed during the last decade, with recognition of the significance of rumen nondegradable protein. This is of special importance in the tropics (Lindsay, 1984).

The outlook then for improvements in pasture and crop production, and of utilisation by sheep and goats in the cropping areas is reasonably encouraging. Whether it can keep pace with the increases in human population is another matter. Fortunately much of the research done in developed countries is less sensitive to environment in a cropping activity than in a grazing activity, and is therefore more likely to find application in the cropping scene. The most important fields of research in the cropping areas as far as sheep and goats are concerned are likely to be further integration of pastoral ism with cropping, conservation and forage production for the dry period, and improvements in the utilisation of straws.

Somewhat similar problems exist in the semi-arid/cold regions of the world such as in the arc from Turkey to China. Here the winter replaces the dry period of the tropics. In the USSR and Northern China for example, many pastoralists have been semi-or wholly sedenterised, and winter bases exist in villages or have been especially constructed. The growing of forage, partly for grazing but mostly for conservation as hay and silage, is a dominant feature of the system (Demiruren, 1982).

SUBHUMID AND HUMID ZONES

Though the line of demarkation between the semi-arid and subhumid zones is diffuse, there is a distinct trend towards tree crop agriculture as well as cropping, towards tall-grass pasture species and a greater density of villages, especially where associated with rice culture. This is accompanied by a shift in the relative importance of large and small ruminants. Whereas in developing countries sheep and goats outnumber cattle by nearly 2 : 1 in the arid and semi-arid zones, cattle outnumber sheep and goats in the subhumid and humid zones. As far as sheep and goats are concerned there are no longer any pastoralists and nearly all the animals are associated with village and cropping agriculture.

Tropical Pasture Development

Present native pastures consisting of *Hyperrhenia*, *Andropogon*, *Themeda* and many other species exist in a savanna landscape derived from forest or woodland. Soils are heavily leached, grazing is primarily with cattle and fire plays an important part in the grass, scrub, tree balance. The most important development in this area in the last few decades has undoubtedly been the selection, breeding and cultivation of improved cultivars of tropical grasses and legumes. The legume is particularly important because of the low nitrogen status of tropical soils. Though this work has been carried out in several tropical environments the driving force has been the CSIRO Division of Tropical Pastures in Queensland, Australia (Mannetje, 1982; Minson, 1982). Now there are established cattle ranches and cattle projects in most tropical countries with rainfall in excess of 800–1000 mm.

Unfortunately, in relation to sheep and goats, the basic grazing experiments and present projects are almost wholly involved with cattle. There are good reasons for this cattle dominance, but not for the exclusion of small ruminants. Very high yields of pasture DM are attainable - up to 30 -40t/ha/annum but control of pasture growth, maintenance of the grass-legume balance, and ingress of weeds do present greater problems than with temperate pastures (Mannetje, 1982). Nevertheless the potential of these tropical pasture species for small ruminants with or without cattle should be explored. Some trials using sheep and goats have been recorded (Boulton and Norton, 1982; Potts and Humphreys, 1983; Susetyo et.al. 1983) but not yet on a farm scale. Some of the improved species, especially legumes such as Stylosanthes humilis and S. guyanensis, Macroptilium, Desmodium spp are also finding use as forages for establishment on fallows which are grazed by sheep and goats in both semi- and subhumid zones.

Sheep and Goats in the Village

The place of sheep and goats in the village is much the same as described for the arid and semi-arid zones. The scope for increases in numbers and production especially of goats has been emphasised (Devendra, 1980; Roy-Smith, 1982; Zulkifli et.al., 1980; Wilson, R. T. 1982), involving greater utilisation of the considerable byproducts available from cereal and tree crop production, the introduction of improved grass and legume species in available land and recognition of the part which the milking goat rather than the cow could play. The opportunity to exploit the production of tropical grasses and legumes is facilitated by the fact that many sheep and goats, especially in the humid zone, are fed under a cut and carry system, or are let out during the day time on a controlled grazing system. There is no doubt that small ruminant production in this zone could be increased and there are good reasons why it should. Most of the arguments about the relative merits of cattle, sheep and goats are based on personal factors, and on calculations of what ought to be, and there is a need for comparisons to be made on a strictly scientific basis. It is encouraging that recognition of animal production potential in the humid tropics is evidenced by the creation of the joint Australian/Indonesian Centre for animal research and development in Ciawi, Indonesia in 1975.

Utilisation of Pasture in Plantations

In the humid tropics there are large areas of tree crops such as coconut, rubber and oil palm. They are established in association with a tropical legume cover crop which in time regresses to grasses and weeds. Except in coconut plantations often grazed by cattle the herbage available is generally not used at all. Attention has been given by the Rubber Research Institute of Malaysia (Tan and Abraham, 1980) to using sheep to consume this herbage and to reduce the high cost of weed control. Promising results are being achieved, confirming that a considerable potential exists for the utilisation of this large feed resource.

Forage Trees and Tree Byproducts

The utilisation of edible trees and shrubs, and of tree byproducts such as leaves, pods and seeds has received considerable attention in recent years. The characteristics and feed values of tree crops have been reviewed recently by Hutagalung (1981). Particular attention has been given to leguminous trees-such as Leucaena, Gliricidia, Tagasaste spp. since the leaves of leguminous trees, and especially L. Leucocephala, have protein levels in excess of 20%. Recent evidence (Bamualim et.al., 1984) shows that the protein is a good by-pass protein, capable of enhancing intake of low quality roughages where these form the main diet. Acacia spp prevalent in many parts of the tropics can also be valuable in droughts (Snook, 1984).

Leguminous trees and edible shrubs are not confined to the subhumid and humid zones, but can contribute also in the semi-arid zone, and are likely to be utilised much more than in the past.

CONCLUSION

There is considerable scientific evidence that both pasture and animal production can be increased substantially in all except the arid zone. The major problems are lack of capital to implement improvement and uncertainty about its viability, economically. The greatest and quickest responses in pasture and forage production are likely to be in the subhumid zone, and also in cropping systems.

To maintain impetus in research it is suggested that priority be given to:

(i) breeding and selection of pasture species for the semi-arid zone aimed at increasing the length of the growing period. Selection of low phosphate demanding legumes for this zone.

(ii) studies of the utilisation of tropical pastures by sheep and goats.

(iii) pasture conservation for the dry period, forage production on cropping land.

(iv) studies to increase the complementarity (or integration) of rangeland and cropping land.

(v) continuation of studies aimed at improving the utilisation of low quality roughages by sheep and goats.

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NUTRITION AND MANAGEMENT OF SHEEP AND GOATS

Soterios Economides

INTRODUCTION

Considerable research work has been carried out with sheep, mainly mutton breeds, but less attention has been given to dairy sheep and particularly goats as milk or meat producers although milk yield and milk composition of goats have been reported (Sands & McDowell, 1978; Devendra & Burns, 1970; Parkash & Jenness, 1968 & Jenness, 1980).

It is difficult to describe the feeding and management of the sheep and goat industry around the world because of the many interacting factors such as production system, management system within each production system, genetic potential of the breeds, biological constraints etc. The systems of sheep and goat production can be divided into the following categories:

1. Finewool production from sheep and goats as the main products and meat as a byproduct.
2. Meat production from sheep and goats as the main product and wool, fibre and skin as byproducts.
3. Dual purpose sheep and goats with the main emphasis on milk or meat production or milk and meat given equal importance.

Within the meat and dual production systems the following four management systems can be identified:

1. Extensive (migratory, free range, pasture or range grazing).
2. Semi-intensive (pasture or range grazing, use of supplementary feeding mainly on crop residues and conserved roughage).
3. Intensive (grazing on improved pastures, zero grazing, conserved forage, crop residues and increased use of concentrates).
4. Tethering (small size flocks of 2–10 animals). This is a subsistence family system and the animals live on kitchen remnants crop residues, grazing near inhabited areas and other supplementary feed).

In the migratory system sheep and goat farmers make use of the seasonal pastures located in different areas. In the mountanious regions of Asia, Europe and North America climatic conditions limit growth of vegetation in winter and so flocks are moved to lowlands; in summer flocks are moved to highlands where feed is available. In the semi-arid and arid regions land use is seasonal and movement of the animals is dictated by rainfall and availibility of grazing.

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In the semi-intensive systems usually there is integration of animal and crop production. Moving from the extensive to the intensive systems of production the performance of animals is improved and higher inputs used with the objective of obtaining a high output of product (Orskov, 1982).

THE NUTRITION OF SHEEP AND GOATS

Nutrient requirements

It is extremely difficult to present data collected from allover the world on the nutrient requirements of sheep and particularly of goats. For this reason as a general guide the recommended minimum requirements of sheep (NRC, 1975) and goats (NRC,1981) are suggested. The energy requirements of sheep and goats are similar according to NRC (1981). For dry non-pregnant animals the maintenance requirements are 0.42 MJME/kg 0.75.

During the first 15 weeks of pregnancy energy requirements increase by 15%, providing also for a slight weight gain, and during the last stages of pregnancy they increase by 80–100% compared with dry animals. For each kg of sheep milk (6% fat) and goat milk (4%) 7.5 MJME and 5.2 MJME are required, respectively. The requirements for digestible crude protein range from 2.3 -2.8 g/kg 0.75 for sheep and goats for maintenance, increasing during the last stages of pregnancy by 80–100%. For each kg of goat milk or sheep milk 45–70 g or 60–90 g digestible crude protein are required, respectively.

Feeding behaviour

Studies on the foraging behaviour and the dietary habits of sheep and goats (type and parts of plants they eat, their tolerance to saline or bitter feed and saline water, the distance of travelling to find food, the frequency of drinking and their walking ability) can provide assistance to range managers for making the right management decisions and improving sheep and goat performance (Malechek & Provenza, 1983; Squires, 1984). Goats have been considered more efficient in the digestion of crude fibre and the utilization of poor roughages than sheep (Malechek & Provenza, 1983; Squires, 1984; Gihad et al.). Possible physiological and behavioural factors for this ability of the goat have been indicated (Louca et al., 1982). However, with medium and good quality forage and adequate feed availability goats apparently are similar to sheep (Malechek & Provenza, 1983; Huston, 1978).

Nutrition and reproduction

Inadequate nutrition, particularly of energy, depressed the reproductive performance of extensively (H.F.R.O.,1979) or intensively managed sheep (Orskov, 1982) and of Indian breeds of goats (Sachdeva et al., 1973). Sexual maturity of sheep and goats is advanced by good feeding (Owen, 1976) and the energy stimulates oestrus activity within the normal breeding season, ovulation rate, fertilization and survival of ova and the maintenance of the resultant embryos to term as viable lambs (Gunn, 1967).

Body condition at mating, achieved over a longer period i.e. the period between one reproductive cycle and the next, has a greater effect on ovulation rate and barrenness than flushing (i.e. increasing the level of nutrition in the immediate pre-mating and mating period) (Owen, 1976; Gunn & Doney, 1975). High producing dairy ewes or goats, require a dry period to achieve maximum prolificacy.

The level of feeding after weaning of female lambs or kids intended for replacements depends on the age at mating. Usually lambs or kids are mated for the first time when they reach 60–80% of their mature weight. This weight is accomplished with proper feeding and management at the age of 8–10 months in France, Norway and Cyprus (Morand-Fehr, et at., 1982; Skjevdal, 1982; Maurogenis & Constantinou, 1983). In France (Blancnart & Sauvant) and Norway (Skjevdal, 1982) tables have been published with recommendations of dietary allowances for breeding female kids at the age of 7–9 months of age.

Nutrition and pregnancy

There is a very slow growth of foetus during the first 100 days of gestation (Blanchart & Sauvant, 1974; Economides, 1981) with more than 80% taking place during the last 8 weeks of gestation. Stress in pregnant goats during late pregnancy increased with increasing kidding percentage as indicated from the total birth weight of kids as a percentage of the dam's weight which was 8, 13.5 and 18.5 for goats giving birth to singles, twins or triplets, respectively (Economides & Louca, 1981). Foetal energy requirements in the final stage of pregnancy are 1.5 MJME/kg foetus/day (H.F.R.O.,1979). This means that a 50 kg ewe carrying twins would have an energy requirement of about 2.5 to 3 times that of a non-pregnant ewe. However, these full requirements are not recommended and 25% lower requirement would reduce birth weight of lambs by only 10% which is acceptable on both biological and economic considerations (H.F.R.O.,1979). Low levels of energy during late pregnancy lead to pregnancy toxaemia particularly with goats (Economides & Louca, 1981; Morand-Fehr & Sauvant, 1979). However, high levels of feeding through pregnancy can lead to pregnancy toxaemia in sheep (Orskov, 1982) and kidding difficulties. The performance of Damascus goats in the last stages of pregnancy was similar with either medium (15.7 MJME/ day) or high (20.1 MJME/day) levels of energy, but a low level of energy (11.3 MJME/ day) resulted in pregnancy toxaemia (Economides and Louca, 1981).

Nutrition and lactation

Lactating sheep and goats have increased requirements for all nutrients. Different methods of estimating milk yield in sheep and goats have been developed which are useful in evaluating the results of various management systems. The lamb suckling technique or the use of oxytocin and milking have been widely used to obtain information in the non-dairy ewe (Owen, 1976) whereas with dual purpose sheep and goats a combination of the suckling technique and milking until weaning is used (Economides, 1984). Hand or machine milking after weaning have also been used (Morag et al., 1970).

Energy intake is the most important factor determining milk production in intensive systems, particularly in the early stages of lactation in sheep and goats (J. C. Flamant, et al., 1982; P. Morand-Fehr, et a!., 1980) but also under extensive systems (Fig. 1 & 2). Similarly under semi-arid conditions in Mexico (Martinez-Parra et al., 1981) and India (Shiarma, 1982) the milk yield of goats is positively related to energy intake.

Pregnancy nutrition in sheep has only a marginal effect on subsequent milk production when grazing on high quality pasture or high level of feeding in early lactation (Peart, 1967); similarly pre-partum energy levels did not influence the performance of Damascus goats in early lactation (Economides & Louca, 1981) when offered a high level of energy (27.8 MJME/goat/day) during lactation. However, the milk yield of high yielding dairy goats (Skjevdal, 1982; Morand-Fehr & Sauvant, 1980) was improved by higher levels of energy intake in late pregnancy becuase of the building up of body reserves and their mobilization in early lactation to produce milk. Under such conditions a protein supplement is also necessary.

NUTRITION OF LAMBS AND KIDS

Birth to weaning

The weight gain of suckling lambs (Owen, 1976; Economides, 1984) and kids (Morand-Fehr et al., 1982) is closely associated with the level of milk intake during the early stages of the milk feeding period and declines with declining milk production. One unit of lamb liveweight gain results from 5 units of sheep milk consumed (Economides, 1984; Robinson et al.,1969), while one unit of kid liveweight gain results from 7 kg of goat's milk (Economides, 1982).

Weaning of lambs and kids can take place from 4 weeks to 5 months of age, depending on the management system. With either artificial rearing or natural suckling the success of early weaning systems onto solid food depends on the state of rumen development at weaning which is governed by the ingestion of solid feed. Solid feed intake is negatively related to milk intake (Economides, 1984; Owen et al., 1969) and after the age of 3 weeks milk should be offered less than ad libitum. Good quality creep feed and roughage should be available to lambs and kids from the age of two weeks.

When the milk supply of ewes or goats is inadequate or absent or when it is necessary to remove the progeny as part of the management system artificial rearing is practised. The lambs or kids are given colostrum within 6–10 hours after birth (Peart, 1982) and weaning within 24 hours after birth is ideal; later weaning increases difficulties of training the lambs or kids to suck from teats. Milk substitute can be given warm or cold (Penning et al., 1973) and should contain 20–25% protein and 25% fat for lambs (Orskov, 1982) and 16–24% fat and 20–28% protein for kids. Good milk replacers have conversion rates of milk solids into lamb gain of 1:1 and for kids 1.1 to 1.3. With dual purpose systems and when artificial rearing is practised the amount of milk replacer fed until weaning is minimized, either with early weaning or restricted milk intake, in order to reduce feed and labour costs. When natural suckling is practised the adoption of early weaning and partial suckling with the objective of increasing commercial milk yields is of great importance. However, the growth of the offspring should not be affected by the lower milk consumption.

A series of experiments carried out in Cyprus (Louca, 1972; Lawlor et al., 1974; Louca et al.,1975; Hadjipanayiotou & Louca, 1976; Economides, 1980, 1982, 1984) showed that early weaning of lambs (0,2 or 3 as compared to 35 and 70 days) adversely affected total milk yield of sheep and particularly of the low yielding breed (i.e. the Cyprus Fat tailed sheep). However, the beneficial effect of suckling did not extend beyond the time of weaning. A combination of partial suckling (12 or 8 h vs 24 h a day) and residual milking can maintain the amount of milk available for commercial purposes without affecting the lamb growth rate. Total milk yield of Damascus goats was not significantly affected by the length of the suckling period (2,35 or 70 days) or suckling regime (continuous or restricted) but commercial milk yield was increased with either early weaning or restricted suckling. However, the growth rate of kids either weaned at 35 days of age or partially suckled from 20 to 70 days of age was poorer than that of kids suckled ad libitum until the age of 70 days.

Comparative trials with lambs and kids (Economides, 1982) showed that lambs grow faster both before and after weaning. The kids could not be weaned as early as lambs and suffered a greater check in growth at weaning than lambs. The growth data and feed intake data suggested that the rumen of lambs develops and begins functioning earlier than kids.

Weaning to slaughter

The performance of lambs grazing poor pastures is low because of low feed intake (inadequate feed supply and low quality roughage) resulting in low energy intake. The importance of adequate nitrogen intake in relation to energy intake for the performance of lambs (Egan, 1965; Orskov, 1977; Kempton & Leng, 1980) and kids (Morand-Fehr et al.,1982; Economides, 1982) has been extensively studied. Feed intake, daily gain and feed efficiency of lambs were improved considerably (Table 1) by supplementing a low quality roughage diet with protected protein and glucose infusion directly into the abomasum (Economides, Leng & Ball, unpublished).

It is apparent that sheep and goat fattening must be based on diets of high energy concentration and adequate in protein. The protein requirement of male lambs declines from 18% crude protein in the dry matter in the early stage of life to 12% at liveweights above 40 kg (Miller, 1968; Andrews and Orskov, 1970) while those of female lambs are about 2% units lower. Male kids responded linearly to increased protein level in the diet (Louca & Hancock, 1977; Mavrogenis et al.,1979) whereas female response was marginal. Growth response of kids to level of protein tend to decline at higher liveweight and/or age than lambs.

When urea was substituted for soyabean as the protein source for lambs carcass gain, feed intake and feed efficiency were reduced during the period from 2 weeks to 3 months of age. From 3 months of age to 45 kg liveweight only feed efficiency was reduced by urea (Economides, 1981).

The physical form of concentrate diets affects efficiency which is lower on a mash diet than on pelletted or whole grain diets for both lambs (Economides, 1983) and kids (Economides, 1984).

The slaughter weight of lambs and kids depends on the desired carcass quality and on seasonal price trends and also on the liveweight which minimizes total cost per kg carcass. Generally lambs are slaughtered at about half the mature weight of the parents, whereas in the United States lambs are slaughtered at even higher liveweights. With increasing carcass weight the fat content and calorific value of carcass increase and water content, ash and protein contents decrease (Morgan & Owen, 1973). The dressing percentage and chemical fat content were increased by fattening in the feedlot (E.S.E. Gaili, et al., 1972) and diets deficient in protein increased the fat to lean ratio in growing lambs (Andrews & Orskov, 1970). Goat carcasses have less fat than those of lambs (E.S.E. Gaili, 1972; A.H. Kirton, 1982). Females have fatter carcasses, at the same liveweight, than males with castrates intermediate. Castration leads to reduced growth rate, a fatter carcass and reduced feed conversion efficiency (Louca et al., 1970). However, a taint of varying intensity was present in the meat of intact goats but not in that from the castrates. Where feeding conditions are good ram lambs and male kids can often be slaughtered before there is any need for castration.

MANAGEMENT OF SHEEP AND GOATS

Feed intake

The aim in sheep and goat feeding is to feed as much forage as possible and satisfy the largest part of requirements. The quantity and quality of roughage available will determine the amount and type of supplement to be fed. The higher the quality of the roughage, the higher the intake and performance with sheep or goats on all roughage diets. The voluntary intake of lactating ewes and goats is 50 to 100% higher than dry animals (Peart, 1982). The level of feed intake immediately after parturition is low but it increases steadily after parturition and maximum intake is reached 2–3 weeks after milk yield peaks. Small amounts of nitrogen (soyabean meal or urea) and energy (grains) increase both the roughage and the total digestible energy intake.

Management of sheep and goats during the reproductive cycle

With one lambing every year the time between weaning and mating should enable ewes to replenish losses from the previous lambing. It is not advisable to improve nutrition, for example before mating only, resulting in higher ovulation and conception rates without making provision for the additional nutritional needs in late pregnancy and early lactation. The most criticial parts of the reproductive cycle must be corrected and not just at mating, or late pregnancy or early lactation.

In intensive sheep and goat systems feeding is based on the nutrient requirements of the animals and the nutritive value of feeds with the formulation of a ration which meets the daily requirements of the animals. Under these conditions feed intake of sheep and goats can easily be measured and available feedstuffs can be given in quantities needed to maintain good body condition. For example at the declining stage of lactation feed is offered according to milk yield. Twin suckling ewes are fed separately from single suckling ewes, or yearlings. During late pregnancy better nutrition is given to yearlings and leaner ewes and early and late lambing ewes and goats are also fed separately. Sheep and goats in intensive systems may rely on large quantities of crop residues or on small quantities of roughage and crop residues with higher quantities of concentrates. The use of concentrates is justified only if local meat and milk prices are high.

With semi-intensive and particularly extensive systems of management supplementing grazed roughage which varies in quantity and quality is a problem. In temperate climates there is usually adequate pasture and supplementation arises only when there is overstocking or when the time of lambing is changed for example with lambing at the end of the grazing season. In highlands as well as in tropical, semi-arid and arid regions the production of roughage is seasonal and varies widely both in quantity and quality. Under these conditions grazing sheep and goats respond to energy, protein and phosphorus supplements when grazing poor quality roughage and vitamin A when animals subsist on dry roughage for more than 4 months.

There is no doubt, particularly with extensive systems of management, that the situation can be improved with increasing the feed resources. Either by increasing the available land and thus increasing roughage production or by improvement of the existing land for increasing production or by supplementary feeding. In addition to increased roughage production and supplementary feeding, improved flock management is necessary. Stocking rate must be decided according to the animal carrying capacity at the worst time of the season, unless supplementary feeding is available at times of roughage scarcity. Part of the existing pasture can be improved and fenced. This area is reserved for grazing when most needed. In these improved areas animals may be brought at mating, during late pregnancy and early lactation. Leaner ewes or ewes suckling twins and yearlings can also make use of the reserved areas. When the quantity of pasture produced from this improved and reserved pasture is not adequate, crop residues, hay, silage and concentrates are used to supplement the animals at times of need.

Crop residues and agro-industrial by products

Crop residues and agroindustrial byproducts can play an important role in the feeding of sheep and goats in all management systems. Such residues can supply a substantial part of the maintenance requirements of all ruminants in the Asian region (Jayasuriya, 1985). Usually their nutritive value is low, mainly because they are deficient in nitrogen and energy. They have to be supplemented when fed to ruminants or their quality must be improved before feeding.

Cereal straw is an important roughage resource and it's nutritive value can be improved with nitrogen supplementation (Hadjipanayiotou et al., 1975), ammoniation (Sundstol et al.,1978), urea solution (Hadjipanayiotu, 1982; Tayasuria & Perera, 1982) and chemical treatment (Klopfenstein, 1978).

The use of poultry litter in the diets of ruminants is possible provided it contains no pathogens, drugs or other medicants (Hadjipanayiotou, 1982; Shah and Muller, 1983).

Machine milking of sheep and goats

Work at the Cyprus Agricultural Research Institute showed that machine milking in sheep results in a reduction of milk yield (7 to 21%) and a decrease in the fat content of milk. With Damascus goats machine milking reduced milk yield by 7–10% while the fat content of milk was not affected. When milk yield per sheep per milking varied from 140–700 g, hand milking was more efficient, but above this level machine milking was more efficient. Ommission of one daily milking caused a 22% reduction in the milk yield of Chios sheep compared with 1% in Damascus goats (Papachristoforou et al., 1982).

Health

Intensification of production can lead to nutritional disorders because animals are of higher productivity, they are fed unusual diets (high in grains) and there are frequent changes of the diets. Such disorders are acidosis, remenitis, pregnancy toxaemia, hypocalcaemia and copper poisoning. Underfeeding during late pregnancy will result in pregnancy toxaemia in sheep and goats. Any stress resulting in anorexia and thereby inadequate energy intake will precipitate this disorder. Dairy sheep and goats, because of prolonged lactation, may have depleted calcium reserves and a constant supply of calcium with the diet is needed to replenish calcium losses (Economides, 1984).

This type of feeding trough (protected to prevent faecal contamination) and diet supplementation with lasalocid sodium (37 mg/kg feed) provided adequate protection from coccidiosis and improved the rate of growth and feed efficiency of kids but had no effect on lambs (Economides, 1984).

CONCLUSION

The present level of productivity of goats and sheep in developing countries is generally low, mainly because of underfeeding, poor management and disease (Devendra, 1979, 1980). Productivity is also low in highlands because of seasonality of roughage production and it's low quality (H.F.R.O.,1979). There is no doubt that considerable increase in animal production can be achieved with improved nutrition and management practices under different production systems and systems of management. For example total edible meat of goats in Malaysia was increased by 40% when improved nutrition and management was applied in goats of the same breed (Economides, 1984). In Syria under pastoral conditions the mortality of sheep from drought has been eliminated and feed conversion efficiency of lambs was improved from

6 to 3 kg per kg liveweight gain in intensive fattening units (Draz, 1983). Under the harsh environmental conditions of Scotland lambing percentage has been increased from 60 - 65% to 80 -85%, liveweight per lamb sold was increased by 1 -2 kg and the number of breeding animals has also been increased (H.F.R.O., 1979). In Cyprus with early weaning systems, fattening on balanced diets and slaughtering at higher liveweights meat production can be doubled from the same number of breeding animals compared with the production under the traditional extensive system of management 30 years ago.

It is true that during the last 20 years extensive scientific progress has been made towards increasing the efficiency of production of small ruminants. However, research findings have not been fully tested or adopted by the farmers either because some of the data obtained in developed temperate countries are not appropriate for the developing countries (semiarid, arid and tropics) or there is a weakness in the institutional frame work for providing technical advice. Weaknesses in providing credit for the application of new technology and lack of organization of the market for the protection of the animal production also inhibit adoption of new methods.

Increased production from sheep and goats can arise from an increase in animal populations. However, an inventory of existing feed resources in relation to animal numbers in each country is necessary. Having in mind what feeds are available and what is the present level of productivity of animals new technologies and research findings can be put together and tested in different production systems to evaluate and select the best systems suited to a particular region within a country under certain conditions.

Immediate results in increasing efficiency of production can be obtained with improved nutrition and management practices and disease control. All breeds respond positively to better nutrition and management practices but there are limits set by genotype. The economic response, however, to improved environmental conditions is higher with sheep and goats of high genetic potential.

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TABLE 1. The effect of supplementing a poor roughage diet with protected protein and/or glucose

	DIETS			
	A Basic diet	B Basic + glucose	C Basic + protected protein	D Basic + glucose + protected protein
Feed intake (kg/day)	0.89	0.79	1.17	1.07
Daily gain (kg)	0.095	0.127	0.183	0.252
Relative gain	100	134	193	265
Feed/Gain ratio	10.4	7.2	6.6	4.35

Basic diet = poor quality oat chaff, urea, sugar, minerals and vitamins

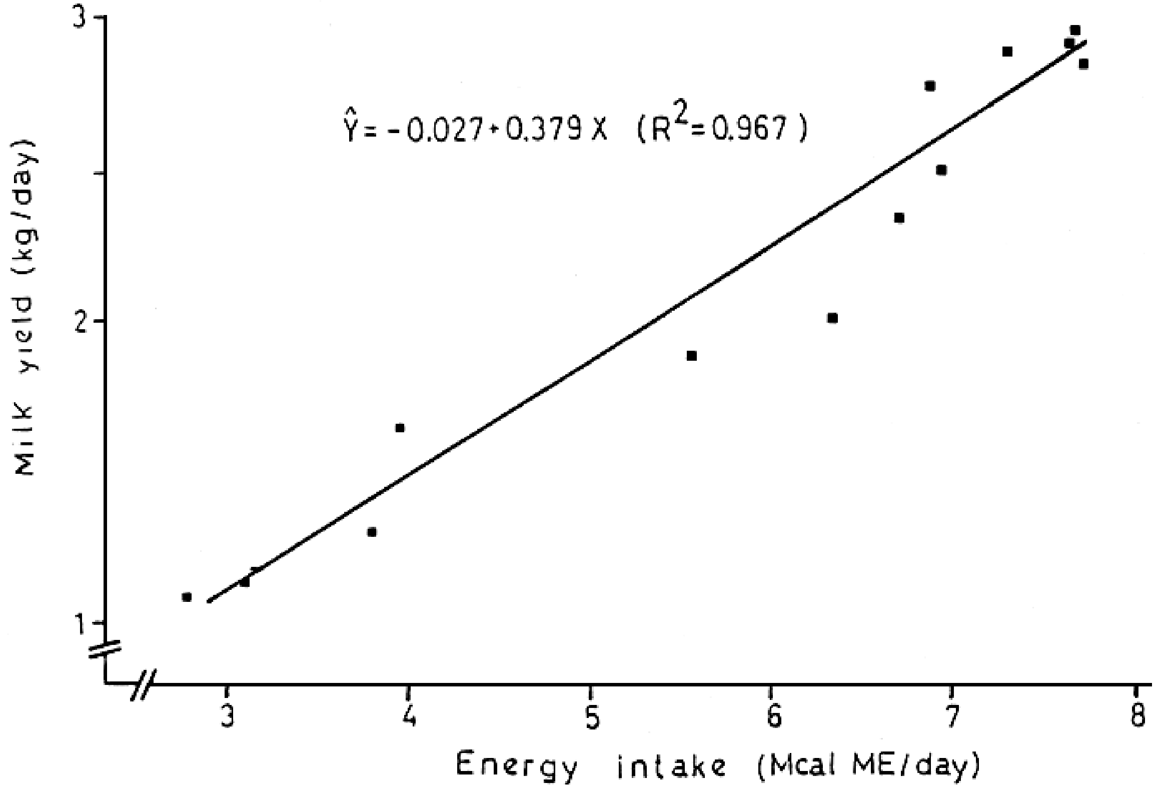

Fig. 1: The effect of energy intake on milk production of sheep in early lactation

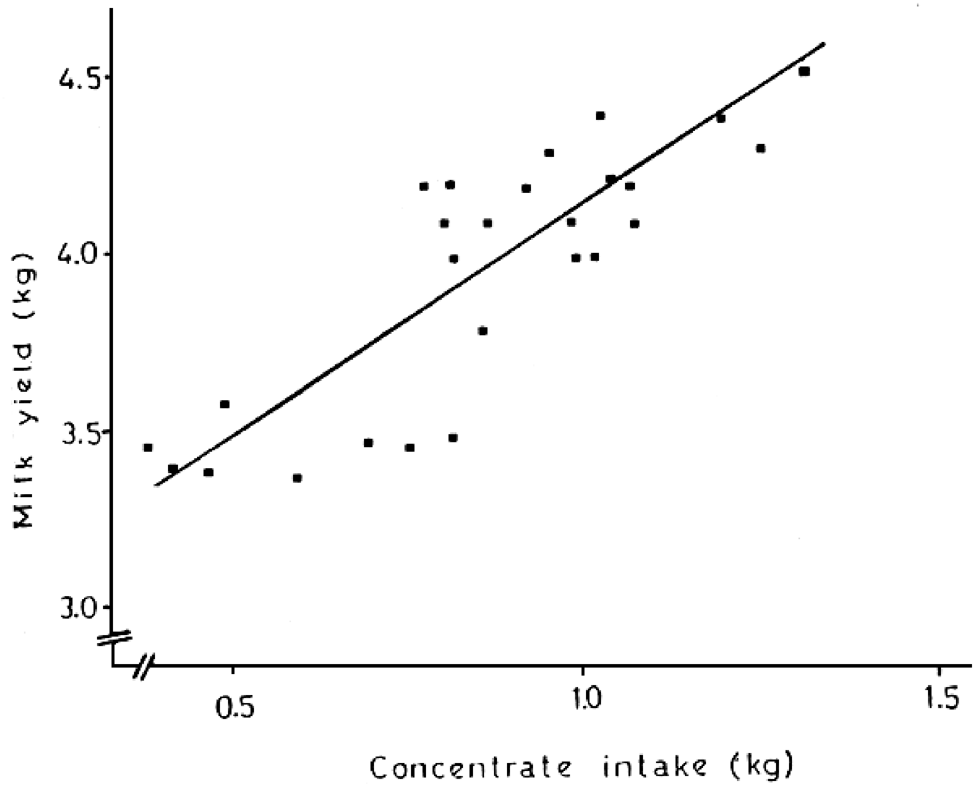

Fig.2: The effect of concentrate intake on milk production in goatskin early lactation (Fehr & Sauvant,1980)

BREEDING PROGRAMME TO INCREASE PRODUCTION EFFICIENCY OF SMALL RUMINANTS IN DEVELOPING COUNTRIES

C.E. Terrill

INTRODUCTION

The breeding programme proposed is very simple and easy to apply. It consists of three essential steps and, if possible, a fourth step to accelerate progress further.

1. Mate all prospective replacement females to give birth at about one year of age.
2. Retain only females for further breeding that wean offspring from this first mating. In subsequent years discard any that fail when they fail.
3. Mate only twin males born from mothers at an age of about one year, or if no twins are born select the heaviest singles from yearling mothers. Mate all males so that the sire is about one year of age when offspring are born.
4. Add research and development in nucleus flocks on experimental or government farms to follow the above steps more exactly and fully, to add selection for success of artificial insemination with frozen semen, and to use embryo transfer to increase selection differentials and to decrease generation interval on the female side.

Success is assured by the high selection differential obtained by using the early weaning performance as an indicator of lifetime performance and of genetic merit for high production, and by turning over male generations every year. Experience has shown that the first step will give 1 percent each year plus about 5 percent immediate, one-time phenotypic gain. Ercanbrack has been applying the first three steps in selected groups at Dubois, Idaho since abour 1977. He states in his 1981 progress report- “Percentage superiority of lines selected solely for reproduction criteria, over the unselected controls, is generally increasing at an absolute percentage rate annually of from 3 to 5 percent”.

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Heritability can be disregarded as the goal is a rapid increase in economic gain which might not be the same as genetic gain if a highly heritable trait like fleece weight would receive more emphasis even though in many cases it is much less important economically. It would be better to let fleece weight remain constant and make more progress on lamb production. Of course it would be fortunate if heritability of weaning production were high, but it does tend to be low, particularly weaning rate. This is one reason the rate of progress is as low as 3 percent per year. However, 3 percent per year is very important in regard to net returns as was shown earlier. Certainly the attitude that selection for lamb production is too slow to be worthwhile is not justified.

Most of the research leading to the above proposal has been done with sheep and not with goats. However, the principles will apply equally to goats as with sheep. Rate of progress might even be higher in goats as the initial weaning rate is generally higher in meat goats. The plan is designed for within flock selection only as this will be more effective.

Many farmers with sheep and goats in developing countries probably cannot go beyond step 2, as identification of individuals preferably with eartags and some record keeping at birth and at weaning would be essential. However, steps 1 and 2 can be taken without records or identification providing those females that fail to wean offspring can be detected and removed. If mating is once per year, this can easily be done by going through the flock at weaning time and sorting out those females which are not suckling young. Failures can be sorted out earlier if this permits them to be sold at a higher price. Pregnancy tests may be practical especially on lambs or kids. Some females that fail may be detected at lambing or kidding time. If shearing is between birth and weaning, some may be found then. If young are born throughout the year, marking those that have young may be needed. If feasible an ear notching system for young born may be useful if the mother can be marked without disturbing her maternal behaviour.

Farmers would not need to be concerned about step 3 if they obtain rams from a government farm where nucleus ram breeding flocks of their breed were following step 3 and hopefully, step 4.

The proposed breeding programme is the one action that will give maximum increase in biological efficiency, in net returns and in total meat produced per female maintained, probably greater than for all other means of increasing efficiency combined, over the long run. This advantage is even more important in light of its wide applicability in every country, whether developing, developed or with a central planned market economy. It is applicable under the most intensive to the most extensive conditions, and under any environmental situation. It enhances and does not conflict with or duplicate any other means of increasing efficiency. It enhances further genetic progress for efficiency because selection differentials can be increased and generation lengths can be decreased as the weaning rate increases. It enhances selection for other traits, although progress may be reduced if much attention is given to other traits. It enhances improvement in adaptability even though such will be slow. The proposed breeding programme should be given priority, both in production and research, over any other means of increasing efficiency because of its promise of greater immediate and permanent gains, especially in net returns to farmers.

SELECTION OF FEMALES

Success in predicting lifetime performances by breeding females giving birth at about one year of age depends in part on the proportion that wean offspring. An average of 50 percent may be optimum, because this will divide the population into those that are above average and those that are below average phenotypically and genetically, of course with some overlap. The numbers that are needed for replacement will be important. The interaction between weaning rate, the number of years a group needs to remain in the flock and average generation interval are shown in Table 1. A small proportion weaning offspring in the first year would probably give a higher selection differential while a higher proportion would permit a shorter generation length. However, where flock weaning rates are generally below 100 percent, the number of females weaning offspring in the first year would need to be 50 percent or better to provide sufficient replacements. This might not be attainable on farms so that selection gains on experiment stations and on government farms who provide sires to producers would be highly important. These values are only a rough guide and actual performance could vary considerably.

If the weaning percentage and/or the number having young at one year is too low to follow the plan completely, the farmer should go as far as he can as even a little effort will be worthwhile. Also, if it is impractical to mate offspring at 7 months of age, it may be done later or at 19 months of age, but the gain will be less. This programme can be effective in increasing net income even if only followed in part. The number reproducing at one year of age may be discouragingly low at first, but it will likely improve every generation and possibly every year.

The proportion of females weaning lambs in the first year could be increased by feeding the lambs from weaning to breeding so that they could reach 60 to 80 percent of their mature weight before breeding. The extra production might pay for the feed. Again this could be done better on government farms than by private farmers. Actual results would vary with breed, location, time of year, quality of feed and possibly other factors so that research is needed in each area to determine the optimum procedure for each breed in that area. This supplemental feeding of female offspring would not be the same as supplemental feeding for production. The objective of feeding these offspring would be to reveal genetic variation and to approach an optimum selection level.

If more female replacements are needed than the number weaning offspring in their first year, the next choice would be females in their first year which had live lambs but did not wean them. Next would be those that became pregnant in their first year but failed to produce live lambs. Keeping high producing ewes in the flock more years might be preferable to retaining females that failed to become pregnant in their first year. At Dubois, Idaho, under certain conditions, some of the highest producing ewes would maintain production through 10 or 11 years of age. If possible, females should always be replaced with younger ones with higher genetic merit as revealed by production at one year of age in a subsequent year.

If more females weaning offspring in their first year are available than are needed for replacements, the oldest ewes with the lowest performance might be culled, thus reducing the generation interval or if indexes are available, the females with the lowest production indexes should be culled regardless of age. If genetic progress is being made, the younger females will have higher average genetic merit than the older ones but judgement needs to be used to retain the ones with highest genetic merit regardless of age.

The recommended selection index is the average lifetime production of a female in total kilogrammes of liveweight weaned annually plus the equivalent weight of wool (actual fleece weight adjusted for the relative value of wool to meat) and with milk production added in the same way if the females are milked. Thus, the females may be ranked at any time on their production index, adjusted to a lifetime equivalent, so that those with the lowest indexes are the first to be culled and sons of those with the best indexes should be used in breeding.

The selection index for females may be easily calculated if individuals are identified, preferably with eartags, and if records of birth dates and weaning weights and dates are taken. Weaning weights may be adjusted to an average age at weaning on the basis of average daily growth from birth. Adjusted lifetime equivalents may be calculated based on the deviations of individuals from age group average, including a correction for number of records, and expressed as a deviation from the lifetime average or by adding or subtracting the deviation to the lifetime average for the entire flock.

SELECTION OF MALES

Selection of males is much more effective than selection of females as a much smaller proportion of males need to be used and male generations in sheep and goats can be turned every year. The rate of progress from selection of males alone will probably be about 2 percent per year or twice as great or more than with females. This assumes that males selected within the flock are the very best for that flock, which cannot be achieved if males are purchased. Individual identification and keeping of some records is essential for selection of males on the farm. If this is impractical then the gains will need to be made on governmental farms or in nucleus flocks from which farmers would obtain rams.

Males should be selected on their mother's performance, because this permits turning generations every year. Annual gain from using male offspring under one year of age is greater than could be obtained from more accurate half-sib records or progeny tests, because male generation length would have to be two years for half-sib records to be used, or three years for progeny records to be used. Therefore, the selection differential would need to be twice or three times as great to offset the longer generation length, and this seems impossible.

Turning male generations every year is responsible for the major gain over traditional methods of selection towards increasing the rate of improvement of lamb production. Male twins from females giving birth at one year of age would have an environmental disadvantage both from their type of birth and young mothers. Therefore, it is essential that the selected males and some substitutes be given supplemental feed from weaning through breeding. Semen tests should be made prior to breeding to see that they are producing ample numbers of sperm with normal motility. Semen can be collected on farms, and the rapid swirling motion of normal sperm can be seen with the naked eye. If group breeding is practiced with at least 3 sires, this test for semen motility is certainly adequate, and it is probably adequate for individual sires to ensure high fertility.

Selection of rams within flocks may introduce danger from inbreeding, although frequent changing of sires tends to slow inbreeding. One sire inbred lines increase in inbreeding at the rate of about 1 percent or more per year (0.5 to 1.7 percent) while lambs weaned of ewes mated tend to decrease about 1 percent or more with each 1 percent increase in inbreeding. Therefore, one and also two sire farm flocks under within farm selection are not recommended even though the selection gain might more than offset the loss from inbreeding. Three sire breeding flocks would probably be satisfactory if 3 sire lines (original unrelated sires) were maintained and if female offspring were rotated among sire lines so that parents would always have the lowest possible relationship within the closed flock. This does put flocks smaller than about 60 females at a disadvantage. Small flocks should probably change sires with other small farms following the same practice or obtain sires part or all of the time from nucleus or government breeding farms, also following the same practice.

NUCLEUS OR GOVERNMENT BREEDING FLOCKS

Small fanners are often unable to practice selection most effectively even if they do identify individuals and keep essential records. Optimum selection groups should have around 200 head for each breed, and most small farmers have less than this. Small farmers rarely have the facilities for satisfactory record keeping or for single sire matings. Also, it is difficult for any farmer to select for only one trait, to believe environmental effects, to select for something like lamb production that he cannot see when making the selection, and to avoid being influenced by appearances that are striking at the time of selection. Professional Animal Breeders sometimes have the same problems, but they are more likely to be entirely objective in selecting the superior animals. Therefore, an experimental or government nucleus flock, with the help of a professional geneticist or animal breeder can probably make progress with selection at a more rapid rate than farmers. They should not be influenced by economic returns, as a farmer must be, and should be able to take more risk and be more ruthless in culling. Where government breeding farms are established, they provide the most effective means of increasing production efficiency through more rapid genetic improvement.

Nucleus or government breeding flocks should be within the ecosystem area in which the farms are located which they are to serve. They should have nucleus flocks for each breed that is important in the area. Methods of feeding and management should be as comparable as possible to farming practices in the area. Plane of nutrition should be the same as on farms. Adaptability is the main genetic asset which native breeds have. It will be improved constantly but slowly by natural selection providing environmental influences are much the same as on the farm.

Farmers should breed females to give birth at about one year of age whether or not they obtain sires from a government farm. The phenotypic gain is important, but it is not permanent like the genetic gain, and therefore, the selection of females must go on without interruption. The additional genetic gain from female selection is well worth making and should be continued indefinitely the same as that for males.

Government breeding farms are well justified because of the public gains from increased efficiency of production. The supply of high quality food is increased and the price usually goes down as efficiency goes up. Rural income goes up which tends to benefit everyone in each rural community. In many countries, the public may benefit even more than the farmer. It is reasonable that the government provides the breeding farm as the gains might not be made otherwise.

SELECTION FOR OTHER TRAITS

The selection for other traits, along with selection for meat production efficiency, can best be done on government farms where professional animal breeders can supply the highly technical input that is needed. Selection for wool quality, efficiency of feed use and even fleece weight and milk production require measurements that may not be practical on the farm. They require a more sophisticated selection index than is recommended for meat production alone so that net returns will be further increased. They may require some research where unknown parameters might be obtained. Research to increase the rate of progress from selection will always be needed.

In areas where breeding seasons are limited, in some or all breeds, and where breeding out-of-season may be desirable, selection for the ability to breed successfully any time of the year should be done in the nucleus or government flocks. This may be done by mating all eligible females every month or every other month. Synchronization should be used so that young are coming in restricted periods. Further procedures would be the same as for breeding once per year. Offspring born at the more difficult times of the year should be favoured in selection.

ARTIFICIAL INSEMINATION

Artificial insemination offers the best means of distributing gains from nucleus or government breeding flocks to many small flocks within each ecosystem area. Use of frozen semem will permit distribution to many places over a relatively wide area compared with the limitation of only a few places with fresh semen. Use of synchronization of oestrus and ovulation will allow the process of artificial insemination to be planned and programmed. However, frozen semen gives such low pregnancy rate (average around 40 percent) that improvement in this trait must be made before A.I. can be used practically.

The most plausible way of improving success of these techniques is through genetic selection for success. Success of synchronization of oestrus and ovulation without reduced fertility is better for some females than others. Likewise, a few rams produce semen with high fertility after freezing. These variations undoubtedly have genetic components. Simply using these techniques in nucleus and government breeding flocks will lead to progress as all replacements will come from those that succeeded. Male selection could emphasize both lambs weaned per ewe mated and success with frozen semen. There would likely be no genetic conflict between the two traits. Degree of success could be predicted from freezing and insemination tests along with early pregnancy diagnosis before the prospective sires were seven months of age. Of course research would be essential but as a part of the selection process. Selection should be started immediately and then enabling research could be done to accelerate progress in selection already underway.

The objective should be to increase the success rate with frozen semen sufficiently to permit farmers to do the insemination themselves rather than depend on technicians. Varied results because of technique of insemination would be much less likely with a high than with a low success rate. Farmers would need to do both the synchronization and insemination techniques themselves to ensure that these would be timed to suit their farming operations rather than the schedule of a technician.

About ten years of selection or ten male generations would be required before success from artificial insemination with frozen semen might reach 60 to 70 percent at which time, use of the technique on selected farms might begin. As the reproductive rate is increased by selection, a lower success rate from synchronization and artificial insemination can be accepted because there would be more room for culling of ewes which fail. Pregnancy diagnosis soon after mating would permit failures to be marketed, many before one year of age, before the costs of feeding to heavier weights, or through the pregnancy interval are incurred. Those that succeed in weaning offspring after birth at one year of age from synchronization and insemination with frozen semen, would probably show a high success rate throughout their lives.

Artificial insemination not only gives the small farmer the advantage of superior sires for increasing meat production, but also he can now economically use more than one sire so that his best females can produce potential replacements and other females could be used to produce market offspring. It seems probable that the cost of using synchronization and artificial insemination might be offset by not having to purchase or to withhold a prospective sire from market or to keep a male year round. The small farmer would thus have the advantage in flexibility and of use of superior sires, probably with no added cost as compared to natural mating.

EMBRYO TRANSFER

Embryo transfer, which requires surgery in sheep, may not become practical in production, but it offers great promise in enhancing genetic progress. Fertilized ova may be transferred from females superior for reproductive rate to less superior foster mothers. Thus, selection gains may be more rapid, because this will increase the selection differential and will decrease the generation interval on the female side. Use of superovulation is not favoured for this procedure in order to give maximum attention to genetic improvement of the entire reproductive process including the natural ovulation rate. Embryo splitting is favoured, however, to increase the number of embryos per collection. Research along with the selection procedure, might result in turning generations every two years with a corresponding increase in the selection differential to about 70 percent of that for males. Further progress could no doubt be made with more research. With selection one should never conclude that current practice is the best that can be done. The goal of research with selection is to find a way to make more rapid progress.

SELECTION IN MULTIPURPOSE SMALL RUMINANTS

Selection for total weight of young weaned per female mated can be added to selection for milk production in small ruminants without loss in milk producing ability. Improvement in one is consistent with improvement in the other, because high milk production contributes to heavy weight of offspring weaned. Of course, milk consumed by the young cannot be sold but management can be used to obtain the optimum yield of each product.

Initial mating of females to give birth at one year should be done. If the weaning rate is such that some which produce offspring at one year could be culled, the ones with the lowest milk yields might be culled. However, it would be more efficient to calculate indexes of adjusted liveweight of offspring weaned times a standard value plus adjusted yield of milk times a standard value. The records available would be adjusted to a lifetime equivalent including correction for the number of records. Males would be selected on their mother's index and females could be selected on their own index. If some females failing to wean offspring after birth at one year would need to be selected, this could be done on their mother's records.

Angora kids produce mohair of higher value than older animals. Thus, it is an added incentive for selecting for those that wean more offspring at a young age. As the rate of reproduction increases, the mothers and females kept for mohair production could be culled at a younger age thus increasing the yield of meat. With much higher weaning rates, it might not be necessary to keep males or mothers after their kid mohair was produced thus still further increasing the economic efficiency of meat and mohair production.

Efficiency of production of slaughter animals from fine wool sheep can be increased in the same way as for milk or mohair simply by selecting for most economical combinations of the products and then following the same procedure as for the production of slaughter animals alone. This procedure has been very successful at Dubois, Idaho with the Rambouillet breed.

TABLE 1. Approximate Guide to Optimum Number of Females weaning Offspring in First Year

Offspring weaned per female mated in flock	Oldest age to remain in Flock by proportion of females weaning offspring in first year						Average generation interval in years for females by proportion of females weaning offspring in first year					
	0.2	0.3	0.4	0.5	0.6	0.7	0.2	0.3	0.4	0.5	0.6	0.7
.7						10						6.0
.8					10	9					5.5	5.0
.9				10	9	8				5.5	4.9	4.4
1.0				9	8	6				5.0	4.4	3.8
1.1			10	8	7	5			5.4	4.5	4.0	3.5
1.2			9	7	6	5			4.9	4.1	3.5	3.3
1.3		10	8	6	5	4		5.5	4.5	3.8	3.3	3.0
1.4		10	7	6	4	4		5.2	4.2	3.5	3.1	2.8
1.5		9	6	5	4	4		4.9	4.0	3.3	2.9	2.7
1.6		8	6	5	4	4		4.5	3.7	3.1	2.8	2.7
1.7		8	5	4	4	4		4.3	3.5	3.0	2.7	2.6
1.8	10	7	5	4	4	3	5.5	4.2	3.3	2.9	2.7	2.6
1.9	9	6	5	4	4	3	5.4	4.0	3.2	2.8	2.6	2.5
2.0	9	6	4	4	4	3	5.0	3.7	3.1	2.7	2.6	2.4

Assumptions:

1. Sex ratio of 0.5
2. Mortality from weaning to breeding of females at 0.05
3. Mandatory culling of female offspring of 0.1 of or defects, small size, and unacceptability
4. Annual mortality of adults 0.05
5. Annual mandatory culling of adults 0.05 for spoiled udder, unthriftiness, unsoundness and failure with age.

METHODS USED AND RESULTS OBTAINED IN THE TRANSFORMATION OF SHEEP BREEDING IN THE PEOPLE'S REPUBLIC OF BULGARIA

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INTRODUCTION

The People's Republic of Bulgaria ranks among the first countries in the world in terms of number of sheep and amount of sheep produced per one hundred hectares of arable land and per capita. Radical changes have taken place in this country's sheep breeding over the past thirty-five years. Prior to World War Two the breeds used were of coarse and semi-coarse wool types, yielding low amounts. As high as 64.5 per cent of the sheep in Bulgaria belonged to unidentified breeds and were predominantly crosses between aboriginal breeds. Of the indigenous sheep the Karnobat-Shoumenska breed (22.2%) accounted for the highest proportion.

At present, sheep of newly developed fine wool, semi-fine wool and local coarse wool breeds are raised in the People's Republic of Bulgaria. On a national scale with regard to the number of sheep that were raised in this country in 1982 fine wool breeds accounted for the highest proportion (41%), followed by the Tsigai sheep (25.3%) and the semifine-wool breeds (16.7%) It is envisaged that the number of specialised milk sheep will increase in the near future as against a slight decline in the number of fine wool and semi-fine wool sheep.

There has been a large increase in the amount of wool and meat produced and to a lesser extent in the output of sheep milk during the 1939 -1982 period. The production of wool rose 2.8 times and the production of sheep meat increased by 90 per cent, while that of sheep milk rose by 10 per cent.

PERFORMANCE RESULTS

Bulgaria is one of the few countries in the world, and the only one in Europe that meets the needs of its well developed wool-textile industy with wool of its own production. This is the result of the proper structure of sheep breeding, in compliance with the demands of the country, and of a unified programme concerning the breed transformation of the sheep population on a national scale. Research teams of outstanding scientists, experts, and practitioners were assigned the task of leading the work in this respect. In a comparatively short time as many as four fine wool breeds were developed in the lowland regions of this country, and two semifine-wool breeds and two Tsigai-type breeds will shortly be developed for the semimountainous and mountainous regions. A specialized milk breed is also in the course of development.

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The method of multiple reproductive crossbreeding was the basic one to be employed in the transformation of sheep breeding - aboriginal sheep were mated with rams of breeds that were imported from the USSR and the German Democratic Republic. The main breeds that were used as improvers in fine-wool breeding were Mutton Merino, Caucasian, Askania and Stavropol; in semifine-wool breeding the North Caucasian was used and in recent years Corriedale, imported from New Zealand and Australia, has also been used. Tsigai sheep breeding was developed on the base of the Tsigai breed. The programmes that were worked out beforehand for breed development were theoretically substantiated and applied in compliance with the quality of the initial populations and with the ecologic conditions.

With the fine-wool breeds the desired selection type was most frequently reached in F_3 after which inbreeding was practised. In individual cases only inbreeding was shown to start in F_2. In the first stage of breed development semi-fine-wool sheep were created through crossing the local sheep with fine-wool rams. In the second stage the resulting merino-like sheep were mated with rams of the North Caucasian breed and with Corriedale rams. Romney Marsh and Lincoln rams were used on a limited scale. The desired crossbred type of sheep were produced most frequently with animals having 3/4 blood of breeds obtained through crossbreeding.

In the development of Tsigai sheep breeding a higher generation of crosses was reached with a view to equating the wool of a given type and obtaining higher productivity with the sheep in the mountainous regions.

The selection of sheep for various purposes at the Agro-Industrial Complexes and recording their performance are now carried out by the Animal Selection Centres, established in all districts of the country. A pedigree structure is built in all populations, including nearly 16% elite, 61% reproductive, and 23% stock flocks. Particular attention is paid in this country to the wool performance of sheep. That is why it is referred to as a fundamental selection character with sheep for all purposes except for those bred for milk.

Although the wool yielding capacity of sheep is genetically highly determined, it varies largely on a year-to-year basis under the effect of the environment. Over the 1970 -1984 period the average wool yield from the elite part of the fine-wool population has varied from 6.1 to 6.9 kg, while that obtained from the semi fine-wooled and the Tsigai population has varied from 4.1 to 4.3 kg, and from 3.1 to 3.3 kg, respectively.

The wool yielding capacity of ewes in the ram producing flocks has been considerably higher (Table 1). For the 1980 -1984 period the amount of grease wool with the fine-wool breeds has been from 6.42 kg for Dounavska breed up to 7.73 kg for the Northeast Bulgarian one, and the amount of scoured wool has ranged from 3.02 to 3.50 kg. On individual cooperative farms, such as Sadievo and Samouilovo (District of Sliven) and Kochovo (District of Shoumen) an exclusively high yield of wool has been obtained - 9.8 kg per ewe, on an average. The record amounts with individual animals have reached 15.0 kg. With semifine-wool breeds the amount of scoured wool per animal has ranged from 2.7 to 2.8 kg. With Tsigai sheep it has been from 2.4 to 2.7 kg.

The ewes of the elite part of the populations have good length of the staple. For the 1980 -1983 period it has varied from 8.6 to 9.1 cm for the finewooled populations, from 9.2 to 10.7 cm for the semifine-wool populations, and from 9.8 to 10.0 cm for the Tsigai populations.

With regard to wool quality of fine-wool sheep 45.7 percent of the yield is of 70s and 64s, and 51.35 percent of 60s.

It is known that the quality of the young generation of rams used is of great importance for the genetic progress of the populations. In 1984 as many as 10,000 young fine-wool, semi fine-wool and Tsigai rams were used chiefly for artificial insemination in the flocks of the Agro-Industrial Complexes. They had comparatively high productivity (Table 2) The liveweight of the young rams belonging to the fine-wool breeds imported from the Soviet Union, but raised in this country, varies within the 94 - 99 kg range, while that of the young rams of the Bulgarian fine-wooled breeds is highest, ranging from 100 to 104 kg. The live weight of the semifine-wool young rams is from 91 to 93 kg, and that of the Tsigai young rams - from 80 to 84 kg.

The wool productivity of the young rams is high. At the age of 18 months the fine-wool rams have yielded more than 13.3 kg, on an average, of greasy wool. Karnobatska fine-wool rams produce 16.2 kg. The respective amounts of scoured wool per head have been more than 5.6 kg, and 7.1 kg (Karnobatska). The quantity of scoured wool is also high with the semifine-wool breeds giving 5.6 and 6.5 kg. With individual animals the maximum amount of 10.66 kg has been obtained.

The precocity of animals has steadily been given due consideration in the process of selection and development with regard to all Bulgarian breeds. At equal properties and qualities only those of the animals with a high liveweight at weaning are kept for breeding. With the fine-wool and the Tsigai breed the live weight of the lambs at weaning equals 46% of the weight of adult sheep, and with the semifine-wool breed it is 45%.

The information obtained by the regular recording of productivity in the elite and the reproductive part of the populations shows that the sheep of all breeds are distinguished by high liveweight. At the age of 2.5 years in 1980 the finewooled ewes weighed 61.3 kg, the semi-finewooled ones - 55.8 kg, and Tsigai ones - 49.6 kg.

The assessment of the Bulgarian fine-wool breeds at competitions has shown that at fattening the lambs exhibit a good growth rate and good feed conversion (Table 3) The average daily gain with the individual breeds varies from 272 to 305 g. The food intake (fodder units) per kg gain ranges from 4.44 to 4.96, and that of digestible protein from 349.8 to 361.0 g.

The fattened fine-wool lambs have been shown to have good meat performance. Depending on the breed the portion of meat in the carcass is from 58.6% to 60.6%, that of bone from 19.4 to 22.0%, and that of fat from 6.6 to 9.2%.

Comparatively good fertility of sheep has been reached in overcoming the low fertility of the indigenous breeds in the process of developing the new fine-wool and semifine-wool breeds. Records kept on a mass scale, with sheep of the elite part of the populations, reveal that with the fine-wool breeds fertility rates vary on a year-to-year basis within the range 119.6 to 129.1 per cent; with the semifine-wool breeds they vary from 105.0 to 116.3 per cent; and with the Tsigai sheep they are from 104.2 to 106.0 per cent. On individual farms of the Agro-Industrial Complexes where the animals are raised under very good conditions fertility rate varies from 130.0 to 140.0 per cent.

It is known that from time immemorial the sheep in Bulgaria were used as dairy animals, the milk obtained being processed into white brine cheese, kashkaval (yellow cheese), and sour milk (not to be confused with yoghurt) which have invariably been traditional foods for the Bulgarian people. Records on milk production in the elite flocks of the populations has shown that, depending on the year, 68.7 to 70.6 litres of milk (lactational capacity) are obtainable for a 120 day lactation with the fine-wool breeds. In the period following the weaning of lambs 37.0 to 44.1 litres of milk is produced by a ewe, on an average. With the semifine-wool breeds the milk yielding capacity is higher - up to 52.0 litres per ewe.

At the present stage of purebreed reproduction with fine-wool sheep the main source of genetic progress is the selection carried out. In the elite part of the breeds the pairs for mating are chosen Individually, chiefly on the basis of progeny testing of the rams or their sons. The selection of sheep in the nucleus flocks of the breeds is carried out at five age levels - one month, 100 days, 6 months, 16 months, and 2.5 years (by reproductive qualities).

Five Stations for testing the breeding value of rams are working now in this country. Nearly 15,000 newly produced young rams are annually studied in terms of wool yield and fineness via the employment of objective methods. With the progeny testing of rams records are kept of the productivity of their offspring at the ages of 6 and 16 months.

A considerable number of characters constitute the subject of selection with sheep. In the case of dual-purpose animals (wool and meat) and for the fine-wool, semifine-wool, and Tsigai type sheep the selection traits are graded in significance as follows: most important - scoured wool yield; important - liveweight at 100 days and 18 months of age, fertility, and wool length; while traits under observation include fibre diameter, fleece density, wool whiteness, and staple crimp. With the rams and the ram-producing ewes due consideration is given to the scoured fleece, while with the remaining types of sheep records are kept of the greasy wool.

The great number of selection characteristics limits the effect of each of them, however, it makes possible the overall improvement of the performance qualities of sheep, though at a slower pace.

SIMULATION RESULTS

Parallel to the accomplishments of practical selection, research is going on with regard to the maximisation of genetic progress and to raising the response to selection that follows different patterns. The prevailing values of coefficients as established by various authors for the most important heritable character-wool yield - are within the 0.3 to 0.5 range, and for the inheritance of the live weight quality they are from 0.1 to 0.4.

The value of genetic progress is studied by simulated selection on the base of real data for certain breeds. Table 4 reflects a selection index composed of seven characters used by Hinkovski (1971) with the Askania breed. Highest is the economic value of two characters: number of offsprings at the age of 2.5 years, and wool yielding capacity at the age of 18 months. As the result of selection carried out by this index with 30 per cent of the ewes the highest genetic progress per generation has been obtained for the quantity of milk and the number of offspring, at 2.5 years as well as for the liveweight at weaning (from 4.8 up to 6.7 per cent). A comparatively good selection effect has also been produced with the wool yield (3.4 per cent). In other words, an overall upgrading effect is recorded by means of this index so far as important productive qualities of the Askania sheep is concerned, particularly the reproductive and growth performance of these animals.

With direct selection on liveweight at various ages of the sheep of the Karnobatska fine-wool breed a higher selection response is produced at 9 and 18 months than at weaning and at 2.5 years (2.9 and 2.9 as against 0.6 and 1.2 per cent) (Lazarov, 1981). This demonstrates the dependability of the definite selection based on live weight at the age of 18 months.

The response to selection on wool yield was investigated with sheep belong ing to the Dobrouja type of the Northeast Bulgarian fine-wool breed that were selected (25 per cent) directly on the weight of greasy wool or using the trait that was most strongly associated with it, and by one of the most effective selection indexes of 2, 3, 4, and 5 components of the fleece weight (Mihailova, 1983). The improvement per generation from direct selection (10.9 per cent) is almost twice as high as that recorded for selection using a correlated character (5.7 per cent). Selection indices that include 2 to 4 characters produced similar effects on the amount of wool, but these constitute 68 to 72 per cent of the effects produced with direct selection on wool yield.

With the study on the parameters of the genetic effectiveness with sheep, belonging to the Shoumen type of the Northeast Bulgarian fine-wool breed the annual genetic progress from selection on wool yield was 3.04 per cent when 8 rams and 4 lines were used as against 0.60 per cent with the use of 24 -30 rams and 6 lines (Stoyanov, 1980). This showed that it was very important to optimize the individual elements of selection work in order to obtain maximum genetic progress with each breed of sheep. In the working out of an optimized selection programme for the Askania breed (Hinkovski and Aleksiev, 1980) only 21 out of a total of 46,080 variants were determined as optimal from the genetic viewpoint.

In the scheme reflecting the results of the progeny testing of rams the highest annual genetic progress for wool yielding capacity (4.41 per cent) is obtained with the use of two rams only, i.e., when no genealogical structure of the population is maintained (Hinkovski and Alexsiev, 1980). The application of an optimal variant, envisaging the maintenance of six genealogical lines results in 4.05 per cent annual genetic progress in wool yield. Both variants contribute to the substantiation of an equal genetic progress by growth performance at the rate of 0.52 per cent per year.

In the scheme reflecting the results of selection on performance test of rams at the age of 18 months with the maintenance of genealogic structure of six lines the maximum genetic progress obtained was 4.84 per cent with regard to wool yield, and 0.97 per cent with regard to growth capacity. The effectiveness of this variant is chiefly triggered by the shortening of the generation interval-from 4.08 to 2 years - as well as by the enhanced intensity of selection with the rams (8.3 vs 33.3 per cent). From testing on own phenotype, using no linear structure, the genetic progress with rams is lower (3.11 per cent per year).

The practical use of optimized selection programmes with sheep in this country makes it necessary to perfect the system of selection and to adopt the machine processing of information for the elite part of each breed. Work has been initiated along these lines, referring to the implementation of some elements of the large-scale selection in sheep breeding, the application of the best linear unbiased production (BLUP) method in testing the breeding value of sheep and the working out of programmes to streamline the work associated with the retrieval, processing, and use of data. The building up and the practical application of such programmes will create conditions for the optimization of the selection process and for the enhancement of the genetic progress made in regard to the economically valuable traits with sheep.

TABLE 1. Wool yielding capacity of ewes at the ram producing flocks over the 1980–1984 period.

Breeds	Number	Greasy wool (kg)		Scoured wool
		Average	Maximum	
Fine-wool				
Northeast Bulgarian	3566	7.7	15.0	43.4
Thracian	3990	7.4	13.6	43.4
Dounavska	3590	6.4	13.4	46.8
Karnobatska	4056	7.6	11.6	46.1
Semi fine-wool				
North and South west Bulgaria	4421	4.8	10.0	55.2
South Bulgaria	3133	5.8	10.2	49.8
Tsigai Type				
North and Southwest Bulgaria	3936	4.4	6.9	60.2
South Bulgaria	3174	4.1	7.8	58.8

TABLE 2. Characteristics of the breeding rams at the age of 18 months (1984)

Breed	Number	Live weight (kg)	Greasy wool (kg)	Scoured yield (%)
Fine-wool				
Askania	859	99.1	13.4	40.0
Caucasian	901	98.0	14.1	42.2
Stavropol	52	94.9	13.7	47.6
Northeast Bulgarian	1521	103.5	14.8	38.0
Thracian	1043	101.1	13.3	43.6
Dounavska	785	100.7	13.8	42.8
Karnobatska	319	104.4	16.2	44.0
Semi fine-wool				
North Caucasian	492	93.6	10.6	61.5
Crossbred-type	1456	91.8	10.4	53.2
Tsigai	1798	80.5	7.3	57.9
Tsigai type	935	84.5	8.1	54.6

TABLE 3. Growth of lambs and utilization of food by fine-wool breeds

Breed	Growth rate (9/day)	Food Intake	
		Food Units (No.)	Digestible Protein (g)
Askania	284	4.46	352.3
Thracian	305	4.48	355.7
Caucasian	282	4.44	349.8
Northeast Bulgarian	272	4.96	391.0

Dounavska	285	4.58	361.0

TABLE 4. Selection index (1_4) for testing the breeding sheep of the Askania breed (after Ts. Hinkovski, 1971)

Traits	Symbol	Economic value
Live weight at birth	X_1	0.70
Live weight at weaning	X_2	1.00
Live weight at 18 months	X_3	0.50
Wool at 18 months	X_4	7.00
Wool Length at 18 months	X_5	0.80
Offsprings at 2.5 years	X_6	20.00
Milk at 2.5 years	X_7	0.30

$1_4 = 2.736\ x_1 + 0.204\ x_2 + 0.076\ x_3 + 1.147 x_4 + 0.359\ x_5 + 0.062\ x_6 + 0.051\ x_7$

USE OF HIGHLY PROLIFIC BREEDS AND CROSSBREEDING

S. Kukovics

INTRODUCTION

Ewe reproductive rates are not very high - under 100 percent - in most sheep breeding countries. The efficiency of the sheep industry together with the production of prime lamb needs to be improved. A great potential exists to increase sheep productivity and efficiency by increasing reproductive rate, largely through exploitation of genetic variation among breeds.

Profitability mainly depends on lamb production and various genetic and management methods exists to increase lamb output which depends on fertility, fecundity, lamb survival and number of lambings per lifetime.

To improve prime lamb yield per ewe per year the highly prolific breeds must be exploited. However, many researchers have shown (Watson and Elder, 1961; Purser and Young, 1964) that neonatal losses increase with incidence of twin lambs and with further increases in litter size losses may be even greater. Highly fertile and prolific sheep are presently available and the challenge is to exploit this potential commercially. Several management options are available for producers: annual lambing; different forms of frequent lambing; continuous lambing, etc.

Whatever system is chosen, the full potential of sheep will only be realized by good sheep managers who are able to:

- meet the nutritional requirements of ewes bearing various litter sizes;
- optimize conception rates, through ram and ewe management;
- optimize lamb survival by management during pregnancy and lambing;
- increase lamb output by increasing the frequency of lambings; (Jelbart and Dawe, 1984).

The aim of this paper is to review highly prolific sheep breeds and their use in different crossbreeding programmes. Prolific sheep are characterized by high fertility and fecundity values. Both, but mainly the litter size, vary greatly between breeds, as well as with season, age and nutrition.

Some breeds, such as the Romanov, Finnish Landrace and Booroola Merino, have litter sizes well over 2.0, while the other merino breeds generally have litter sizes below 1.3 The most popular breeds used for prime lamb production, such as the Border Leicester and Dorset, have intermediate litter sizes. Breeds such as the Clun Forest and East Friesian also have high prolificacy and a litter size of around 2.0, mainly the latter breed, but this review will summarize the role of the Finn Landrace (together with the Swedish), Romanov and the Booroola Merino in different crossbreeding trials and programmes, because these breeds have the highest reproduction rate.

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PROLIFIC BREEDS

The Finnish Landrace

Finn sheep were the first to be discovered as a highly fertile breed and results were reviewed by Maijala and Oesterberg (1977). Average production traits of Finn sheep were summarized as:

- conception rate	- 94–96% for ewe lambs (1-year old)
	- 95–98% for adult ewes
- litter size	- 180% for ewe lambs (1-year old)
	- 240% for 2-year old ewes
	- 270% for adult ewes
- average birth weight	- 2.4 kg
- average daily gain	- 180 g
- average daily milk production	- 1.81 kg
- body weight at 150 days	- 30 kg.

Because of its production data Finn sheep are used from Europe to the USA and to New Zealand. Perhaps it is most popular in Europe, where it has its own particular role in sheep improvement trials in almost every country. Table 1 summarizes litter size data of Finn sheep and its crossbred progenies published by different authors. It can be seen that the Finnish Landrace, which has litter sizes of between 200–291 percent, increased the productivity of crossbred progeny of less fertile sheep.

In Czechoslovakia, in addition to the work on increasing prolificacy of Merinos, Czigaja, Improved Valashka and Improved Sumavka (Jakubecz, 1975; Jakubecz et al., 1978, 1979; Machacek and Jakubecz, 1981; Slana, 1981) wool production of crossbreds was also studied. No great difference was found in wool yields of Czigaja and Finn × Czigaja (2.98 and 2.76 kg greasy wool weight, respectively).

Several crossbreeding trials were carried out in the USSR using Finnish Landrace. Shatskii et al. (1978 a, b) and Musabaev (1983), reported very successful experiments on improving the lambing percentage of the breeds studied. Some other researchers have also studied meat production of crossbred progeny of Finn sheep (Table 2) As one can see, the data are quite different. Another conclusion that can be drawn from the results of using Finn sheep is that greasy wool weight decreased and the average fibre diameter increased when it was crossed with Caucasian Merino (Timashev, et al. 1976).

Nitter (1977) reported (from the Federal Republic of Germany) from his studies on the Würtenberg Merino and its crosses with Finn sheep, that the lambing rate, at the experimental and at the commercial flock levels, was 1.20 -1.42 and 0.83 -1.33 for purebreds; and 1.64 -1.87 and 1.30 -2.12 for crossbreds, respectively.

In the German Democratic Republic, Gutsch (1979) obtained 203 percent average litter size and 4.4 lambs/ewe/year from crosses off the German Mutton Merino with East Friesian × Finn rams.

Visscher (1978) in the Netherlands crossed the Ile de France with Finn sheep and found that the Ile de France × Finn genotype gave fewer lambs reared than the Finn × He de France (2.21 and 2.54, respectively).

In Spain, Espejo Diaz et al. (1977) increased the body weight gain of Aragon sheep by crossing with Finn sheep. According to Latif (1980), Finn × Dorset ewes give the best maternal progeny for prime lamb production.

Crossing the Dala and Steiger breeds with Finnish Landrace in Norway, Steine (1980) found that ewes having 1/4 Finnish blood gave 0.18 lambs more than the flock average; however their body weight and greasy wool weight was 0.10 and 0.16 kg less, respectively.

In their work on improving Irish Galway sheep Flanagan et al. (1979) produced new strains having 1/8 and 1/4 Finnish blood. O'Ferrall et al. (1975) carrying out cross-breeding trials with Galway, Border Leicester, Cheviot, Scottish Blackface and Finnish Landrace, concluded that the progenies of Finn sheep were samaller but they had the highest prolificacy.

In New Zealand, Meyer et al. (1978) crossed the Romney with Finn sheep to improve productivity.

More trials were carried out in the USA using Finn (F), Dorset (D) and Rambouillet (R) sheep. Thomas et al. (1975) studying the 1/4 F × 3/4 R, 1/4 F × 1/4 D × 1/2 R and 1/4 F × 1/2 D × 1/4 R genotypes concluded that lambing percentage increased with decreasing R percentage, the lambing rate was higher by about 20 percent after mating in August than after May and June; greasy and clean wool weight declined with increasing D blood (4.6; 4.5; 3.9 kg and 2.35; 2.25; 2.10 kg, respectively). Examining 1/2 F × 1/2 R and 1/4 F × 3/4 R ewes Notter and Copenhaver (1980), found that ewes of 1/2 F blood bad 0.48 more lambs. Average litter size in January was 2.21, in April 2.46 and in September 1.84 and the differences were significant between them. Cochrain et al. (1984) established by studying 1/2 F × 1/2 D and 1/4 F × 3/4 D ewes that halfbreds gave 0.23 more lambs.

In Israel Amir et al.(1981) and Goot and Foote (1983) carried out experiments to improve the prolificacy of Awassi sheep. They managed to reach 1.45–2.14 and 2.20 - 2.45 lambing percentage with Finnish Landrace x Awassi sheep, respectively.

The Swedish Landrace

Though this breed has somewhat less importance, its production values are quite close to those of Finn sheep. In 1956, the average litter size was 1.85 and in 1980 this number increased to 2.25. Weight of lamb (at the age of 120 days) per ewe increased by 25.7 kg between 1956 and 1980 (Brasch, 1981) There are two strains within the breed: Finn-Ull and Rya, the latter producing carpet wool. The Finn-Ull has a higher lambing percentage (2.61 versus 2.10) and weaning percentage (2.03 versus 1.57) but a lower birthweight (3.4 versus 3.7 kg) than the Rya strain (Nilsson, 1976). The Swedish Landrace (Finn-Ull type) is more important in Hungary than the Finn sheep because of its stronger body and ability to tolerate the drier weather.

Mihalka et al. (1982) carried out a repetitive crossbreeding experiment using Finn and Swedish sheep and Hungarian Merinos. Among the different crossbred genotypes the Merino female × Swedish male - F_1 proved the best under Hungarian conditions. This genotype is the maternal line of the so called J-AKI hybrid and the male line is the Suffolk breed. The lambing percentage per ewe per year in this genotype is 0.52 higher, and the litter size weaned about 0.37 higher than that of the Hungarian Merino (1.07 and 0.93) though greasy wool weight is less by about 0.7 kg/ewe (Table 3).

Because of the acclimatization problems of Finn sheep in Hungary another cross-breeding programme is going on at the Agricultural Combinat (Babolna) where the grand-parent population is a combination of Finn sheep and Romanov greater part) and Hungarian Merino (smaller part). These are crossed with Ile de France to produce the maternal line which is mated with Suffolk rams to give prime lambs for slaughter. Average litter size is around 1.8 -2.0, birthweight between 2.2 -3.0 kg, and weaning percentage is 1.4 -1.6.

The Romanov

This breed was discovered as a highly fertile sheep somewhat later than the Finn. However, Kovnerev (1969) reported that where nutrition and management were sufficient it could be bred every six months. In the USSR a great programme was built up on this breed with 15 units, with 5–5000 ewes in each and with 1.5 lambing per ewe year (V. Tosev, personal communication).

As can be seen in Tables 4 and 5 this breed has a litter size between 1.85–2.90 depending on place and nutrition as well as on other circumstances. Average birth weight is between 2.5 and 3.0 kg. Meat production capacity differs from place to place. From the data it appears that the use of this breed significantly increases the prolificacy of other breeds. In the USSR, Shatskii et al. (1976, 1978) stated in their experiments, that the use of the Romanov breed in crossings increases prolificacy and dressing percentage. Meat production of three crossbred was studied by Sallam (1978), Antonova (1979) and Erokhin et al.(1981) and they reported quite good results (Table 5) In the Trial of Timashev et al. (1976) the effect of using the Romanov breed gave less greasy wool weight and coarser wool when crossed with the Caucasian breed.

Czechoslovakian researchers (Jakubec 1975, Jakubec et al. 1978, 1979, Machacek and Jakubec, 1981) also improved the prolificacy of their breeds (Czigaja, Valashka and Sumava) but they reported some disadvantages regarding wool production.

In Spain many crossbreeding trials were carried out to improve the reproductive rate of local breeds. Sierra (1977, 1978, 1980) reported on several experiments. According to his data the Romanov × Aragon F_1 ewes produced 25–70 percent more lambs than pure Aragon sheep depending on the time of first matings. The litter size of F_1 ewes after autumn mating was 2.12, after the spring mating only 1.65, while the purebred Aragons had 1.39 and 1.17, respectively. Sierra (1982) reported on a new Spanish synthetic sheep breed, which has 50 percent of blood from the Romanov and Aragon breeds. Its fertility is 86 percent and the litter size is 1.87 and 2.13 after the spring and autumn matings. Espejo et al. (1977, 1982) and Sierra (1983) gave reports on acceptable meat production data of Spanish Merino and Romanov crossbreds (Table 5) A hybrid programme is now operating in Spain, in which the first cross Aragon × Romanov ewes are mated with Ile de France rams to get first class lambs for slaughter (L. Lopez-Francos, personal communication).

In France the Romanov breed has been given great attention during the last ten years. According to the data of Ricordeau et al. (1976) the purebred Romanov produced 2.88 lambs per ewe and the best combination, Romanov × Cher Berrichon, had a litter size of 2.05 (Cotentin, Border Leicester, Cher Berrichon and Romanov were used in the trial. Ricordeau et al.(1977) reported that the C. Berrichon × Romanov F_1 and F_2 ewes had a 0.66 higher litter size than that of the purebred C. Berrichon ewes. The lambing rate of C. Berrichon × Romanov, 1/2 C. Berrichon × 1/4 Cotentin × T/4 Romanov and 1/2 C. Berrichon × 1/4 Border L. × 1/4 Romanov ewes exceeded that of purebred C. Berrichon ewes by 0.57, 0.30 and 0.36, respectively (Tchamitchian and Ricordeau, 1976).

The conception rates of F_1, F_2, F_3, and F_4, C. Berrichon × Romanov crossbreds were 86, 82, 97 and 99 percent respectively while the corresponding lambing rates were 1.67, 1.87, 1.98 and 2.01, (Ricordear et al., 1982). The INRA 401 maternal line was produced from crossing the Romanov and the Cher Berrichon, work which was done by Tchamitchian et al. (1979) for INRA's crossbreeding programmes. In a comparison of

Limousin and Limousin × Romanov F_1 ewes Marzin et al. (1979) found that litter size was 1.63 and 2.25, birthweight 3.56 and 3.40 kg and mortality was 10.4 and 12.8 percent in the two genotypes, respectively. Though ewes lambed three times within two years, the lambs born per ewe per year were 2.15 and 3.06 and weaning rate per ewe per year 1.92 and 2.66, respectively.

In South Africa Faure et al. (1983) tried to improve the prolificacy of Karakul sheep. They produced crossbred sheep having 25, 50 and 75 percent Romanov blood and the litter size of these genotypes was 1.17, 1.74 and 1.74 respectively. The first genotype did not differ significantly from purebred Karakul.

In Hungary a programme led by Prof. Veress developed a so called “Fertile Merino” by crossing the Romanov breed with the Hungarian Merino. The aim of this programme was to produce a genotype of 1/4 Romanov × 3/4 Merino. This sheep population produced Merino-type wool with a 20 percent longer staple than the original Merino without any coloured fibres. These ewes had 20–30 percent more lambings per year (1.3 -1.4) and 20–30 percent higher litter size (1.50–1.60) than the Merinos. In frequent lambings the ewes of this genotype give two or more lambs per ewe per year (Tables 6 and 7) In fattening the male lambs of the “Fertile Merino” breed daily growth rate was 294–307 g compared with 207–227 g in the females. That of the control Merinos was between 264–281 g and 194–200: g for the sexes, respectively. Wool production data of this breed are as follows: staple length 9–11 cm, greasy wool weight 4.8 -5.2 kg, yield 49 percent, fibre diameter 23–24 microns (only the greasy wool weight data are less favourable than those of the Merino). (Veress and Lovas, 1978; Veress, 1982).

The Booroola Merino

This is the most recently discovered fertile breed, which may have better prospects than the others. It has Merino wool and high prolificacy, having oestrus any time of the year as well as high fertility and fecundity and this quality is determined by only one major gene - “F” so called fertility gene (Davis et al., 1982). This breed was developed in Australia and nowadays is also bred in New Zealand. During the last few years many countries in South America and Europe have tried to obtain this valuable breed. Production data of the Booroola Merino and its crossbreds is summarised in Table 8. These reports have come from Australia and New Zealand.

In the experiment of Piper et al. (1979), studying Collinsville Merino, Medium non-Peppin Merino ewes and their crossbreds with Booroola, it was found that lambing rate was significantly higher but survival rate and clean wool weight was lower in the crossbreds.

In producing halfbred Booroola and 1/4 Booroola genotypes, using Collinsville and Muray Merino ewes, Beetson (1982) reported that the halfbreds gave 58 percent more lambs and weaned 33 percent more progenies than the control ewes.

Allison et al.(1982) carrying out crossbreeding experiments with Booroola × Merino and Booroola × N.Z. Romney accompanied by purebred controls found that crossbred ewes had an ovulation rate of 1.95–2.50, which was higher by 0.72 -0.94 than that of purebreds. Lambing rate was 0.43 -0.73 higher in the crossbreds.

Piper and Bindon (1982) found a litter size of 2.30 in Booroola ewes compared with 1.30 for control Merino. The survival rate was higher in the control up to weaning. They established that the high prolificacy of Booroola ewes could result from the action of only one major gene or numerous very closely-linked minor genes. Robertson (1982) reported on a new strain of the Booroola breed which had a some-what lower litter size and weaning rate.

CH'ang et al. (1982) stated that Booroola Merinos had a 70 percent higher ovulation rate and 50 percent bigger litter sizes than Merinos as well as a 25 percent higher lambing rate than that of N.Z. Romney ewes.

The Hyfer synthetic breed was developed in Australia (Hall et al., 1982) using Booroola × Dorset and Booroola × Dorset × Trangie Fertility Merino genotypes. Ovulation rates of adult ewes were between 2.11 -2.80 in different lines. Due to segregation at the F-gene locus Booroola crosses can fall into one of three groups: Homozygous (FF) and heterozygous (F+) carriers as well as non-carrier (++) (Davis et al., 1984; Kelly et al., 1984, Owens et al., 1984; Owens, 1984). They found in their experiments that the “FF” genotypes had 0.8 -1.02 and the “F+” genotypes 0.4 -0.6 higher ovulation rates and weaning percentage than the non-carriers. Also, the non-carriers had 0.2 -0.4 kg more greasy wool weight and 3.0 -5.0 kg higher body weight than the “F+” and “FF” genotypes, respectively.

Some preliminary results of slaughtered Booroola crossbreds were published by Geenty (1981, 1982).

In Hungary two crossbreeding programmes are presently going on based on the Booroola breed. The most recent is connected with the Oviscoop Sheep Production System in which Booroola rams are mated with Hungarian Merino ewes selected for a high twinning rate and the F_1 female progenies will be crossed with the rams of USA Suffolk or German Blackheaded mutton breeds. The older programme is led by Prof. Veress, who started crossing Hungarian Merino ewes of several cooperative farms with Booroola rams in 1980. According to his results the crossbred progenies of Booroola rams have 6–10 percent smaller body weight than Merinos (2–4 kg). Their greasy wool weight was less by 0.2 -1.2 kg, though the staple length was 1.0–2.0 cm longer.

Unfortunately, the Booroola crossbred progenies have not produced the prolificacy results expected from the literature. After the first two lambings of 400 first cross ewes the fertility rates were found to be between 62–92 and lambing percentage 100–150 percent. After checking the origin of the Booroola rams the results can be explained; there was only one purebred and 6 Booroola (75 percent) crossbred rams in the programme, and four of them were non-carriers (++).

In fact the use of the Booroola breed in crossbreeding could lead to a completely new situation: due to the “F” gene one may not speak of 1/4, 1/2 or 3/4 (or more) Booroola blood in crossbred progenies, but only of homozygous (FF) and heterozygous (F+) carriers as well as non-carriers (++).

CONCLUSION

In summary, collecting experiences from crossbreeding experiments using highly fertile sheep breeds, one can conclude that it is not too difficult to obtain higher prolificacy in first cross progeny. A major problem still remains: how to rear these extra lambs.

In the use of high fecundity breeds to improve the number of lambs reared per ewe per year, the chances of survival to weaning will be increased if birthweight can be controlled through efficient management and satisfactory nutrition. To achieve this and to reduce lamb losses, intensive lambing systems are necessary.

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TABLE 1. Litter size of Finnish Landrace and its crossbreds

Authors	Breed or cross	Litter size
Jakubec, 1975	Finnish Landrace (or Finn sheep)	2.03 -2.67
	German M. Merino	1.12 -1.56
	Finn × German M.M.	1.47 -1.73
Thomas et al., 1975	1/4 Finn × 3/4 Rambouillet	1.20 -1.46
	1/4 Finn × 1/4 Dorset × 1/2 Rambouillet	1.46 -1.62
	1/4 Finn × 1/2 Dorset × 1/4 Rambouillet	1.67 -1.91
Kallweit, 1976	Finnish Landrace	238
Robinson et al., 1976	Finn × Dorset	1.52 -1.70
Nitter, 1977	Würtenberg Merino	1.42
	Würtenberg M × Finn	1.87
Jakubec et al., 1978	Tzigaja	1.11
	Finn × Tzigaja	1.72
Shatskii et al., 1978	M. Precoce	1.06
	Finn × M. Precoce	1.07 -1.78
Shatskii, 1983	Finn × Romanov	2.00
Jakubec et al., 1979	Improved Valashka	1.45
	Finn × I. Valashka	1.74
Gutsche, 1979	Finn sheep	2.91
	G. Merino (East Friesian × Finn)	2.03
Machacek and	Improved Valashka	1.12 -1.33
Jakubec, 1981	Finn × I. Valashka	1.14 -1.57
Visscher, 1981	Ile de France	1.84
	Ile de France × Finn	2.39
	Finn × Ile de France	2.75
Amir et al., 1981	Finn × Awassi	1.45 -2.14
Goot et al., 1982	Finn × Awassi F_1	2.20
	F_2	2.45
Cochran et al., 1984	1/2 Finn - 1/2 Dorset	1.97
	1/4 Finn - 3/4 Dorset	1.74

TABLE 2. Meat production traits of sheep crossed with Finnish Landrace according to USSR authors

Source		Body weight (kg)				Average daily gain (g)	Carcass weight (kg)	Dressing (%)
		At birth 4	At months	At 8 months	At 18 months			
Timashev et al., 1976	Caucasian				42.1		16.36	42.3
	Finn × Caucasian				41.3		17.12	44.0
Shatskii et al., 1978	M. Precoce	3.96				231		45.8
	Finn × M. Precoce	4.26				274		45.3
	Finn × Romanov	2.69				241		47.8
Erokhin et al., 1981	Finn	3.12		38.2				
	Romanov × Finn	3.04		42.6				
	Finn × Romanov	3.49		38.6				
Pliev, 1982	North Caucasian (NC)		29.0	36.0	49.0			45.6–47.7
	NC × Finn		24.2	32.5	44.5			44.3–48.7
	NC × (Finn × NC)		27.2	34.0	46.0			43.5–47.1
	NC × (NC × Finn)		23.7	33.7	46.3			44.1–47.5
Mushabaev, 1983	Finn			40.6			17.7	48.3
	Estonian Black Headed × Finn			43.6			19.7	50.0
Shatskii, 1983	Finn × Precoce			44.7		221		
	(Finn × Precoce) × Latvian B.H.			43.1		206		

TABLE 3. Lifetime production of Hungarian Merino and J-AKI hybrid ewes (Mihalka et al., 1982)

Ewe breed	No. of ewes	No. of ewe × year records	Production	No. of lambings	Lambs born		Lambs reared	Greasy wool weight (kg)	Average diameter micron
					Total	Live			
Merino	207	1196	Total	961	1304	1280	110		
			Per ewe × year	0.80	1.09	1.07	0.93	5.07	23.0
J-AKI	170	558	Total	538	925	888	726		
(Merino × Swedish Landrace)			Per ewe × year	0.96	1.66	1.59	1.30	4.33	24.5

TABLE 4. Litter size of Romanov and its crossbreds

Source	Breed or cross	Litter size
Jakubec, 1975	Romanov	1.86 -2.34
	Romanov × German M. Merino	1.29
Shatskii et al., 1976	Precoce	1.10
	Romanov	2.30
	Precoce × Romanov	2.36
	Romanov × Precoce	1.10
Veress, 1976	Romanov	2.42
Ricordeau et al., 1976	Romanov	2.88
Sierra, 1977–78	Aragon	1.17 -1.39
	Aragon × Romanov	1.65 -2.12
Sierra, 1978	Romanov × Aragon	1.29 -1.72
Shatskii et al., 1978a	Romanov	2.52
	Romanov × Precoce	1.27
	Precoce × Romanov	1.93
Shatskii et al., 1978b	Precoce	1.06
	Romanov × Precoce	1.26
	Romanov	2.52
	Precoce × Romanov	1.93
	Finn × Romanov	2.00
Jakubec et al., 1978	Tzigaja	1.11
	Romanov × Tzigaja	1.72
Jakubec et al., 1979	Romanov × Improved Valashka	1.74
Flamant et al., 1979	Romanov	2.16
Marzin et al., 1979	Limousin	1.63
	Romanov × Limousin	2.25
Antonova, 1979	Romanov × Russian Merino	1.57 -2.00
	Romanov × Tzigaja	1.10 -1.71
Sierra, 1980	Romanov	1.96 -2.96
	Aragon	1.07
	Romanov × Aragon	1.96
Faure et al., 1983	1/4 Romanov - 3/4 Karakul	1.17
	1/2 Romanov - 1/2 Karakul	1.74
	3/4 Romanov - 1/4 Karakul	1.74
Machacek and Jakubec, 1981	Improved Sumava	1.05 -1.29
	Romanov × I. Sumava	1.50 -1.56

TABLE 5. Some meat production data of the Romanov and its crossbreds

Source	Breed or cross	Body weight (kg) at			Average daily gain (g)	Carcass weight (kg)	Dressing (%)
		Birth	3 months	8 months			
Shatskii et al.,	Precoce	4.3				17.8	42.7
	Romanov	2.5				13.9	45.9
	Precoce × Romanov	2.8				17.1	43.3
	Romanov × Precoce	3.9				16.4	42.8
Espejo et al., 1977	Romanov × Spanish M.		19.7				
	Sp. Merino		18.6				
Shatskii et al.,	Precoce	4.0			231		45.8
	Romanov	2.6			180		49.2
	Romanov × Precoce	4.0			263		45.2
	Precoce × Romanov	3.2			245		44.8
	Finn × Romanov	2.7			241		47.8
Sallam, 1978	Romanov × Tzigaja/x Suff.	3.8		37.3			46.4
	Romanov × Tzigaja/x Romn.	3.6		33.8			45.0
	Romanov × Tzigaja/x lie de France	3.7		35.9			48.2
Antonova, 1979	(Mer. × Rom.) × Ile de F.				297		53.4
	(Mer. × Rom.) × Ile de F.				215		54.3
	(Tzig. × Rom.) × Ile de F.				276		48.1
Erokhin et al., 1981	Romanov	3.0		36.4			
	Finn	3.1		38.2			
	Romanov × Finn	3.0		42.6			
	Finn × Romanov	3.5		38.6			
Espejo et al., 1982	Sp. Merino	4.1	22.0		204		
	Sp. Merino × Romanov	4.3	22.9		195		

Sierra, 1983	Romanov × Suffolk	2.9	27.7						49.4
	(Romanov × Aragon) × Suffolk	3.5	31.2						50.0

TABLE 6. Productivity of Merino × Romanov F_1 ewes on different farms in Hungary [+]

	Farms				Pooled
	1	2	3	4	
First year data					
No. of ewes	47	371	647	59	1 124
Lambings per year	1.69	1.37	1.08	0.779	1.18
Litter size	2.45	1.77	1.32	1.56	1.57
Lambs per ewe per year	4.15	2.44	1.35	1.22	1.84
Weaning rate (%)	87.6	93.1	94.2	75.8	94.0
Summarized data of the first 5 years					
No. of ewes	148	1805		443	
No. of lambings	180	2116		319	
No. of lambs born	430	3555		517	
No. of lambings per year	1.22	1.18		0.72	
Litter size	2.39	1.68		1.62	
No. of lambs per ewe per year	2.90	1.97		1.16	

[+] Based on Veress and Lavas (1978) and Veress (1980, 1982).

TABLE 7. Production data of Merino and Fertile Merino ewes in their first two lambings [+]

	Merino	Fertile Merino
Number of ewes	58	58
Number of lambings	67	107
Number of lambs born	71	145
Number of lambs weaned	66	117
Number of lambings per year	1.16	1.84
Litter size	1.06	1.36
Number of lambs per ewe per year	1.22	2.50
Lambs reared per ewe	1.14	2.02

[+] (Veress, personal communication, 1985)

TABLE 8. Prolificacy of the Booroola Merino and its crossbreds

Source	Breed	Ovulation rate	Lambing (%)	Survival rate	Weaning rate	Clean wool (kg) weight
Piper et al., 1979	Collinsvilie Merino		117		78	3.7
	Medium n.P. Merino		118		88	2.2
	Booroola × Collinsvilie M.		155		64	3.3
	Booroola × M.n.P. Merino		184		62	2.2
Piper and Bindon, 1982	Booroola		230		125	
	Merino		130		98	
Owens et al., 1980	Booroola		228	92 -44 (singl.-quadruplets)		
Robertson, 1982	Booroola 2 y ewes		154	83 -25	95	
	adult ewes		199	95 -44 (singl.-quadruplets)	144	
Davis et al., 1982	(Booroola × Romney) F_2 ("FF")	2.53	2			
	("F+")	1.95				
	("++")	1.52				
	Booroola × Merino ("FF")	2.67				
	("F+")	1.81				
	("++")	1.32				
McGuirk	Booroola × Collinsvilie M.	1.88	159		112	
	Collinsvilie Merino	1.24	113		83	
	Border L. × Collinsville M.	1.56	147		129	

DEVELOPMENT OF WOOL GOAT BREEDING IN THE USSR

Dr. Dauletbaev

INTRODUCTION

Our Government has a large programme in the development of sheep and goat breeding. Goat breeding is based upon planned development. Because of the financial interest of the kolhozes and sovhozes, as well as of the private sector, for the last 10 years commodity prices of mohair, goat down and other goat products have been increased several times. Due to this the number of goats is increasing, productivity is also increasing and consequently total production. Specialization of the farms and the concentration of goat herds is under way, there are now big breeding and commodity farms having 10 to 40 -50 thousand head each. All around the country goat breeding yields a high income.

In many regions of the country goat breeding is a traditional activity. The people of many regions of RSFSR and other republics for a long time bred milk goats and are famous for their milk products, while the people of Asian republics are famous for home-made carpets, no lower in quality and beauty than Persian. Orenburg produces the famous down shawls - where from century to century and hand to hand the skill and love of the profession is passed. Thus, a long time ago was born the down knitting craft. The fineness of work, original pattern and the beauty of the whole trimming made the Orenburg shawls world famous. For the first time in 1857 and 1862 at the international fairs in Paris and London, the visitors were able to admire the unique articles of the Orenburg knitting craft, which even today, at the international fairs are valued as artworks.

All this was possible owing to the existence of the unique domestic goat breeds. The Orenburg goat has the finest down (fibre thickness ranging from 10 to 15 μm). The average yield of down is 350 -400 g (fibre length 5 to 11 cm). Among all known mohair goats those living near the river Don have the highest down productivity. The average yield from the productive bucks is 1.1 kg, maximum 2.1 kg, while from does the corresponding values are 600 g and 2 kg. Adult goats have an average fibre thickness of down of 18 μm and the length of down fibre varies from 6.7 to 13.2 cm.

The high-mountain Altay breed has similar qualities. The body weight of bucks is 65 to 70 kg, the yield of down equals 600 to 900 g, length of fibre -8 to 9 cm, thickness of fibres - 17 to 18 μm and the content of down in the fleece is 65 -75%. Corresponding figures for does are 41–44 kg, 450 -600 gr, 8 -9 cm, 16 -17 urn and 65 -70%

Our mohair goat breeds have many valuable biological qualities as a result of long-term selection under severe natural conditions, which range from burning deserts to rocky high mountains. While many goat breeds in the world, especially in Europe, are selected and bred in good environmental conditions, in many regions of our country nature is not favourable. Our breeds withstand temperatures down to -40°C and summer heat and drought. Because of such training the goats are less dependent on conditions of maintenance at pasture; at the same time they are responsive to the good conditions of feeding and maintenance.

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Since my theme is concerning mohair goat breeding in the USSR I would like to present to you the materials we have. To describe the methods related to the creation of mohair production in our country it is necessary to present the historical aspect. The mohair goat breeding in USSR began from the angora goat. The Turks jealously protected the angora goat as their monopoly. The exclusive qualities of mohair is the reason that the Europeans insistently solicited the goat and later the Americans tried to obtain them.

The breeders who improved and developed the angora breed left to us a valuable monument. In the features of these beautiful animals is reflected the perfection of folk skill and experience, or as Marx said, "in the livestock is the stamp of man's hand". It is still of interest to the researchers to discover how, when and where the angora goat had its origins. As it is known, when man for the first time met the angora goat in Turkey people tried to acclimatize her in different countries.

HISTORICAL DEVELOPMENT

The Angora was first imported into Russia in 1811 and 1814, but the Angora goats failed to acclimatize and became only decorative animals. In some places there were even attempts to bring Turkish goat families, but the results even successful in the begining did not leave positive traces. The Soviet Government got interested in this breed in the early thirties. In February 1936 goats from Texas, America were delivered to Novorossiysk and were distributed to different regions of the country. However, from literature sources it is known, that these animals did not adapt well to the new conditions being least satisfactory in the mountain regions of the Asian and Caucassus republics, also in Dagestan ASSR. Among them was observed great sterility of the does with many deaths and a drastic decrease in wool productivity.

Therefore, solving this problem by breeding pure breeds of angora goats using their acclimatization had no prospects. It became obvious that it was necessary to conduct crossing between domestic does and angora bucks. The work was done mainly in the Asian republics and Kazahstan. The resulting research on different crossbreds enabled choices to be made as to what direction and to which generation to keep the crossbreeding, how the productive qualities were inherited and formed through both parental forms in the generation and in which one to select the desired type.

Thus, the work on creation of the mohair goat breeding went in two phases: the first, when we used the converting method of crossbreeding to obtain domestic animals of different generations, the second, when we used the method of reproductive crossbreeding to consolidate the desired factors. By the end of the fifties the work of creating a wool goat breed was completed.

Considering the identity of the main manner in breeding and the shared origins of the animals, the scientific and technical council of the Ministry of Agriculture of the USSR decided in 1962 to amalgamate all breed groups of goats in the Asian republics and Kazahstan into one giving it the "sovietskaya sherstyanaya"-soviet woolen. At the time of officially approving the herds of soviet wool breeds and their crosses in our country there were about 500,000 head, including 200,000 purebred.

BREEDING AND PRODUCTION

The Soviet wool goats are well adapted to different conditions in the Soviet Union. The goat has a firm body, strong limbs with hard hooves and is adapted to stony pastures and long drives. The wool of our mohair goats is known in manufacturing as "mohair" or "tiftic". In accordance with the existing standards the mohair is divided in two groups. In the first is included the wool of the pure-breeds; in the second - the crossbreds. For the manufacturing standards the mohair is divided further into classes corresponding to the thickness of the fibre. In both standards the length of the wool must be no less than 10 cm. In favourable conditions the mohair can grow up to 2.5 cm per month, so harvesting can be done twice a year. Annual growth of the wool varies from 18 to 30 cm, and the output of pure fibre at 85 -92%. The napping of does when the nap is once a year gives 1.8 -2.1 kg, when twice a year - 2.1 to 2.5 kg; the bucks give, respectively, 3.5 to 5 kg and 4.9 to 6 kg.

Goats selected for breeding are of great value because of the level of their wool productivity. The record nap in bucks is 9.1 kg and in does is 5.5 kg.

Most of the Soviet wool goats in Kazakhstan are bred in the Semi palatine area where the breed was created.

The climatic conditions of the north east part of Kazakhstan differ from the conditions of the areas of intensive Angora goat breeding. Winter temperatures vary to a great extent and sometimes they fall to -45°C. In summer the temperatures can reach +41°C. Hence, the annual amplitude of the mean monthly temperature is almost twice that found in Texas, New Mexico and Turkish central Anadole. Thus, unlike all other wool goat breeds the Kazakhstan wool goats are highly adaptable to the severe conditions of the republic. It should be noted that the semi-palatine area is in the northernmost area of Angora goat breeding in the world and of wool goat breeding in the country. It shows the wide ecologic capacities of the Kazakhstan population. The winter period lasts 160 -180 days. When they are housed the goats receive 2 -3 kg of roughage (hay, alfalfa and straw) plus concentrate (250 -300 g) per head. The goats are kept in sheephouses with heating provided. Flocks of old goats consist of 400 -500 heads, young animals, 600 -650 head, breeding bucks, 100 -220 and castrates, 800 - 850 head. During the winter housing period the goat population is concentrated on a specialized farm while the mother goats are kept on state farms.

We have developed and produced the technical equipment in accordance with the biological peculiarities and the exterior of the goats. Thus, food distribution, watering and removal of manure are mechanized. Feeding of the goats in winter is effected on fenced sites in the open air where the racks are placed. Mating of goats is organised in two periods: the first one being in September, the second in November. Shearing of goats is effected in the middle of April. In Autumn, flocks are formed according to grades and age on the basis of goat evaluation. Selection of first grade and elite animals is individual.

The higher the stock and breeding value of the breed, the more perfect should the methods of selection be. The great demand for mohair in the country puts forward the scientific and research work in the field of improvement of productive qualities and breeding traits of the Soviet wool breed.

In our selection work we support the consolidated adaptive qualities of the Soviet wool breed inherited from the domestic Kazakh breed. Nowadays the Kazakh wool goats significantly excell the Angora and other analogous wool breeds in the world in terms of body weight and the exterior. Thus, according to Bilgemre (1953) height at withers of Angora goats is 25.6 cm at birth, 41.2 cm at 12 months of age and 48.2 cm at 18 months of age, while height at withers of the soviet wool breed is 26.3%, 14.8% and 6.8% higher at the respective ages. Liveweight of female kids is 2.3 kg at birth, 15.5 kg at 4 months of age, and 33.5 kg at 18 months of age for male kids the corresponding figures are 2.5 kg, 17.4 kg and 35.1 kg, respectively.

Of a great commercial value is the wool of these goats. The length of the wool is up to 20 cm and more. A specific characteristic of this wool is its strong “silk shine” and its great strength. The output of pure wool in all sex and age groups is high (78 to 92.5%).

The Kazakhstan population of wool goats is positively different from the Turkish and American Angora goats - it has more fine wool. While the fibre thickness of the angora wool goats varies in the range 32.4 to 49.3 microns, that of the Kazakhstan type is 23.9 microns for one year olds, 28.0 at two years of age and 32.7 in three year olds. Breeding bucks average 39.6 microns.

The overwhelming part of the wool sorts are 58, 56, 50 and 48 quality One of the important physico-mechanical quality indicators of wool is the uneven-ness coefficient. In accordance to the technical demands wool of the angora goats having the heterogenity coefficient of 27.7% for the 48 quality is considered equivalent to 24.2% for 46 quality. As it is seen in our data the unevenness co-efficient in groups of animals is 23.0% for the 56 quality; 25.2% for 50 and 48 quality and 28.3% for 44 quality. Thus the mohair wool corresponds to the wool standards.

I would like to draw attention to one of the most importance moments in the selection of wool goats. As it is known to you, the wool of the Angora and the Soviet wool breeds varies over a wide range. Such variation in thickness makes it difficult to keep the mohair standards and also defining and choosing the type wanted for selection. Some scientists prefer 44 -breed goats with thinner fibres.

In our pedigree-selection work with the Kazahstan population of wool goats we have the need to breed goats with wool having semi-rough fibres as well as with semi-fine. It is very important for the reason that the production of different mohair sorts enables more specific rational use of the raw material in manufacturing a greater assortment of products. We have established that the wool of the one year old goats of the line with fine fleeces has the quality of down. The Soviet wool goats may be recommended as a source of improvement for crossing of aboriginal goats. This gives the possibility of changing the domestic low productivity goat breeds and obtain wool with improved technological qualities.

To establish the effectiveness fo this crossing we conducted special experiments. A flock of does, numbering 700 head, was formed for this purpose and they were either black or black-and-brown. From the 775 kids born 636 (82.4%) were white; 51 (6.6%) were grey; 20(2.7%) were straw coloured; 16(1.8%) were black and 50(6.5%) had assorted colours. The wool colour of the offspring generation, in contrast to the mothers, is characterized with great homogenity of the down and the transition hair. At the moment of weaning their rough hair falls and is replaced by light wool. The content of down and transition hair in the youngsters is 62.4%, while the original domestic goats had only 21.4% of down and transition hair.

CONCLUSION

In the matter of the goat breeding development we have many common problems. In the world there are many goat-wool products most of them are authentic art crafts and are liked by all the women in the world. But, despite the acknowledgement of these products, yet their quantity is far from enough.

Of course in a single speech it is not possible to state all the problems, scientific elaborations and achievements related to the goat breeding. There is no doubt that this activity will be the beginning to further useful cooperation between the scientists of many countries. There is a great field for such an activity. First of all I would like to create a goat breeding council which would enable the exchange of scientific and technical information, plan joint meetings for further scientific discussions of the problems, coordinate the question of exchange of pedigree goats, scientific staff training and solving many other questions concerning goat breeding development.

I would like on behalf of all colleagues of our country and of myself warmly to thank the organizers and initiators of the present meeting, which should serve well the on-going progress of science in the field of goat breeding.

SELECTION FOR INCREASED PRODUCTION IN MULTI-PURPOSE SHEEP AND GOATS

E. S. E. Galal

INTRODUCTION

Although very few breeds of sheep may be classified as specialised in producing carpet-wool, e.g. Scottish Black-face and Drydsdale, the wool produced from the majority of non-fine wool breeds can be utilized in the wool-carpet industry. Properties required by the industry can be met by blending different types of wools produced by different sheep. This paper deals with selection for increased production in multi-purpose sheep excluding fine-wool, hairy and fur breeds.

The multi-product nature of these sheep and the wide range of environments under which they produce do not make possible generalisations with regard to genetic improvement. Based on data presented by Mason (1969) and World Bank (1984), when sheep used for carpet-wool are raised for mutton and wool approximately 60% of the breeds have wool as their primary purpose; when they are raised for mutton, milk and wool the three products have an average rank of 2.1,1.9 and 2.1 respectively, as the primary purpose for raising these breeds. Thus, from these data it may be concluded that on the average wool is more or equally often a primary purpose for raising sheep breeds compared with mutton and both are more frequently the primary reason than milk. Very few breeds are raised primarily for pelts or fur.

Most carpet-wool sheep are raised under extensive systems, nomadic, semi-nomadic and transhumance. However, some are raised under intensive and semi-intensive systems where wool is an important by-product. Thus selection objectives and mode of disseminating genetic gain would necessarily vary according to, among other things, system of production.

TRAITS OF IMPORTANCE IN CARPET-WOOL SHEEP

Beside adaptation and fitness traits, the following are the main ones that are of economic importance:

Meat Production

This is a complex function depending on the number of sheep slaughtered and their average weight. Heritability of slaughter weight and liveweight ranges from medium to high (0.2 -0.5) (Mavrogenis, Louca and Robinson, 1980; Guirgis, Afifi and Galal, 1982 and Rae, 1982) which implies that marketing weight is a trait that could respond to mass selection. However, slaughter weight is highly and positively genetically correlated with mature body weight and any increase in slaughter weight could be associated with increase in mature body weight which entails an increase in feed costs in the flock. This is particularly important in sheep where the cost of the breeding female constitutes a relatively larger proportion of the total costs than in other farm animals. An ideal situation would be to increase slaughter weight with a ceiling on mature body weight, i.e. selection for changing the growth curve. Other techniques to minimize the increases in mature body weight are discussed later.

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Although slaughter weight is the most important single measurable indicator for meat production (Bradford,1974), dressing percentage and meat quality become important in some situations. Most of the carcass traits have medium to high (0.25 -0.50) heritability.

Reproduction Rate

A convenient operational definition of reproduction rate is the number of lambs weaned per ewe joined with the ram per unit of time, LWEJ. It includes fertility, fecundity, lamb survival and maternal effects. High LWEJ is desirable when other inputs like feed and managerial skills are available. LWEJ has a low to medium repeatability (0.10–0.25) which means that taking more records on the individual substantially increases the accuracy of measurement. Although selection has been successful in increasing fecundity in Merino (Turner, 1978) and in Romney (Clarke, 1972) most of the current work emphasizes the utilization of interbreed rather than intra-breed additive genetic variance. Among all reproductive traits fecundity seems to be the one most likely to respond effectively to selection. Turner (1979) discussed conditions necessary for the improvement through crossing to exceed that through intra-breed selection.

Studies are underway to investigate the possibility of improving reproductive traits indirectly through selection for other potentially correlated traits, e.g. testis growth (Smith, 1985).

Wool Production

Fleece weight is often the most important factor, among all fleece aspects, in determining the financial returns from wool. There exist no universal standard specifications for carpet-wools. Turner (1979) cited the definition of “desirable characteristics for Indian carpet breeds” as: average fibre diameter 30-40 μ, percent fibres without medullation ≥40, percent heterotype fibres (interrupted medullation) ≥20, percent hair (medulla 60% of the diameter) ≤10, percent kemp ≤ and length 7.6 -8.9 cm. Fleece weight, fibre diameter and medullation are all highly heritable traits with heritability ranging from 0.30 to 0.60 (Rae, 1982) while heritability of kemp score was estimated as 0.43 by Guirgis et al. (1982).

Milk Production

Milk production in sheep is an important trait for rearing lambs and sometimes for human consumption. Some of the breeds producing carpet-wool are also renowned for their high milk yield, e.g. Awassi and Chios. Milk production has a heritability of 0.15–0.50.

RELATION BETWEEN IMPORTANT TRAITS

Genetic correlations between live weight and reproduction traits are generally positive and those between live weight and fleece weight are mostly positive and small to medium in size. Guirgis et al. (1982) reported positive genetic correlations of 0.15 between weaning weight and staple length and 0.06 between weaning weight and kemp score. The estimates of the genetic correlation between live weight and milk yield are mostly positive but small.

Estimates of the genetic correlation between reproduction rate and fleece weight are variable. However, effecting desired changes in both traits simultaneously is possible (Rae, 1982). There is a scarcity of estimates of the genetic correlation between reproduction rate and milk yield but it is well known that bigger litter size is phenotypically associated with higher milk yield.

Greasy fleece weight has a high positive genetic correlation with clean fleece weight, moderately positive with staple length, low positive with each of average fibre diameter and medullation and non-consistent estimates with milk yield (Rae, 1982) and moderately negative (-0.27) with kemp score (Guirgis et al., 1982). The latter authors reported a genetic correlation of -0.13 between staple length and kemp score.

GENETIC IMPROVEMENT THROUGH SELECTION

Single Traits

This is the easiest and in many situations the only practical method of selection. Given the above described structure of the genetic correlations between important traits, it is possible to say that selecting for one trait will be associated with improvement in most other traits with little or no deterioration in a few traits. Guirgis et al. (1982) estimated direct and correlated responses expected per generation when selecting for different traits in a Barki flock at an arbitrary selection pressure of 5% in the rams and 50 % in the ewes. An extract from their results, expressing the genetic change as percentage of the trait mean, is given in Table 1. Among the three fleece traits, selection against kemp is expected to be accompanied by the largest response in yearling weight. Also, selection against kemp is expected to produce changes in the desired direction in both fleece weight and staple length.

The single trait could be a simple trait like body or fleece weight, for instance, or a complex one as kg weaned per ewe or fleece weight per unit body weight. The latter index was used as a selection criterion for the Australian Merino Society during 1963/70 (Shepherd, 1979). The relationships between the components of complex traits and their relative heritabilities are important in determining the net outcome of using such complex traits as criteria for selection. If the complex trait is a non-linear expression of its components the prediction of genetic change due to selection is often inaccurate and the selection intensity affects the contribution of each component trait to the net change. Gunset (1984) found that linearizing feed efficiency (measured as a complex non-linear function: kg feed consumed/kg gain) in a form of an additive selection index was more efficient in causing genetic gain in the ration than direct selection on the ratio when heritabilities of the two component traits were different. In practice, selection for single traits is often coupled with independent culling levels for other traits.

Selection Indices

Theoretically, selection indices are the most efficient method of selection. The construction of selection indices requires the measurement of genetic and phenotypic variation and co-variation of and between traits without error and the economic values of these traits. The availability of all these estimates would allow what Williams (1962) called "optimum index method". However, in the absence of some of the estimates "a reduced index method" may be devised which is less efficient than the optimum but could be more efficient than single trait selection.

Selection indices in the absence of economic values: Elston (1969) proposed a non-linear index $I = \prod^{n} P_i$, where P is the phenotype of the trait, coded by subtracting the minimum of each respective trait and n is the number of traits involved. Baker (1974) found that $I = \sigma_{p2} P_1 + \sigma_{p1} P_2$ is a good linear approximation of Elston's index. Dividing the index by a $\sigma_{p1} \sigma_{p2}$ it becomes $I = P_1/ \sigma_{p1} + P_2/ \sigma_{p2}$, i.e. the linear approximation $\sigma_{p1}\sigma_{p2}$ amounts to equal weighting per phenotypic standard deviation. Elston's index does not even require estimates of genetic parameters. Pesek and Baker (1969) proposed another index which is free of economic weights but instead, the desired genetic changes are stated and taken into consideration. If the desired genetic changes were arbitrarily set equal to the genetic standard deviations, Pesek and Baker index and that of Elston would give similar results. Baker (1974) compared the two indices with selection for two individual traits-under 12 different combinations of genetic correlations and heritabilities. He found that the expected responses by using either selection index was higher than when selection was performed on individual traits when the magnitude of the genetic correlation was ≤ 0.65. However, when the genetic correlation gets high enough (viz.0.8 in his study) the high correlated response in one trait associated with the selection for the other makes the overall response in the two traits in the case of individual trait selection some times higher than selection by either index especially when the selection is performed primarily for the trait with the highest heritability.,

Restricted selected indices: When a trait is genetically correlated with other trait (s) in a selection index it is expected to change with changes in these other traits. However, the change in such a trait could be controlled (or restricted) (Kempthorne and Nordskog, 1959; Tallis, 1962; Cunningham, Moen and Gjedrem, 1970 and Brascamp, 1984). A trait in question is the ewe live weight where it is in general genetically correlated in a positive way with other traits of interest mainly lamb growth. It is desired to restrict the increase of ewe weight, while improving the others, in order to minimize the maintenance costs of the breeding ewes. To effect such restriction, Cunningham et al. (1970) used a dummy variable in the basic selection index, I = b_1 × fleece weight (FW) + b_2 × number of lambs produced (NL) + b_3 × weaning weight (WW) + b_4 ewe weight (EW) + b_5 × dummy variate, to select for an aggregate genotype defined as T = 2 FW + + 22 NL + 1 WW + OEW. They compared four situations, ewe weight is completely ignored in the selection index, not included in the index but restricted through the dummy variate, included in the index but not restricted and included in the index and restricted through the dummy variate. They found under sets of genetic parameters differing mainly in genetic correlations that the maximum genetic response to the index was obtained when EW was not restricted. Only very slight loss in genetic response occurred when EW was restricted but included in the index while the loss was substantial when EW was restricted and not included in the index. Table 2, from Cunningham and Gjedrem (1970), compares the correlation between the index and the aggregate genotype, as a measure of the relative response in each case, under different situations. They also found that change in EW could be brought to zero with negligible effect on the response of other traits and of the aggregate genotype and that unless EW is being restricted there is no need to include it in the index. That work showed that WW and NL were the highest in terms of their contribution to the overall genetic gain and they were the least affected traits by restricting EW. It also showed that the relationship between the degree of the restriction of EW and the change in genetic gain in other traits and in aggregate genotype was linear. Cunningham and Gjedrem (1970) also examined the stabilization of EW by assigning to it a negative economic value in the aggregate genotype but they recommend against such procedure.

While selection indices are considered the most efficient in causing genetic changes, they are also the most expensive to construct. The cost of genetic gain should be taken into consideration when deciding on an improvement scheme. For instance, in circumstances where phenotypic parameters are estimated from previous records, when great accuracy in selection is not required and when traits may be measured at different stages to enable early culling of surplus animals the method of the independent culling levels may be preferred to that of the selection index (Young and Weiler, 1959).

DISSEMINATION OF GENETIC GAIN

An efficient dissemination of genetic gain often requires a degree of organized flock structure and sheep record keeping. The stratification of the flock into two tiers, nucleus and base flocks, or into three tiers, nucleus, multiplier and commercial flocks is followed in major sheep countries. The nucleus may be closed or open to allow the movements of the genes upward in the hierarchy.

In developing countries two situations exist, one where the flock (usually extensively run) size is substantial but taking records is impractical and the other where the flock is small (often below 20) and selection within it is not possible due to the diminished selection differential and to avoid inbreeding. In these circumstances the only practical means to spread the genetic gain is through the distribution of improved rams produced in governmental or semi-governmental flocks either directly to commercial and village flocks or after they have multiplied in selected larger flocks. Artificial insemination could accelerate the rate of genetic improvement but for practical considerations its use is limited in such countries.

Genetic gain realized under one environment (governmental station) is likely to be transferable to sheep raised under commercial situations. Results of research have shown that genetic-environment interactions in sheep are not very important unless the genotypes are to be used over a wide range of environments.

MAJOR GENES

Major genes can be important in introducing characters that are originally lacking in certain populations. One example is the discovery of the N multiple allelic series (N^t, N^d, N^J, n) in the Romney sheep and the formation of Tukidale, Drysdale and Carpetmaster sheep “breeds” in New Zealand (Wickham, 1978 and Wickham and Rae, 1977) for specialized carpet-wool production. The homozygous NN genotypes have the highest density of halo hair but the heterozygous Nn has a varying density of halo hair depending on the allele.

The Booroola gene in the Australian Merino (Piper and Bindon, 1982) is another example for major genes which increase ovulation rate. It offers opportunity for increasing fecundity in Merino sheep (Robertson, 1979).

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TABLE 1. Effect of selection (as % of the mean) in Barki sheep

Trait	Direct Selection	Correlated response when selecting		
		Against Kemp	For Staple length	For Fleece weight
Yearling weight	6.7	4.2	2.10	2.6
Fleece weight	13.0	5.0	1.60	
Staple length	5.3	1.1		0.9
Kemp score	-30.1		2.40	1.3

Source: Guirgis et al. (1982)

TABLE 2. Accuracy of selection index with and without restriction on ewe bodyweight (EW)

	EW not included in the index		EW included in the index	
	Non-restricted	Restricted	Non-restricted	Restricted
Parameter set 1	0.41	0.22	0.42	0.38
Parameter set 11	0.41	0.26	0.41	0.40

Source: Cunningham and Gjedrem (1970)

STRATEGIES TO INCREASE SHEEP PRODUCTION IN EAST AFRICA

R. T. Wilson

INTRODUCTION

Latest estimates of livestock populations in nine East African countries provide a total of about 64 million sheep equivalent to about one half of a sheep per head of the human population in the area. Sheep represent about 8 percent of the total domestic ruminant biomass but, because of their rapid reproduction rate and the early age at which offtake occurs, they provide a disproportionate amount of animal products. This is probably equivalent to about twice the figure represented by their biomass.

With the exception of some commercial enterprises in Kenya whose production goals are either wool or meat all sheep in eastern Africa are managed in traditional systems. Ownership patterns and flock sizes vary, depending on whether livestock is the principal occupation or a subsidiary one of the owners. The end product is almost entirely meat, either for home consumption or to an internal or external market through sales. In parts of Sudan, sheep are also kept to provide milk.

CURRENT PRODUCTIVITY IN TRADITIONAL SYSTEMS

The productivity levels of traditionally managed sheep are higher than has generally been accepted. Long-term studies carried out over periods of several years have shown that the annual reproductive rate (number of young produced per breeding female per year) varies from 1.5 to over two lambs. This rate of reproduction results in part from the uncontrolled access of rams to ewes on a permanent basis and in part from the litter size. Some representative annual reproductive rates for a number of African countries are shown in Table 1.

The interacting effects of litter size and the parturition interval are clearly demonstrated by Table 1. “Control” of breeding usually means attempts to induce lambing at what is considered to be the most favourable period of the year. This control normally results in longer parturition intervals than are found when breeding is allowed year round. Control leads to only one lamb crop per year for example in Rwanda, under station conditions and slightly in excess of one in the traditional Masai system in Kenya. In the semi-arid to arid zones of Mali and Sudan, uncontrolled breeding results in shorter parturition intervals enabling approximately three lamb crops to be obtained in two years. Shorter intervals coupled with moderate litter sizes lead to relatively high annual reproductive rates compared with longer intervals even if sheep are highly prolific.

Total lifetime production of young can be increased by encouraging first lambing at early ages. In most traditional societies, first lambing occurs at 15–18 months when ewe weights are 80–85 per cent of mature size. Control of age at first breeding usually means delaying this and may result in first lambing not taking place until 2 years or older.

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The growth rate is an important factor in livestock productivity. In traditional systems, because of overstocking, genetic potential is rarely expressed. Growth rates vary from as little as 40 g per day in Kenya Masai sheep to as much as 70 g per day in Sudan Desert type from western Sudan. These are averages for all sheep from all birth types over all seasons. Male sheep born as singles in the pre-rains period usually have much higher growth rates to weaning. As an example of the potential for increased growth under improved conditions of nutrition and management, the “Mouton de Case” sheep in West Africa achieves a growth rate of 117 g per day to 40 weeks of age compared with only 60 g for its range-reared contemporaries.

Management practices in many traditional societies are such that the best adapted sheep or those with superior genetic potential are not used as breeding stock. This is because of the cultural or religious requirements for large fat sheep for slaughter at social and sacrificial occasions.

Pre-weaning mortality has been shown to be an extremely important constraint on productivity of sheep. Levels of up to 30 or even 40 per cent losses before weaning are not uncommon. Examples of the rates of death in several areas and some of the environmental variables affecting the death rate are shown in Table 2.

From the three production parameters just discussed, it is possible to construct a series of simple productivity indices. These can be calculated as total liveweight of weaned young produced per breeding female per year (I) or liveweight produced per unit weight (II) or per unit metabolic weight (III) of female per year. Some examples of overall productivuty indices are provided in Table 3. These are affected by the same variables as shown in Table 2.

IMPROVING SHEEP PRODUCTION IN EAST AFRICA

The standard approach to improving the supposedly unproductive indigenous African sheep types has been to import exotic breeds, usually of European origin. They have then been kept on research stations, “under mosquito nets” as one French colonial administrator once described it, and given all the care and attention needed to force them to survive under climatic, disease and nutritional conditions totally alien to them. There have rarely been successful transfers of these breeds (or crossbreds with high levels of exotic blood in them) to traditional systems. In East Africa, successes have almost entirely been confined to those cases where modern management practices can be assured and high levels of veterinary and nutritional inputs maintained.

It does not appear that this classic method can be expected to produce worthwhile improvements in sheep production across the whole spectrum of pastoral and agro-pastoral systems to be found in East Africa. The methods employed to improve productivity must be geared, especially in the initial stages, to the existing systems of production and their capacities to provide managerial, nutritional and health inputs. “Improved” animals to be used in or released into these systems must also be capable of surviving under prevailing conditions. Table 3 has shown the variation among African indigenous breeds in productivity: it should be perfectly feasible to use these as improvers by making use of their comparative advantages, whether these relate to reproductive performance, capacity for growth, high survival rates or tolerance of mediocre management. Experiments under controlled station conditions should be paralleled with continuous monitoring of traditionally owned and managed flocks.

Where outstanding performance in indigenous flocks is noted, the reasons for this should be identified and, where possible, extended to contemporary owners and even research stations. If better performance is shown to be due to individual animals, these should be used to improve further the overall production. There are good reasons to believe, from the evidence of recent studies of traditional systems, that such outstanding animals do exist and may carry single genes which would enable rapid improvement in overall reproductive performance or in tolerance to internal parasites, for example.

A considerable degree of improvement could be achieved, however, in traditional flocks by identifying the environmental variables within the productivity indices which contribute most to the variation in productivity. From these variations, it should be possible to design pathways which, sequentially in order of their importance, would improve in a cost- and resource effective manner overall flock productivity. As examples of the kind of exercise being advocated Table 4 shows ratios of comparative advantages calculated on an index of productivity for unit weight of dam for a number of environmental variables. It should be noted that some of what might be considered the obvious improvements, such as selection for twinning, might not be appropriate in every case. The disadvantage to twins in Table 4 results from the very high death rate of this class of animal coupled with the low growth rate of any surviving twins. Increasing the viability of twins would, of course, then lead to an improved index and a high precedence in the improvement programme.

The greatest advantages are due to flock, which can to a large extent be associated with individual management practices and abilities. Identifying these practices and abilities and extending them to other owners would lead to overall improvement. A plan for improvement of a traditional flock with the minimum of outside and costly interventions is shown in Figure 1. At a later developmental stage, the order of application of improvements might change if for example, as already mentioned, it were possible to reduce mortality of twins, to improve the growth rate of twin-born lambs or to distribute superior stock with high genetic potential for reproductive improvement or disease resistance, yet capable of withstanding the local environmental and management conditions.

TABLE 1. Litter size, parturition interval and annual reproductive rate (ARR) for sheep in some African livestock systems

Country-System			Litter Size	Parturition interval (days)	ARR
Sudan: - pastoral			1.14	275	1.51
Ethiopia:	-	pastoral	1.03	315	1.20
	-	agro-pastoral	1.05	365	1.05
Kenya:	-	pastoral	1.05	312	1.23
Rwanda:	-	station	1.54	365	1.54
Mali:	-	agro-pastoral	1.04	261	1.45

ARR = Litter Size × 365/Parturition interval

TABLE 2. Pre-weaning death rate (%) for different variables at six sites

Variable		Sudan	Mali	Kenya I[1]	Kenya II[1]	Nigeria	Ethiopia
Overall LS Mean		30.2	28.0	19.1	16.3	16.0	12.6
System[2] :	A	35.3[a]	32.1[a]	-	16.6	-	-
	B	25.1[b]	23.9[b]	-	14.6	-	-
Sex: male		30.9	27.9	18.2	16.7	15.0	10.5
female		29.5	28.1	20.0	15.8	17.0	14.6
Birth type:	single	23.1[a]	22.9[a]	6.7[a]	9.6[a]	16.0	12.1
	twin	36. 7[b]	33.0[b]	31.4[b]	22.9[b]	14.0	13.1
Birth season[3] :	A	26.9[a]	32.8[a]	17.2[a]	12.2[a]	-	4.6[a]
	B	43.3[b]	28.1[a]	13.9[b]	-	-	-
	C	27.9[a]	23.0[a]	22.4[C]	23.3[b]	-	-
	D	22.7[a]	27.1[a]	22.7[C]	13.2[a]	-	21.4[b]
Parity:	1	27.6[a]	38.6[a]	28.6[a]	-	19.0	19.5[a]
	2	26.8[a]	22.7[b]	24.4[b]	-	-	12.7[b]
	3	14.8[b]	24.1[b]	20.7[b]	-	-	-
	9[4]	34.4[C]	26.2[b]	12.2[C]	-	13.0	5.4[C]
Flock:	best	21.1[a]	9.4[a]	12.1[a]	-	-	2 1[a]
	worst	42.2[b]	55.9[b]	26.8[b]	-	-	29.3[b]

Notes:
1 Kenya 1 = Elangata Wuas Group Ranch 1978–81; Kenya 11 = Three Kaputeo Section Group Ranches 1981–83
2 Sudan A = sedentary, B = migratory; Mali A = rainfed millet B = irrigated rice; Kenya 11 A = small flocks, B = large flocks
3 Sudan, Mali, A = cold dry, B = hot dry, C = rains, D = post rains; Kenya, A = short dry, B = long rains, C = long dry, D = short rains; Ethiopia, A = best month, D = worst month
4 Parity 9 = parities ≥ 4 except Nigeria ≥ 2 and Ethiopia ≤ 3

Within variables means in same column with different superscript differ significantly.

TABLE 3. Productivity indices for some African sheep types under conditions of traditional management

Country + Sheep type	Index 1 (kg)	Index 11 (kg)	Index 111 (kg)
Sudan - Desert	22.2	598	1.47
Ethiopia - East-Africa Fat Tail	16.9	582	1.45
- Menz	16.1	704	1.64
Kenya - Masai	14.1	473	1.18
Mali - Sahel	29.1	870	2.24

TABLE 4. Ratios of comparative advantage for sources of variance in an index for unit weight for Kenya sheep

Sources of variance	Ratio
Flock: best to worst	1.76
Birth season: best to worst	1.67
Birth type: singles to twins	1.31
Parity: overall mean to first	1.29
Sex: female to male	1.02

Figure 1 Potential improvement pathways for traditionally managed small ruminant flocks on Masai group ranches