ARDA

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 73

1. SUBJECT CLASSIFICATION

A. PRIMARY
Food production and nutrition — AL00-5200-0000

B. SECONDARY
Animal production--Ruminants

2. TITLE AND SUBTITLE

Proceedings

3. AUTHOR(S)

(101) Workshop on the Role of Sheep and Goats in Agricultural Development,Morrilton, Ark.,1976; Winrock Int.Livestock Research and Training Ctr.,Morrilton,Ark.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1977	~~43p.~~ 44p	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS

Winrock

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)

9. ABSTRACT

Summarizes technical papers and discussions at the workshop on "The Role of Sheep and Goats in Agricultural Development," held on November 15-17, 1976 at the Winrock International Center, Morrilton, Arkansas. The workshop participants agreed on the need to increase efforts in the development of sheep and goat production throughout the world. The approximately 1.5 billion sheep and goats of the world are the major single commercial source of animal fiber, and their relatively small carcasses and daily milk yields contribute significantly to the nutrition of local populations in LDCs. The major sections of this report include: "Summary and Conclusions;" "Genetic Resources for Meat, Milk and Fiber Production; Management Systems;" "Disease, Parasite and Environmental Constraints to Production;" "Small Ruminant Production in Various Regions of the World;" "Sheep and Goats as Food and Fiber Resources -- Current and Future;" and "List of Participants -- Names and Addresses." This workshop initiated a research project sponsored by Winrock International Livestock Research and Training Center and A.I.D. to (1) document production coefficients for sheep and goat systems, (2) identify contraints and potentials for production and marketing systems, (3) assess research, training and development programs involving sheep and goats, (4) characterize prevailing attitudes of policy makers and planners toward these animals,and (5) suggest projects and locations for sheep and goat improvement projects.

10. CONTROL NUMBER

PN-AAF-028

11. PRICE OF DOCUMENT

12. DESCRIPTORS

Goats
Meetings
Research
Sheep

13. PROJECT NUMBER

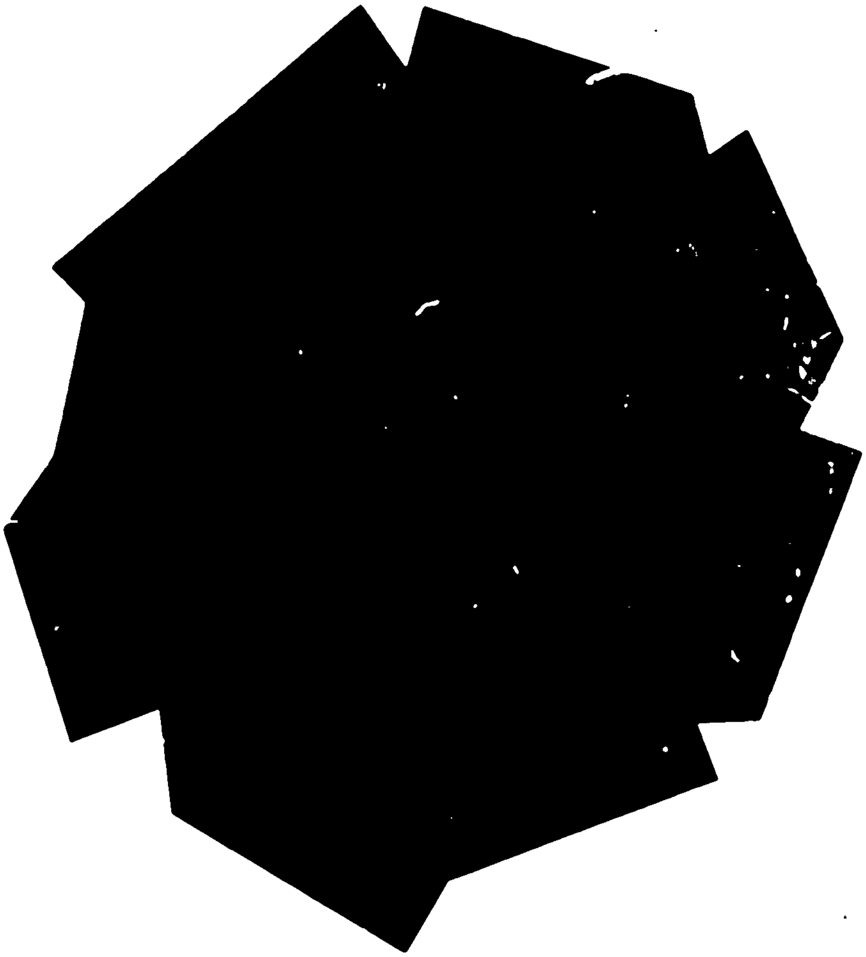
14. CONTRACT NUMBER

AID/ta-G-1395 GTS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

WINROCK REPORT



Proceedings of a Workshop on:

The Role of Sheep and Goats in Agricultural Development

Winrock Report

Proceedings of a Workshop

on

THE ROLE OF SHEEP AND GOATS

IN

AGRICULTURAL DEVELOPMENT

November 15-17, 1976
Winrock International Center
Morrilton, Arkansas

Sponsored by:
Winrock International Livestock Research and Training Center
Petit Jean Mountain, Morrilton, Arkansas 72110

and

United States Agency for International Development
Technical Assistance/Agriculture
Washington, D.C.

CONTENTS

PREFACE

This workshop on "The Role of Sheep and Goats in Agricultural Development" initiated a research project sponsored by Winrock International Livestock Research and Training Center and the United States Agency for International Development. The objectives of this project include: (1) documentation of production coefficients for sheep and goat systems, (2) identification of constraints and potentials for production and marketing systems, (3) assessment of research, training and development programs involving sheep and goats, (4) characterization of prevailing attitudes of policy makers and planners toward sheep and goats, and (5) suggestion of projects and locations for sheep and goat improvement projects from which important social and economic benefits are likely to result.

Participants in this workshop included international authorities on sheep and goat production and on agricultural development. Technical papers were presented by some participants with the intent of providing focus to the general discussion. These technical papers and following discussions have been summarized by the editors of these proceedings. The final afternoon of the workshop was devoted to discussion of important advantages and disadvantages of sheep and goats and to potentials and constraints to improvement of production and marketing systems.

The combined knowledge and practical experience of the participants lends credibility to the conclusions from this workshop. Yet, it was generally recognized that too many of these conclusions and recommendations were based on subjective observations and intuition and too few on well documented, objective information.

Considerable satisfaction may be derived from knowing that the special values of sheep and goats are receiving more general recognition. The ultimate success of this workshop will be measured by the degree to which it stimulates needed objective research, and creative development programs to improve the contributions of sheep and goats in the service of mankind.

Editors:

E. A. Oltenacu
A. Martinez
H. A. Glimp
H. A. Fitzhugh

WINROCK INTERNATIONAL LIVESTOCK RESEARCH AND TRAINING CENTER

Winrock's broad mission is the improvement of human nutrition and the quality of human life through support of research and training programs for the advancement of animal agriculture.

Winrock has its headquarters on Petit Jean Mountain in Arkansas (about seventy miles west of Little Rock). Extensive livestock facilities surrounding its offices were built by the late Winthrop Rockefeller, Governor of Arkansas from 1967 until 1971. It was Mr. Rockefeller's wish that the work he had started, using livestock to improve both nutrition and the lives of rural producers, be continued. A grant was made from his estate which enabled the Center to begin its operations in 1975.

The Center is an independent, non-profit institution, not connected with any governmental, commercial or professional agency. All of its operations and financial transactions are publicly reported.

All Winrock International Center training and research programs are supported by funds from its own endowment and by funds from foundations, individuals, corporations, government contracts, and grants. As a publicly supported organization, Winrock International Center accepts and actively seeks tax deductible gifts from individuals, foundations, governments and corporate donors.

Winrock International Livestock Research and Training Center is classified as a non-profit, publicly supported organization described in Section 170 (b) (1) (A) (vi) and 509 (a) (1); exempt from federal income tax under Section 501 (c) (3) of the United States Internal Revenue Code.

SUMMARY AND CONCLUSIONS

The consensus reached by the participants attending this workshop was for increased efforts in development of sheep and goat production throughout the world. Sheep and goat programs are clearly not receiving research, education and development support in relation to their current and potential contributions in developing countries. The approximately 1.5 billion sheep and goats of the world are the major single commercial source of animal fiber. Their relatively small carcasses and daily milk yields make an exceedingly important contribution to the nutrition of local populations in developing regions where food preservation technology is still primitive. This contribution is often overlooked in estimates of production on a national basis, because the product is often consumed by the family without ever entering the market. As the human population increases and pressure on land becomes greater, the need for small, highly efficient livestock will also increase, and the contribution of sheep and goat products to the well-being of humanity must be expected to assume a major role. The period of relative neglect that the sheep and goat industries have received from governments, academic and research organizations, and other international and private organizations must end. Additional effort must be devoted to advancing these industries in developing and underdeveloped countries.

Advantages and Disadvantages of Small Ruminants

The listing of advantages and disadvantages carries with it certain risks, since characteristics that may be an advantage in one situation may be a liability in other cases. Nevertheless, it is informative to look at potentially positive and negative aspects of sheep and goat production as they may affect the use of these species.

Special Advantages

- Increased production efficiency can be expected from the small ruminant. Higher reproductive efficiency is possible with the potential for increased litter size and the shorter gestation interval that may permit more than one crop per year. Also, the energetic efficiency of milk production may be higher in dairy goats than for other dairy animals.

- Sheep and goats are highly adaptable to a broad range of different environments. Both sheep and goats can utilize a wide variety of plant species. Goats appear to be more effective at grazing selectively than any other domestic livestock species. There is evidence that, of the two species, goats utilize poor quality forage and browse better than sheep. Certain breeds of goats have a high tolerance to trypanosomiasis, and probably other diseases, thus permitting use of land not available to other domestic livestock. In addition, certain types of goats have lower water requirements and greater heat tolerance than most domestic ruminants. At the other climatic extreme, the sheep's fleece provides effective insulation against cold.

- The small size and early maturity of sheep and goats give them distinct economic advantages for use by the smallholder. Because they are small, they can efficiently utilize marginal and small plots of land. The risk on investment is reduced by smaller individual size, allowing more production units per unit of investment. There is also a faster turnover of capital because of earlier sexual maturity and younger age at slaughter. Smaller carcasses are easier to merchandise and can be consumed in a short period of time, which is important in undeveloped or remote markets. More efficient use of labor may be possible in certain cases, for example, herding, assisted by the strong flocking instinct of these animals, is easier for the younger and older members of the family.

- Sheep and goats yield a wide variety of products, including meat, milk, fiber and skins. Goat's milk has special market opportunities since certain people cannot drink cow's milk because of allergies or other health problems. Wool and mohair can be expected to become more important as petroleum derived synthetic fibers become more expensive.
- The lack of major religious taboos on sheep or goat meat presents major opportunities for increasing their consumption. In some areas, sheep or goat meat and dairy products, such as cheeses, are preferred over other meat and milk products.

Special Problems or Disadvantages

- Their small size makes sheep and goats more susceptible to predation and theft. If, in smallholder development programs, the objectives are to develop large-scale cooperative production systems, then fixed costs and labor required per economic unit may be higher for these small ruminants.
- Behaviorally, these species are adapted to herding and grazing close together, so population and management control are critical in areas where overgrazing is a problem.
- Most breeds of sheep and goats have restricted breeding seasons, especially away from the equator. This often results in reduced marketing and management options.
- Disease control efforts have received less emphasis in sheep and goats than in cattle. Diseases, such as brucellosis, can present a human health hazard.

Major Constraints To Production

Certain constraints to the proper use of sheep and goats result from lack of understanding of the advantages and disadvantages and from independent factors such as social and political biases. Identifying major constraints should provide a better insight into the major public policy, research, education and development needs for implementing sheep and goat programs.

Constraints due to public policy

- Planners and policy makers are often not willing to resolve such problems as land tenure, overgrazing, predator control, market development and credit availability that are basic to improved productivity and profitability.
- Planners often have a negative attitude toward these species, and towards goats in particular. Goats are frequently blamed for erosion, deforestation and other range degradation problems. It is not known if the presence of goats initiated these problems or if they are present because they are the only species that can still be productive on the already degraded land. Evidence exists that goats can be used for efficient biological control of brush on range lands. In general, livestock programs receive relatively little attention in the allocation of agricultural development funds. Sheep and goat programs tend to rank lowest in priority for development.
- The ultimate users of any development program should be actively involved in planning and decision making from the start. This is, perhaps, more important for smallholders than for any other group. Techniques for involving smallholders in the decision making process have been tried in various countries and should be studied. In particular, cooperative systems for disseminating information, introducing new technology, buying supplies and marketing products might be one answer. Such systems are already in operation in various countries and their operation and possible adaptation to other situations should be investigated.

Constraints due to inadequate technology

- Continued research on infectious agents is needed. Simplification of control programs is essential for smallholder implementation. There appears to be potential for selection for tolerance resistance to diseases and parasites. There is a need for better communication between veterinary scientists and scientists from other disciplines in order to avoid the potential "second generation" problems created by reduction or eradication of a disease.

- Feed resources are a major constraint in many areas. The selective grazing habits and intakes of sheep, goats, cattle and indigenous wildlife need to be better understood, before multi-species grazing systems can be developed for specific grazing habitats. The basic nutrient requirements have not been adequately evaluated, making it difficult to plan effective feeding and management programs. This is especially critical for high-producing milk and meat-type goats. More information is needed on the nutritional value of crop residues of all types and on methods of utilizing these residues for sheep and goat production. Strategic supplementation programs are needed for range production systems.

- Genetic resources in sheep and goats are vast but require better characterization and evaluation, especially in the case of local and native breeds. These evaluations need to be conducted under the "improved" conditions, that can be anticipated from the recommended smallholder production systems, as well as under the existing "unimproved" conditions. The development of frozen sheep and goat semen processing for use in artificial insemination programs would permit more efficient transfer of exotic germ plasm between regions. Aids to selection for meat and milk production in goats must be developed. These include genetic and phenotypic statistics and appropriate adjustment factors. Dual-purpose (milk and meat) breeds of goats adapted to stall feeding are needed for smallholder and/or landless producers. More knowledge on the importance of special adaptations (e.g., the fat tail on most African and Near East desert sheep) is needed to plan genetic improvement programs for harsh environments.

- Mobile milking, collecting, preservation, and processing systems for sheep and goat milk adaptable to transhumant and nomadic production systems are needed.

- There is a need for the collation of existing data as well as the collection of additional information before recommended production systems and practices can be developed. The systems approach to decision making at all levels of research, planning, development and production programs for smallholders must receive greater attention than it has in the past. Production systems for smallholders need to be developed for sheep and goats in tropical and subtropical mixed farming areas.

GENETIC RESOURCES FOR MEAT, MILK AND FIBER PRODUCTION

Intensive Production Systems

I. L. Mason

Livestock kept in intensive production systems are subjected to an essentially artificial environment. They are closely supervised, housed in relative confinement where careful veterinary control is vital and often fed a diet high in concentrates. Under such intensive conditions, fiber production is of minor importance and production of milk and meat is emphasized. In the artificial environment, careful management at critical periods of the life cycle has limited natural selection for fitness from acting on a breed. Although mortality rates can be high for young livestock in intensive conditions, fitness characters have not been considered in this discussion.

There are among the world's genetic resources over 320 known breeds of sheep and over 60 goat breeds. Accurate information is lacking on many of these breeds, and attention might be profitably directed to some of the lesser known among them. This paper deals primarily with the genetic resources available for increasing meat and milk production under intensive conditions.

In a discussion of sheep for meat production, the importance of ewe prolificacy cannot be overemphasized. Some of the attributes of the highly prolific breeds found in various regions of the world are presented in Table II. 1. These breeds include the widely-researched Finnish Landrace and the lesser known D'man of Morocco and the Hanyang and Huyang breeds of China. Typically, the highly prolific breeds have been developed in small, household flocks protected from the local environment. Many of these breeds are numerically very small and their distribution is highly localized. Included in the group of prolific breeds are the wool sheep of temperate zones (e.g., Finnish Landrace, Romanov) and the hair sheep (e.g., Barbados Blackbelly) found in tropical areas. The Blackbelly is adapted to its local environment in its lack of wool and in its apparent increased resistance to gastro-intestinal parasites.

The indications are that prolificacy is the most important character in meat production, and less emphasis should be put on growth rate. However, there are breeds producing large, fast-growing lambs with excellent carcass qualities that have great potential for use as terminal sires in a crossbreeding system (Table II. 2). The combined use of prolific dam lines and terminal crossing with meat-type sires in a stratified crossbreeding system is one way to fully exploit the qualities of both types.

The outstanding milk breeds of sheep are mostly Mediterranean in origin, and are generally kept in intensive systems like the highly

Table II. 1. Some Prolific Breeds of Sheep

Breed	Country	Age at 1st Lamb (Mo.)	Lambs/Birth	Lambings Per Year	Weight Adult Ewe (kg)
Finnish Landrace	Finland	11-13	2.7 (adults)	Usually 1, 2 possible	40-50
Romanov	USSR	—	(Similar to Finnish Landrace)	—	—
Chios	Greece/Turkey	13+	2.0	2 possible	48-52
D'man	Morocco	12-14	2.7 (adult)	2	30-40
Hanyang	China	—	2	—	35-50
Huyang	China	13-16	2	1½-2	30-45
Blackbelly	Barbados	—	1-3	can be 2	50

Table II. 2. Comparison of Fat-Lamb Sire Breeds in Ireland

Breed of Sire	Weaning Weight (lbs)	Daily Gain Birth-Sltr.	Six Rib Cut Lean (%)	Six Rib Cut Fat (%)	Six Rib Cut Lean/Bone
Suffolk	62.3	0.42	56.9	27.4	3.39
Texel	60.9	0.40	59.9	22.7	3.58
Dorset Horn	61.1	0.41	57.4	25.8	3.50
Hampshire	60.6	0.39	55.7	27.6	3.44
Oxford Down	62.1	0.42	56.1	26.6	3.32
Lincoln	56.5	0.38	56.1	26.2	3.22
Ile de France	59.7	0.33	55.1	26.8	3.34
Dorset Down	60.4	0.33	54.7	29.8	3.59

Source Timon, V. H (1974) Proc Working Symp. Breed Evaluation and Crossing, Zeist p. 367-387

prolific breeds. Notable for dairy production are the Chios of Greece and Turkey, the Awassi of Israel and the East Friesian of Germany (Table II. 3). For the intensively kept goat breeds, milk rather than meat is the primary product, and there are breeds of dairy goat adapted to most of the world's climatic zones The Saanen is well adapted to high milk production under European conditions, but a breed such as the Anglo-Nubian performs better in a tropical climate. Adaptation to the local environment can have a major effect on the productivity of a dairy breed. In dairy breeds of sheep and goats, there is a tremendous opportunity for selection for milk yield that could, together with improved management, lead to substantial increases in milk production.

Table II. 3. Milk Sheep Breeds

Breed	Country	Milk Yield (kg/day)	% Improvement When Crossed With E. Friesian	Weight of Adult Ewe (kg)
East Friesian	Germany	2-2.5	–	70-90
Awassi	Israel	1-1.5	2	50
Chios	Greece/Turkey	1-1.2	20	48-52
Langhe	Italy	1	–	53-60
Sardinian	Italy	0.9	22	35-45
Comisana	Italy	0.8	–	40-50
Lacaune	France	0.6	30-42	60-65
Churro	Spain	0.6	–	35

Sources Mason, I L (1967) Sheep Breeds of the Mediterranean. J G Boyazoglu, (1968) Annals Zootech 12 237 296. Boyazoglu, *et al.* (1976) Options Mediterraneennes

Extensive Production Systems

H. N. Turner

An "extensive" system is one in which animals gain most of their nutritional requirements by grazing or browsing in the open. Within this type of system, there is likely to be much more variation than there is in systems defined as "intensive". Management varies with climate, vegetation, disease control, and available supplementary feed. Efficiency of conversion is less crucial with extensive than with intensive systems, where most or all feed has to be brought to the animals. Production in extensive systems is best defined as production per head, because this is closely correlated with production per unit of feed, and most costs are on a per head basis.

A paper on genetic resources would perhaps be expected to tabulate available production data. Because of the great environmental variation in extensive systems, production data from one area cannot be extrapolated to another, and this paper will deal instead with genetic ways of improving production per head for extensive systems.

Three categories of product are of greatest importance, i.e., wool, meat and milk; and for all three quantity and quality of product must be considered. A high reproduction rate is desirable for all forms of product. But if the conditions are harsh it may be preferable to ensure that every ewe produces a lamb rather than to seek high prolificacy; survival of lambs, particularly those from multiple births, is often difficult under harsh conditions.

(1) Wool is broadly classified as apparel or carpet. It can be produced for (a) the world market, (b) the local market (e.g. sale from village to village for small local mills or cottage industry), or (c) the home market, where the wool is not sold but processed by the producer. In all cases weight of wool per head is the measure of quantity, and average fibre diameter is generally the most important quality characteristic. The desirable level of fibre diameter varies with wool type and market. For the world market, fine, white wool that is free from medullation is optimal for apparel wool. For carpet wool, coarse diameter and a percentage of medullated fibres are sought and some pigmented wools are accepted. For other markets, intermediate fibre diameters are sought for hand-processing of apparel wool, coarse diameters for carpet wool, and higher levels of medullation are tolerated even for apparel wool. In some cases pigmented wools are preferred to white.

(2) Meat production is dependent for quantity on reproduction rate, body weight and early growth rate. Quality is largely influenced by age and pre and post-slaughter handling.

(3) Milk production practices vary from region to region, but quantity and quality of milk need to be considered where dairying is important.

The question of whether selection or crossbreeding should be the chosen means of genetic improvement of livestock rests on several factors.

(1) The desired product must be considered. Crossbreeding may result in undesirable changes in the end product, e.g., any cross with the Merino will produce poorer quality wool than does the purebred Merino. In this breed, and in Indian carpet wool breeds, selection is more effective than crossbreeding in improving the end product.

(2) The environment must be considered. Local conditions such as temperatures, humidity and prevalent diseases can have drastic effects on introduced livestock. The specific adaptations of native breeds are of primary importance in determining the success or failure of an extensive production system, and it should not automatically be assumed that a cross with an exotic breed will be more productive than an improved native breed.

(3) A point for consideration is the likely response to selection. Mass selection (on the individual's own performance) is a relatively simple and cheap way to achieve genetic progress, if it can be effected. It has been successfully used in selection for wool production with Australian Merinos. Selection for higher reproduction rate is also proving effective, using dam's record for rams and (dam's + individual's) for ewes. The basic essential for the success of selection is that there must be genetic variation present on which it can operate. The potential gain from selection should always be compared with that from crossbreeding, before a choice is made between the two systems.

Crossbreeding may be classified under three headings — gene replacement, continued formation of a first-cross, and exploitation of hybrid vigor.

(1) Exploitation of hybrid vigor is a sophisticated technique not adapted for use with limited resources. Continued formation of a first-cross animal also has distinct disadvantages under such conditions, because of the cost of maintaining purebreds as well as crosses. It is mainly of value in stratified systems, where the crosses can graduate from extensive to semi-intensive conditions.

(2) The most frequent use of crossing for extensive systems when resources are limited is by gene replacement, where one native breed is completely replaced by another, or by a combination of the native breed with one or more exotic breeds.

(3) Crossbreeding must be assessed in the environment in which the crossbred animal is expected to produce. The crossbred should be evaluated alongside the native breed for quantity and quality of product and its suitability for the target market — a point often overlooked.

The introduction of exotic genes to replace a portion, or all, of the native genes may take some time before having any impact on a local industry. This will depend on the size of that industry, and the availabiltiy of exotic genes. A considerable length of time is required to develop a synthesized breed.

Techniques for achieving genetic improvement through selection are varied. Within a breed, a 2-tier or 3-tier system is often developed, with a ram-breeding nucleus supplying males direct to flocks (2-tier) or through multipliers (3-tier). The nucleus may be government controlled or privately run. A cooperative system may be set up among breeders to screen large numbers of animals and place the best in the central ram-breeding nucleus. Greatest genetic gains are achieved if there is a continual flow of highly selected replacement ewes from cooperators into the nucleus, but the ram flow should be outward only. Cooperative systems are of particular value when individual flocks are small. They have proven popular and quite successful in New Zealand. There are some cooperative groups in Australia with large flocks.

"Ram circles" are used for small flocks in Norway and Ireland, providing progeny-testing of rams in association with performance recording. Either the rams are moved from farm to farm, or ewes from different farms are distributed among rams on other farms.

For crossing in a gene replacement system, three steps are needed: (1) establishment of a source of exotic genes from which the cross can be evaluated. (2) If the cross succeeds, then establishment of a longer-term source of exotic genes, and finally, (3) development of methods of gene distribution Artificial insemination would be useful for the first introduction of exotic genes, as it obviates the need for maintaining susceptible exotic purebreds in harsh environments. The source of exotic genes must be longer term if the cross is proven successful, but if distribution is to be through crossbred rams, exotic gene inputs will only be needed for 10-13 years. Here again, frozen semen would be invaluable.

Distribution of exotic genes may prove difficult when local flocks are migratory. Inevitably, it takes some time to establish a crossbred type in a whole industry, and though crossing may be the best way to achieve improvement in a given situation, it is not necessarily fast.

In conclusion, it should be emphasized again that both selection and crossbreeding must be carefully considered before a choice is made between the two for a method of achieving genetic improvement in a given situation.

Feral and Wild Genotypes*

W. C. Foote

The potential for utilizing feral and wild genotypes of sheep and goats to harvest the forage production of some of the world's 7.1 billion hectares of non-arable agriculture land is important. Approximately 100 such genotypes are available, with feral sheep and goats being more widely distributed than the wild genotypes. Four methods exist for utilizing these resources in increasing food supplies.

(1) There is the direct harvest of non-domestic sheep and goats for food and pelts, which is already carried out in some areas of the world. This can be complicated by political-sociological problems associated with the control of hunting to avoid over-exploitation of such resources. However, game animals are a potential source of substantial amounts of human food, and there are sheep and goat

*Feral refers to those genotypes that were once tame and reverted to a wild state; while wild genotypes were always in a wild environment.

populations that would actually benefit from being harvested for this purpose. While some breeds and genotypes are in danger of extinction because of habitat destruction or overexploitation, there are others that have reached the optimum or maximum number of animals that can be supported by the environment. It is these that would respond with increased vigor and levels of production, if managed for both production and conservation. Meat produced from this source could contribute substantially to feeding the human population, at least on a local basis.

The potential contribution of wild species should not be overlooked. For example, the Utah Fish and Game Commission reports for 1970 indicated that 63,367 buck mule deer were harvested for a total dressed carcass weight production of 4,032 metric tons. If this can be achieved where a species is harvested primarily for sport, then deliberate harvesting of the species as a food resource could give considerable yields.

(2) A method of utilizing wild and feral genotypes is to select those that would fit into a multi-species grazing program. If the overlap of species in terms of preferred grazing areas and feed plants is minimized, the carrying capacity and efficiency of production of a given area can be increased considerably. The carrying capacity of land in the Red Desert of Wyoming has been studied as an example. Capacity was increased from 8.0 pronghorn antelope or 7.2 sheep per approximately 49 hectares, under single species use, to 6.0 antelope plus 6.2 sheep with combined grazing. This increase was largely due to the antelope preferring to graze shrubs and the sheep preferring grass. There is great scope, for example, in Africa for multispecies grazing of sheep, cattle and certain species of antelope in game ranching systems. This would have the additional benefit of utilizing native genotypes that are best adapted to the local environment. In South Africa and Kenya domestic sheep, goats and cattle are being managed with Thompson's gazelle, impala, eland and oryx in grazing programs. The results indicate that these species can be managed together and that they probably possess complementary characteristics.

(3) A way of taking advantage of available genotypes is by creating new genetic combinations to fit a particular local need. The interfertility of most of these genotypes makes such an objective feasible. Some combination of wild, feral and domestic sheep or goats could be used either as wild or as domestic livestock, depending on the available niche. This system could take advantage of the superior adaptability of wild forms together with their later age at maturity and their lower tendency to deposit fat as compared with domestic genotypes at similar stages of maturity. Research to assess the potential of wild X domestic crosses has been conducted in Cyprus, Israel, Russia, Iran and other countries. A crossbred could have distinct advantages in stress resistance, as wild genotypes brought into confinement systems tend to be very sensitive to stress and disease, and generally have high mortality rates. The wild X domestic crossbred sheep appears to be adaptable to some extensive management programs, but would likely fail to adapt to confined or drylot conditions.

The three methods of utilization of wild and feral genotypes discussed so far have practical value in contributing to production of food for man, and are either under investigation or are already being put to use, to some degree, in various regions of the world. The resources and technology needed to carry out these methods of utilization are already in existence.

(4) The behavioral characteristics and stress susceptibility of wild genotypes create problems with utilizing them by domestication. Only 16 out of an available 4500 species of the world have been domesticated. This number is currently being extended to include the impala, eland and the oryx, and there is potential for still further utilization through domestication. There is a real possibility for the redomestication of feral sheep and goats. This may be more practical than the long and tedious procedure of domestication of wild species which may, in addition, minimize their desirable characteristics such as adaptation to local conditions.

Discussion of Papers Presented by Mason, Turner and Foote:

Discussion centered on the best methods of utilizing the wide range of available genetic resources in the world's sheep and goat populations. The importance of matching genetic resources to the production system best suited to their efficient exploitation was stressed. It was emphasized that a production system which is successful in a developed country may not be feasible in one where resources are limited. This is often the deciding factor in a choice, for example, between an intensive and extensive production system; or between a complex crossbreeding scheme and a relatively straightforward program to improve native breeds.

Utilization of genetic resources was considered in terms of purebreeding and crossbreeding systems. Purebred flocks maintain the available resources, and a purebred native breed will often succeed where crossbreeding with exotics would have disastrous results because of reduced adaptability to local conditions. For example, crossbreeding of the Barbados Blackbelly in the humid tropics with other breeds has resulted in increased mortality and decreased fertility. Improvements in nutrition and parasite control would allow native breeds to express their true potential, and permit accurate evaluation. Decisions could then be made on the most efficient method of utilizing these indigenous breeds.

Crossbreeding to form new breeds for meat or milk production is underway in some countries, notably France. This potentially can produce an animal that incorporates the high productivity of one breed with the superior local adaptation of another, thus maximizing efficiency of utilization of the available genetic resources.

The potential of the prolific breeds appears to be best exploited in intensive production systems, where increased progeny numbers and the earlier start to productive life due to sexual precocity can be fully utilized. Largescale commercial operations may not be suited to these highly productive breeds, as much individual attention is necessary in order to avoid high mortality rates.

Wild and feral genotypes are not suited to intensive management systems because of their high susceptibility to stress and disease. Crossbreeding is one way of incorporating wild genes into domestic flocks, although even this is complicated by the difficulty of maintaining wild individuals in captivity. Semen collection from wild males not kept in captivity, followed by artificial insemination of domestic females, may prove to be the most effective and successful way of utilizing wild genotypes.

Crossbreeding is a useful tool for the most efficient utilization of available genetic resources in many situations. For example, the judicious use of crossbreeding with specialized terminal sire breeds has great potential for increasing meat production. However, in developing regions of the world, adaptation to local conditions is an important factor that should not be lost by indiscriminate crossbreeding with exotic breeds. Crossbreeding of local breeds may be worth consideration, rather than the introduction of exotic breeds for this purpose.

The continuous production of a first-cross animal is a difficult program to maintain with the limited resources of producers in developing regions. However, the fact that sheep seem to show more heterosis in poor conditions than in good ones may indicate that crossbreeding should be given more consideration despite the problems of maintaining purebreds. In a developing country, any scheme for upgrading local livestock is difficult to manipulate at the level of the individual farmer when more than one breed is involved. In general, in such situations, disease and malnutrition tend to be the limiting factors rather than genetic resources.

It was pointed out that there is a risk of losing potentially valuable genetic resources because of the small population numbers in many existing local breeds. Inbreeding is a threat to the continued existence of such breeds; although the development of prolific breeds that has occurred in various geographic locations, despite this constraint, is remarkable.

Full utilization of available resources involves consideration of the primary and secondary products of a breed. For example, meat is increasingly important as a by-product of dairy production systems. Market development for sheep and goat products is necessary in many areas in order to fully utilize the output of such intensive livestock systems.

Similarly, exploitation of wild and feral genetic resources may depend on consumer attitudes. These animals constitute a real resource whose harvest should be feasible in most locations, once a suitable system of utilization has been established. In Australia, for example, there are large numbers of feral goats, and the New S uth Wales Department of Agriculture has developed a program to harvest and export meat from these goats in addition to utilizing them for shrub control. The possibility of redomesticating them for use in low rainfall areas of Australia is now under investigation.

In some regions of the world there is a basic problem of actually assessing the numbers of wild and feral sheep and goats. There is confusion as to whether feral animals are included in the available FAO statistics, but it would appear that at least in certain areas, there are considerable numbers of these animals. In Iran, for example, herds of wild goats can include as many as 15,000 individuals.

The observation was made that it may not, in fact, be known how to best utilize the genetic diversity that exists among sheep and goats. The question was raised of whether anyone had actually assessed the status of ongoing research in relation to the systematic evaluation and use of these resources around the world. The need for such an assessment was stressed. An attempt must be made to match genetic resources with particular environmental constraints and economic requirements.Utilization studies and research on sheep and goats have an increased credibility; and a clear definition of problems and objectives is necessary to encourage this attitude. A growing recognition exists of the need for the small ruminant, not only in developing areas, but also in the developed regions of the world.

MANAGEMENT SYSTEMS

Extensive Range Conditions

R. W. Rice

In a discussion of management for extensive range conditions, the emphasis must be on the development of a rangeland management philosophy aimed at maximization of productivity from such areas, while conserving them for continued use. To achieve this objective, it is necessary to consider the integration of information from various disciplines. It is of little use, for example, to make genetic improvements if management policies for optimum utilization of resources are not developed. Several points related to the development of a management philosophy must be considered:

- The function of the herbivore is to convert rangeland grazing to food and fiber for man.
- Management must be designed to obtain optimal use of a given resource while maintaining that resource.
- Implementation of a management system must be within the existing socio-political constraints.
- Herbivore productivity and land improvement are not necessarily conflicting goals.
- Resources can be integrated into food production systems including intensive agriculture.

The ability of herbivores to utilize given resources varies with species. If rangeland is not maintained as it is grazed, it can deteriorate beyond the point at which cattle can utilize it, and it is then that the small ruminant comes into its own. Sheep can utilize and be productive on deteriorated rangeland, and goats will thrive on even more severely depleted resources. Hence, the increase in the world's goat population with increasing rangeland deterioration; and the erroneous assumption that goats, because they are observed on deteriorated pasture, must be the cause of the damage. Any species, if inadequately controlled, can be destructive to rangeland once animal numbers have become excessive for the available resources. The value of the small ruminant is apparent in its ability to utilize a damaged resource which otherwise would be lost to production entirely. Overpopulation of rangeland is often a problem and is one important area where improved management strategy is needed. Recovery of abused pasture is a very slow process and it is important to avoid situations leading to deterioration of grazing land.

The manipulation of stocking rates for maximum production, while taking into account the annual cycle of the livestock and their rangeland area, requires greater emphasis. A general principle that defines stocking strategy under varying conditions needs to be developed. Ideally, this should be independent of the land area involved, and could be, for example, in terms of amount of herbage per animal. Production of a pasture tends to stabilize at a level decided by the grazing pressure applied, and an equilibrium is reached with the livestock consuming the total annual production of the pasture. No evidence exists that heavy grazing is detrimental to pasture quality and production. Mismanagement in terms of overpopulation is frequently the factor leading to a decline in pasture quality. It appears to be possible to develop generalizations on stocking management from results reported in the literature, but it is difficult to develop a principle because often nothing is said about forage production. In addition, a major problem is often not the development of a principle, but the implementation of techniques available to improve productivity. The farmer in many regions of the world is poor in resources and cannot achieve the necessary improvements in management systems.

Another important rangeland management factor is the interaction between animal species and herbage. On good quality feed, the various livestock species appear to be equally efficient. As feed quality declines, the relative efficiency of digestion by goats increases, because they utilize high fiber, poor quality roughages better than do other ruminants. Goats use the strategy of selecting the higher nutritive value components from the diet presented to them. Therefore, although the overall nutritive quality of the available feed may be low, that actually consumed by the goat constitutes a fairly high-quality diet.

The interaction among various livestock species needs to be considered. If dietary overlap in terms of the similarity of feedstuffs consumed is minimized, productivity of rangeland can be maximized with mixed species grazing. The degree of dietary overlap for four species on prairie pasture is indicated by the following data:

	Pronghorn	*Sheep*	*Cattle*	*Bison*
Bison	0.32	0.75	0.88	1.00
Cattle	0.38	0.87	1.00	
Sheep	0.54	1.00		
Pronghorn	1.00			

In this situation, a combination of pronghorn and bison or pronghorn and cattle would probably optimize usage of the pasture. The grazing of different feeds and different areas by each species will contribute to this optimum usage.

The interrelationships between species and their food resources need to be fully understood in order that development and control of stocking rates can be brought about. If the environment cannot be manipulated to the best advantage, then exploitation of, for example, genetic improvements will be severely limited.

Intensive Production Systems

A. Louca

The word "intensive" is generally used to describe a livestock system where the animals are kept in relative confinement, are fed mostly on concentrates, and where a high degree of mechanization and veterinary control are utilized. Effective intensification should increase annual output per female, and generally involves improving reproductive efficiency. The effect of this improvement on productivity and efficiency of feed utilization is clearly shown in Table III. 1, for progressive increases in lambing percentage for a ewe flock, given nearly constant feed supplies of 120,000 Mcal ME per year.

When high concentrate diets are fed, it is important to maximize feed utilization. With increased lamb production, the proportion of feed used for ewe maintenance decreases, and the efficiency of production increases. A "biological ceiling" for sheep production systems has been estimated at 5 lambs/ewe/pregnancy with a lambing interval of 6 months. At present, we are far from this limit and great possibilities exist for improvement.

The breed chosen for an intensive system must be capable of responding to intensive management. It should be prolific, have a long breeding season and be capable of a high milk yield for a long period after weaning. It is a mistake to ignore native stock, as basic environmental adaptation is important. Any animal will respond to improved management with increased productivity, but the breed chosen should not have its response limited by a genotype unsuited to intensive conditions.

Nutrition is a vital feature to consider in an intensive system. Energy, rather than protein (which should not, however, drop below 10 percent in the diet) tends to be the factor limiting production in most sheep dairy systems. Mating, late pregnancy and lactation are the most crucial times for nutrition. At mating, it is more important that ewes are in good body condition than that they have been flushed by feeding. The nutrition of ewes in late pregnancy should ideally be adjusted to take account of variations in the number of

Table III. 1 Flock numbers, lamb production, and maintenance feed requirements for varying lambing rates, with annual feed supplies of 120,000 Mcal ME.

	Lambing percentage (born, weaned and sold)				
	0	100	125	150	200
Number of ewes (and their lambs) fed on 120,000 Mcal ME					
Lamb weight:					
Singles, 30 Kg; twins 23 Kg	150	100	98	95	90
All lambs, 37 Kg	150	90	84	78	68
Kg. lamb produced from 120,000 Mcal ME					
Lamb weight:					
Singles, 30 Kg; twins 23 Kg	0	3,000	3,317	3,595	4,140
All lambs, 37 Kg	0	3,330	3,885	4,229	5,032
Feed energy required for ewe maintenance (%)					
Lamb weight:					
Singles, 30 Kg; twins 23 Kg	100	67	66	64	60
All lambs, 37 Kg	100	60	56	52	46

Source: Swanson & Hogue, 1971, adapted by McDowell, 1975. (McDowell, R.E. 1975. Proc. III World Conf. Anim. Prod. Edited by R. L. Reid, Sydney Univ. Press, Sydney)

fetuses being carried. Undernutrition and pregnancy toxemia may be the result of feeding ewes with multiple fetuses on a plane of nutrition adequate only for ewes with a single fetus.

Milk yield in lactation is closely associated with feeding level, but it can also be affected by weight (condition) of the ewe at lambing. The lactation curve of the ewe shows a peak at 2 weeks post-lambing, and a decline after 5-8 weeks. A good feeding regime therefore provides *ad lib* feeding for 6-8 weeks after lambing, followed by feeding according to milk yield, fat content of the milk and body condition of the ewe. Excessive loss of body condition in the ewe should be avoided, as it may delay rebreeding.

Lambing is a critical period and the time from birth to first suckling is most crucial to the lamb's survival. Good management at this time involves close supervision to ensure mothering of lambs. It is vital that a strong bond be developed between ewe and lamb and the period of intensive care around parturition can end when this contact is well established. In intensively-kept flocks care must be taken to prevent disease build-up in lambing pens.

The length of time that lambs are fed on artificial milk replacer should be minimized, as this is an expensive feed and does not seem to be necessary beyond 21 days of age for the lamb. Early weaning in goats is an advantage in that it increases milk yield for commercial use. This is limited in ewes as milk let-down is less efficient than in goats, and generally requires the presence of the lamb. So a partial suckling system tends to increase milk yield in average ewes, although high-yielding ewes respond more like dairy goats. Lambs grow faster than kids both before and after weaning. Lambs can be weaned earlier and will have less growth check at weaning.

There are many possibilities for increasing lamb output, by management methods as well as by genetic means. Breeding lactating ewes is one method, although lactation anestrus often interferes with this. Work in Scotland has shown that a 205-day reproductive cycle is feasible for ewes, and need not be detrimental. It is important to reduce the unproductive phase of a ewe's life, and there is undoubtedly greater potential for improved reproductive efficiency in sheep and goats than in other livestock. Early breeding of young females is feasible if they are well-grown so that they are physically mature and can mate successfully.

Housing and disease control are fundamental to the success of an intensive system. The concentration of animals causes stress and favors the spread of disease, thus, preventive measures are vital. Housing conditions (temperature, humidity, air flow) must be carefully monitored. In addition, the diet is controlled by the producer, and unless he is careful, dietary imbalances can lead to problems. In dairy flocks, strict control of hygiene must be observed to reduce production losses resulting from mastitis.

The intensification of production systems can lead to large improvements in productivity, but demands considerable management expertise from the producer if it is to succeed.

Discussion of Papers Presented by Rice and Louca:

Nutrition and efficiency of feed utilization are important in intensive and extensive production systems. There is a distinct need for more information on the relative digestion efficiencies of different forages by various species. Evidence appears to be accumulating that the relative digestive efficiency of goats increases as forage quality decreases and the reasons for this need to be investigated. The difference may be in the microbiology of the rumen, or in the speed of rumen movement, for example, but this is a neglected field that requires more research.

Studies in East Africa have shown that the goat's marked preference for browse rather than grass leads to an intake that may reach 43 percent crude protein on some shrubs. If good grass is available, it will be eaten. The value of shrub in the diet of goats, especially in low rainfall areas cannot be overestimated. It is difficult to plan utilization of resources when rainfall is unreliable. While there are problems in estimating annual production from shrubs, they are of value in being able to survive by tapping water supplies that are unavailable to grasses.

Control of stock numbers is a vitally important component of management strategy in extensive systems. However, it is often difficult to achieve the necessary control because of the existing political and social constraints. Communal ownership of land in many developing areas makes grazing control almost impossible, and pasture improvement is often not achieved until the land tenure system has been changed. Recovery practices such as reseeding can then contribute to grazing land improvement and this is another important area from which increased productivity can be derived.

Discussion of the problems of intensive production systems included behavioral limitations of the livestock involved. Milk let-down in ewes is stimulated by the presence of the lamb and this must be considered in the design of the management system. A partial suckling system, in which the lambs are with the ewes for some of the time, appears to be most effective with certain breeds. Milking is easier and yields are maintained longer. Different stimulatory effects of lambs and kids on their respective dams were postulated to be the cause of the difference in growth rate between the two species. However, cross-fostering experiments appear to indicate that differences are more a function of yield level and milk let-down of the dam.

Intensive care at lambing is needed in flocks of prolific ewes in order to alleviate the problem that small, weak lambs from multiple births may have in reaching the udder and suckling the dam. The fact that prolific breeds still have only two teats from which their offspring can feed was mentioned. However, some sheep do have four functional teats and selection for this trait may be feasible.

The economics of sheep production in Cyprus was discussed. The Chios is a breed well suited to the local conditions and in high demand. Grain can be fed economically in early lactation. At this time, the ration is composed of 1/3 grain for grazed animals or 3/4 concentrates for animals kept more intensively indoors.

DISEASE, PARASITE AND ENVIRONMENTAL CONSTRAINTS TO PRODUCTION

Disease and Parasite Constraints

E. W. Allonby

The disease and parasite problem is recognized as a severe constraint to sheep and goat production in many regions of the world. There are some 300-400 diseases that ultimately may affect production. These fall into classic subdivisions:

Infectious	
viral rickettsial mycoplasma bacterial protozoal	Diseases of this group generally show obvious clinical symptoms and most can be controlled.
metazoal	— ecto- and endo-parasites, about which less is known, are very important.
Non-infectious	
metabolic	— these increase in importance as production systems are intensified.
poisoning congenital hereditary	

The start of the production cycle can be affected by infertility preventing successful mating. Infertility can arise from several causes, including nutritional stress and infectious diseases. Various mineral deficiencies can have a severe effect in reducing lambing percentages. In addition, internal parasites can reduce growth and body weight and interfere with fertility. The effect of these diseases and deficiencies on the lifetime productivity of females can be considerable, but has been largely ignored, despite potentially drastic losses in production.

Pre-parturition fetal loss can occur from a variety of causes. A number of diseases can result in abortion in the ewe, as can poor nutritional conditions. When nutritional level is low but not sufficiently poor to cause fetal loss, it may still result in decreased lamb survival because of low birth weights. Lamb birth weight is of primary importance in survival of the newborn lamb; and is reduced by disease and nutritional stress on the dam.

The young lamb is susceptible to many diseases. For example, navel ill is a problem causing lamb loss throughout the world. Many infections can occur as a result of poor hygiene at tagging and docking. This is one area where losses could largely be prevented by management improvements. Other lamb diseases, such as orf, in severe cases, may discourage or entirely stop lamb suckling behavior and lead to loss of condition or even death. Metabolic diseases in the dam can be brought about by stress, and milk supply is reduced by infections such as mastitis. This disease occurs in the sheep and the goat and is a problem for the suckling offspring and for commercial milk production.

Adult mortality can often be prevented by quick recognition and control of diseases, but losses still occur. Very often, exotic livestock introduced into a new environment will have a high mortality from diseases to which local stock may be adapted.

In adults, the severest effects of diseases and parasites are not from mortality, but rather in terms of production losses over time. The productive life of an animal can be severely reduced by the debilitating effects of mineral deficiencies. Debilitating diseases may cause large production losses, but can often be controlled by improved management. Livestock introduced into a new environment tend to be highly susceptible to such diseases. Exotics and crossbreds are more readily infected by diseases carried by wild animals than are the indigenous, adapted livestock. Breed differences in susceptibility can be a limiting factor to the success of crossbreeding programs.

Helminth infections are a major cause of low productivity throughout the world. Their control can have a dramatic effect on improving the growth rate of lambs. The weaned or adult animal is dependent on pasture, and a parasite burden can make a tremendous difference to growth and production. Sub-clinical infections cannot be overemphasized in terms of their detrimental effects on productivity.

The intensification of a livestock system may lead to greatly increased disease problems if management is not sufficiently improved at the same time. The stress of intensification, or simply of transport of livestock, leads to increased susceptibility to pneumonia. Where management is lax, enterotoxemia will strike. Also, the tendency to overstock an intensive production system gives rise to increased problems from coccidia infections.

Various parasites and diseases may have their effect on productivity at the level of the final product. For example, wool is downgraded if fungal infections are present, and fleece quality is reduced by helminth infections. Fungus and mange will also cause downgrading of the quality of skins. Considerable economic loss can result when offal infected by liver fluke or by tapeworms is condemned.

In many areas of the world predation is a severe constraint to livestock production systems. Protection of livestock generally involves confinement overnight which leads to problems with the diseases associated with intensively-housed livestock.

The effect of many diseases may be seasonal in occurrence, thus, their influence on production may fluctuate in magnitude. Overall, the most important point to be emphasized in relation to disease and parasite constraints is that their control through improved management can vastly increase productivity.

Utilizing Genetic Resources Within the Environmental, Disease, and Other Constraints to Optimize Production

M. J. Shelton

It is difficult to accurately determine the magnitude of the contribution made by sheep and goats to man's food supply. Available statistics are misleading, as much of the production from these species does not show up in reported figures. There are many sheep and goats in the developing areas of the world where the milk, meat and fiber, that they produce, are used directly for home consumption and are never reported in official production statistics. It seems reasonable that an effort should be made to optimize production from these livestock, within the existing constraints, as they make a valuable contribution to food resources in areas where it is most needed.

Sheep and goats are often kept together for a number of reasons, as long as the available grazing is not a monoculture. These species utilize a wide range of vegetation, including brush in the case of goats, and mixed grazing will tend to maximize efficiency of utilization on mixed herbage. In addition, goats are good flock leaders, are hardier, and lactate longer than do sheep. The relative values for the several products obtained from sheep and goats, based on FAO figures converted to approximate U.S. dollar values, are:

Product	Percentage of Value	
	Sheep	Goats
Meat	43.35	35.61
Dairy	15.02	58.39
Fiber	39.30	1.70
Hides	2.31	4.27

There are numerous constraints to production from these two species and the importance of each varies with the region being considered.

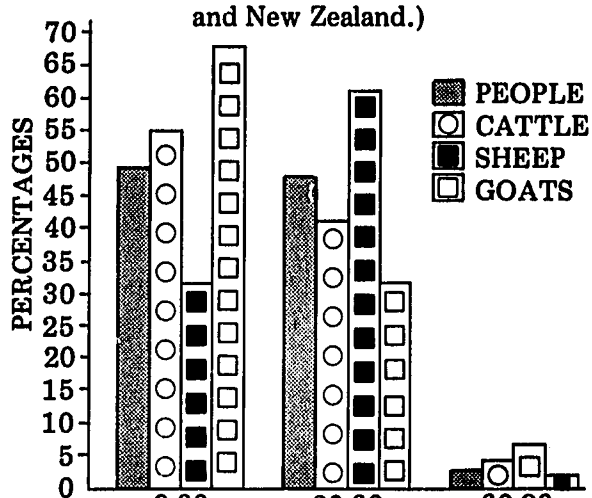
Diseases and parasites, expecially internal parasites, can seriously affect production efficiency. Regions of high rainfall or humidity are particularly conducive to such problems as are areas where animals must be protected from predation by confinement at night. Control of diseases and parasites can be an economically efficient method of bringing about marked production increases. This control can be brought about by various means, with the precise method chosen being dependent on the specific local problems. The various approaches to dealing with disease and parasite problems include immunization, prophylactics, sanitation, and breeding for genetic resistance.

Feed and forage resources can be a greater constraint to production than are diseases and parasites in many regions of the world. Sheep and goats are frequently maintained on pasture that has been abused by overgrazing, so that feed resources are strictly limited. The ability of sheep and goats to utilize poor quality feedstuffs should be exploited, but at the same time, dietary constraints should not be allowed to impose severe limits on production. The technology exists to correct problems of poor grazing management and overuse or abuse of feed resources, but in many areas the prevailing political and social constraints prevent implementation.

Genetic resources are extremely varied in sheep and goats, and genetic adaptations to local conditions can be valuable in providing an animal that is productive in an inhospitable environment. However, this adaptation may have resulted in an animal whose major product is not that most desirable to man, so the potential usefulness of bringing in exotic genotypes for crossbreeding cannot be ignored. Not all exotic genotypes are incapable of adjustment to a new environment, and the wide range of genotypes in sheep and goats provides an extensive base from which a selection can be made.

Temperature influences the distribution of sheep and goats in the world. As Figure IV. 1 indicates, a large proportion of the world's

Figure IV. 1. DISTRIBUTION OF PEOPLE AND LIVESTOCK BY DISTANCE FROM THE EQUATOR (Excludes Australia and New Zealand.)



goat population (over 2/3) is found within 30° of the equator. Sheep make a greater contribution in temperate and cold climates. Their fleece is an advantage in such areas, while restricting their ability to adapt to hot environments. The chart does not include data for Australia and New Zealand. These countries represent a special case in which no extremes are available in the same land mass to be compared. The concentrations of sheep and goats in these areas are largely explained by factors not related to geographic location. The utilization of hair sheep in hot environments has potential for diversifying production in these areas. This would make sheep and goat products available on local markets and grazing land would be better utilized by the mixed species.

Humidity contributes to temperature stress and disease and parasite problems. In equatorial regions, sheep and goats tend to be concentrated in arid areas, rather than in areas of high humidity. The desirability of attempting to maximize the production of these species in the wet tropics remains to be determined.

Altitude is not looked on as a serious limiting factor to sheep and goat production, as these species appear to have evolved in mountainous regions. Its only effect would be mediated through its influence on temperature and feed supply.

Availability of water is a severe constraint on livestock production in arid regions, which comprise some 15-20 percent of the world's land surface. Goats and hair sheep tend to be concentrated in these arid regions and must therefore have potential for raising productivity of such areas. Water requirements of sheep and goats are less than those of cattle, although not as low as the requirements of some highly adapted wild animals. However, this may not be the primary reason for the concentration of hair sheep and goats in arid regions. Forage utilization would appear to be of at least equal importance.

Photoperiod influences sheep and goats markedly in all but equatorial areas. A production system that is out of synchrony with the environmental cycle can be a difficult prospect because of the problem of getting animals to breed at times when the photoperiod is unfavorable.

Social constraints limit production in many ways, especially in terms of land ownership and grazing patterns. Marketing and banking systems also impose restrictions; as does the social stigma against herding or keeping such livestock as goats in many countries. In some countries, especially in the U.S., there is some discrimination against sheep and goat products.

Management systems in terms of developing economic sheep and goat production enterprises as contrasted to simple accumulation of animals, which is often a detriment to the environment, are needed in many regions of the world. Programs to reduce animal numbers on grazing land while optimizing production from those remaining must be developed.

Security can also be a constraint to production. Theft of animals can create problems, as can predation. Often, predation creates secondary problems such as disease when animals are herded together for night-time protection, or actual loss of productive land where predation problems are so severe that livestock can no longer be kept.

Discussion of Papers Presented by Allonby and Shelton

Genetic differences in disease susceptibility could be profitably investigated, according to several conference participants. Natural resistance may become more important as increasingly stringent restrictions on pesticides and medications are introduced. The reasons why some species and breeds within species are less attractive to pests than are others should be studied in this respect. However, the fact that tolerance may be gained at the expense of production also merits consideration. This system may nevertheless be cheaper than treatment of diseased animals, so it should not be dismissed solely on the basis of the associated production loss.

The environment in which the adult animal is reared is very important in the development of disease resistance. Natural selection has probably resulted in a degree of resistance. Where artificial selection is implemented, it should be done in the context of specific production conditions with the emphasis on increasing overall production efficiency. A breed that performs well under one set of conditions may not be the best elsewhere.

Crossbreeding can be used to increase production efficiency, expressed in terms of fertility and meat production. Generally, private breeders cannot afford to invest resources in selection programs, and it must be recognized that governments need to play a part in the development of selection schemes.

The question of the relationship between body size and productivity was raised. Ideally, a small, highly productive animal is most desirable. Dr. Allonby cited figures indicating the much higher efficiency of smaller animals for meat production. Up to 2 kg meat per kg adult ewe body weight is produced by some African breeds of sheep, in contrast to the 0.16 kg per kg usually quoted for cattle in Africa. Sheep may produce up to three to four times more per kg of body weight than cattle on range if they have the same feed resources. At the present, beef cattle have a very low efficiency rating and small ruminants are on the increase where land pressure exists.

More work is needed on the optimization of mixed species grazing for various areas. Data are needed for different grazing conditions so that specific recommendations can be developed. Accessibility of information on mixed species grazing studies is a problem where such work has been carried out. The fact that such data tend to be "messy" may often discourage publication. The question of whether the product from an optimized mixed grazing scheme is, in fact, the most desirable for available markets must also be asked, and answered at some point before such programs are recommended in practice.

Interest was expressed in the use of parasite-free pastures in East Africa to establish the effect that parasite infestations have on productivity. This is an expensive system to set up initially but may well prove profitable on a long-term basis. The economics of the helminth program discussed by Dr. Allonby resulted in a sevenfold return in terms of extra meat production from the ewe. With complete control, a 50 percent increase was achieved in the second year and 100 percent in the third year, i.e., returns are delayed. The question of whether this is a feasible system is being studied.

Dr. Rachel Galun discussed the potential for controlling livestock parasites by means of insect growth regulators. The small farmer needs a simple and effective method of controlling parasites. The development of a single, systemic insect growth regulator effective against all arthropods and helminths which inhabit the living animal or its feces would be of great value in developing countries. Such a chemical would simplify parasite control programs, while also being much less persistent and damaging to the environment than are most insecticides currently in use.

The development of a new pesticide is an expensive operation. The commercial applications need to be wide if a company is to undertake such development. The insect growth regulators lack the extreme specificity of, e.g., pheromones, which are relatively innocuous to man and other animals, and thus show potential for development as pesticides. A compound that can be fed directly to the infested animal will bring the pest into direct contact with the control agent. If one mode of application, using one compound will suffice to control all pests, then the high price of such a chemical may be offset.

Many compounds have been tested, but much work remains to be done. The low selectivity of some chemicals means that they will affect some non-target insects also, but the biodegradability of insect growth regulators makes this a limited and short-term effect. Insect molting hormone antagonists have not progressed beyond the stage of laboratory research, and at present appear to be outside the realm of economic feasibility. Juvenile hormones offer more immediate potential for use as hormonal insecticides. Many are extremely active compounds that can be effective in very low dosages.

The effect of insect growth regulators, can be on the growth and molting of juveniles, the development of eggs, or the reproductive system in males or females. The USDA laboratory in Beltsville, Maryland is currently screening the effects of juvenile hormone analogues on nematodes. However, further work with a range of chemicals and species is required before a suitable systemic insect growth regulator can be developed for parasite control in livestock.

SMALL RUMINANT PRODUCTION IN VARIOUS REGIONS OF THE WORLD

Production in Tropical and Subtropical Regions

C. Devendra

The population of sheep and goats in the tropic and subtropic regions in 1974 was about 460 and 315 million, respectively. The tropics and subtropics account for 45 percent and 79 percent of the total world population of sheep and goats. In relation to the total population of 685.4 million cattle and 99.5 million buffaloes in the tropics and subtropics, the populations of sheep and goats in these areas represent 29.4 and 20.2 percent, respectively of the total grazing domestic ruminants.

Goats appear to have greater importance than sheep in the tropics and subtropics since the contribution by goats to meat and milk production as a percentage of the total world supply is greater than that of sheep (Table V. 1).

Table V. 1. Comparative Productivity of Meat, Milk, and Fresh Skins By Goats and Sheep in the Tropics and Subtropics (10^3 tons)

Species	Production	As % of Total World Production
GOATS		
Goat meat	1,047	72.3
Milk	4,732	67.7
Fresh goat skins (tonnes)	221,526	77.8
SHEEP		
Mutton and Lamb	1,796	33.2
Milk	3,389	46.2
Fresh sheep skins (tonnes)	356,323	38.3

Source: F.A.O. (1974)

Between the two species however, goats are more neglected than sheep in view of the importance of sheep in temperate regions.

The majority of sheep and goats are kept by small holders or small farmers in rural and rural-fringe areas. In this capacity they serve a number of important functions, mainly to: (1) complement crop production; (2) supplement farmers' income; and (3) enhance the nutritional and social well being of the rural community. Generally, goats are of secondary importance to the main agricultural or livestock enterprises.

Contribution of Goats — The contribution of goats to the general community include:

- Goat meat — The importance of goats throughout the tropic and sub-tropic regions is primarily for meat production.
- Milk — Milk production from goats is of secondary importance, but it is consumed widely in rural areas where goats are kept. In some countries, the contribution by goats to the total milk production is quite significant. (Table V. 2).
- Fiber, skins and hides — Fiber (goat hair, cashmere and mohair) products from goats, especially cashmere and mohair, are particularly sought after. Mohair from Angora goats is becoming increasingly of interest to Madagascar, Pakistan and India.
- Miscellaneous functions — valuable functions include sources of income, investment, prestige in their ownership, slaughter

Table V. 2. The Contribution by Goats to Milk Production In Some Countries in the Tropics and Subtropics

Country	Milk production from goats as % of the total milk produced
India	2.7
Brazil	4.5
Greece	26.2
Turkey	23.0
Morocco	33.0
Cyprus	50.0
Libya	50.0
Iraq	58.0

during festive occasions, recreation, production of manure, experimental animals, and commercial value of by-products such as horns, hooves, blood, and bone meal.

Systems of Production — The systems of sheep and goat production in the tropics and subtropics can be grouped into four categories:

Tethering — In the tethering system, goats are pegged to a rope about 3 meters long. By changing the peg location once daily, free access to a fresh browsing area is provided. Very little or no concentrates are provided except for household scraps or small quantities of grains or their by-products. Tethering is common practice in South East Asia, Central America and the Caribbean, and parts of Africa.

Extensive Production — Extensive production is probably the most popular system of goat and sheep production. In Guyana, for example, 48 percent of the sheep and goats are managed extensively. In the Caribbean two types of extensive management systems are recognized: (1) small scale production of about 5 to 40 goats in urban fringe areas; and (2) large scale production of about 50 to 400 goats in rural fringe areas. In the rice growing countries such as Thailand, Indonesia, Malaysia and Philippines goats and sheep often graze stubble in between rice harvests. In Indonesia and Malaysia, as well as in the West Indies, it is common to feed cut leaves from trees.

Intensive Production — In the tropic and subtropic regions, intensive production of goats whether on cultivated fodder and pastures or stall fed in pens is not a common practice.

Integration Into Crop Agriculture — This system involves the integration of sheep and goats into plantation crops such as rubber, oil palm or coconuts. The system has been tried in a limited scale in Sri Lanka, Malaysia, Indonesia, and the Philippines. The value of the system is dependent on: no adverse effect on the crop, the availability of herbage, yield of dry matter, proper time of introduction of animals, correct stocking rate, and profitable returns from the crop and the livestock. The potential benefits from this integration include: (1) increased fertility of the land by the return of dung and urine; (2) control of waste herbage growth; (3) reduced loss of nutrients to the crop supplied by fertilizers; (4) possibility of increased crop yield due to 1, 2 and 3 above; (5) easier management of the crop; and (6) greater economic returns to the farmer.

Level of Production — The present level of productivity of both sheep and goats in the tropics and subtropics is in general low. The low productivity is due to a combination of underfeeding, unthrifty goats, diseases, and poor husbandry. Nutrition is by far the most limiting factor in goat production. Lack of purposeful breeding and selection and limited information on the characteristics of individual breeds are also constraints to high productivity in goats.

Efficiency of Meat and Milk Production in Goats — Calculations have been reported on data published previously on milk production and meat production, with respect to energy and protein conversion by goats. These calculations are presented in Table V. 3.

Table V. 3. Approximate Efficiencies of Energy and Protein Conversion in Goats

Goats	% Efficiency		Energy cost of protein
	Energy*	Protein**	(g./Mcal ME)***
Milk production (lactation)	24.0	23.7	14.5
Mutton production (fattening)			
On grass	4.7	9.1	5.1
On grass + concentrates	6.7	10.2	7.5

* Energy expressed as Kcal/100 kcal of metabolisable feed energy consumed.
** Proteins are expressed as edible protein per 100 g. of feed proteins consumed.
*** Edible protein per Mcal ME.

have been shown to have a higher efficiency of milk production than cows, buffaloes and sheep. The efficiency of goat meat production

Dairy goats with high genetic merit such as the Saanen, British or French Alpine breeds is comparable to beef production. The apparent higher margin of return from keeping goats suggests that the economic efficiency is higher in goats, under some circumstances, in the developing areas of the world. With reference to extensive goat production and the use of marginal or waste land by this species, it is clear that goats are presently making the most efficient use of these areas which are unimportant for other agricultural purposes or unproductive otherwise. The economics of high biological efficiency in such environments with minimum capital investment suggests that the returns fully justify their retention.

In conclusion, the future for increasing the contribution from goats and sheep merits a balanced development in the context of expanding the overall contribution from livestock. Their contribution presently is relatively low, and the case for meat and milk production is therefore real. Concerning the latter, it may be of interest to note that milk production from goats has already been considered as a temporary substitute for dairy development based on cattle and/or buffaloes in the Far East.

Sheep and Goat Production in India

O. P. S. Sengar

Presently, India has over 40 million sheep and 68 million goats. They provide a source of livelihood to a large number of the country's population since they fit in better than any other livestock to the economy of smallholders; and represent the second largest number of the ruminant livestock population. By the year 2000 the Government proposes an increase in sheep numbers to 60 million and a decrease in goats to 40 million.

Sheep Production

The 40 million sheep in India produce annually about 35 million kg of wool, 101 million kg of mutton and 15 million skins which earn considerable foreign exchange. The overall production of wool is somewhat poor, varying from 34 to 1800 grams, for an average of 680 grams per head per year. There is considerable demand for India wool for carpet making. It is considered to be lacking in desired luster and uniformity, but has excessive medullation and is kempy in nature. In the international market, therefore, Indian carpets obtain only 20 to 25 percent of the price of Persian, Afghan or Chinese carpets. The Himalayan breeds produce superior wool for apparel and those of the Southern Peninsula produce hairy wool for coarse rugs.

Breeds and Breeding — The sheep rearing areas in the country can be classified into:

- **The temperate Himalayan region** — where superior wool types such as Gaddi and Bhakarwall are common.
- **The semi-arid western region** — where carpet wool is produced from long eared Lohi and Nali, brown faced Bikaneri and black faced Marwari and Jaisalmeri.
- **The Southern humid region** — which primarily produces rough wool and mutton from Daccani, Billory and Hassan (produce mainly coarse, colored wool for blankets) and the Nellore, Mandya and Bandur (meat types with practically no wool production) breeds.

The majority of the native breeds have two distinct breeding seasons: July/August and March/April. Breeding in March/April is more desirable since feed conditions are better at lambing.

Production Systems — Sheep in India are primarily maintained by a specialized class of people who have linked this industry with the agricultural occupation. The majority of them move from place to place according to the changes in season and the availability of grazing.

Generally the minimum economic unit is 50 to 60 sheep, but units having 100 to 1000 and even more are also common. Flocks maintained as a side occupation to farming have on the average 20 to 30 ewes.

A 1972 survey on the economics of sheep rearing in the Chokla and Nali regions of Rajasthan indicated that the average annual income from a 100-ewe flock (along with the rams and followers) was U.S. $444 for Chokla and U.S. $649 for Nali flocks. When comparing the theoretic economic potential of 100 ewes, 100 does and 15 cows (7 sheep/goats = 1 cow) and their followers under free range grazing, the projected income was U.S. $2,164 from sheep, U.S. $4,730 from goats and U.S. $2,013 from cattle in a 6 year period. The economic potential of rearing sheep in India is, therefore, more attractive than rearing cattle but is considerably inferior to goat farming.

From the management and husbandry points of view, sheep production systems in India can be divided into sedentarized and migratory.

The sedentarized flocks are located in areas of sufficient grazing/forest land and do not move far from their permanent abodes. Integrated sheep improvement programs for providing breeding and management inputs, developing and maintaining pastures and organizing wool grading and marketing centers are required to develop the sheep industry in these areas.

The migratory system includes the nomadic flocks in areas where vegetation is scanty and flocks must move from one place to another in search of feed and water. In general, reasonably good grazing is available from July to October after which the pastures deteriorate rapidly. From February to June feed supplies become critical and flocks are forced to migrate.

As a rule, surplus ram lambs are usually castrated at an early age and are marketed between 6 and 12 months of age. Ewes that do not breed before 1½ years of age and those beyond 5 years old are culled. Sheep tend to suffer from heavy mortality due to contagious diseases such as enterotoxemia, pneumonia, sheep pox and gastro-intestinal parasitism.

Many state governments are now introducing prophylactic measures and providing some veterinary personnel to monitor migratory flocks.

Development Plans — With the present vegetation resources of the country and the nutrients available from them, it is not possible to improve the meat production potential of sheep in the near future. Government's policy has been orientated, therefore, primarily to improvement programs for wool production.

Breeding plans for Himalayan types and some of the better wool types of the Western plains are directed towards the improvement of fine wool production through the introduction of Merino and Rambouillet rams. This is expected to increase wool production to about 2.5 kg per animal per year.

A large central sheep breeding farm operates in Hissar (Haryana) to handle the large number of Merino and Corriedale sheep imported during 1972 to 1975 for the introduction of fine wool. Seven more state sheep breeding farms are being started and the wool grading and marketing scheme, assisted by the U.N.D.P., is already in progress. Difficulties with imported rams include lack of libido and poor semen quality particularly in the summer months. Rams selected for greasy fleece weight and against medullation are being used for improving the carpet wool.

Goat Production

India has the largest national goat population (68 million) in the world. Goats produce about 3 percent of the total milk and about 35 percent of the total meat consumed in the country. In addition, goats produce 30.3 million skins and 4.5 million kg of hair annually. They are generally kept by landless people and marginal and sub-marginal farmers in numbers ranging from 2 to 10 on a subsistence basis. Large flocks of 100 or more are also sometimes owned in areas of natural grazing.

Indian goats are widely adapted to a variety of climates and agro-economic situations. They provide milk and meat for family consumption and often some side income. The future of the goat industry in India shows promise.

Breeds and Breeding — Goats in India are found in a number of distinct breeds and varieties. In general, goats have a dual utility for their owners, milk and meat or fiber and meat, and have not been bred for any specialized purpose.

Indian goat breeds can be broadly classified on the basis of size into:

- **Large breeds** — Jamunapari, Beetal, Osmanabadi and Kashmiri
- **Medium breeds** — Barbari, Cutchi, Gaddi and Malabari

- **Small breeds** — Assam hill goats, Bengals and Surties

With some exceptions goats have two distinct breeding seasons with kidding occurring for the most part in February and March. Indian goats are more prolific and have higher incidence of multiple births than Indian sheep.

Production Systems — The vast majority of the goat population is maintained by poverty stricken people at practically no maintenance cost in a sedentarized system of grazing on harvested or fallow fields, road and canal sides and overgrazed commons. Numbers per flock range from 2 to 10. Commercial flocks of 100 or more are sometimes kept by landless people who derive their income exclusively from the sale of milk and kids.

Does are milked twice a day or when the need arises. Male kids are castrated and fattened for sale. Culls and surplus animals are regularly collected by contractors for urban meat supply and meat processing plants.

Under the present smallholder production system, separate housing is not provided for goats but in climatic extremes they share housing with their owners or with other livestock. Important goat diseases include diarrhea, goat pox, pneumonia, kid scour, coccidiosis, scabies, gastrointestinal parasitism, lameness, and mange. Mortality is higher during the winter months.

Development Plans — The goat will not replace high yielding cows or buffaloes in milk production; however, in the developing countries, where average cow milk yields are low, the dairy goat is expected to do well and prosper. Goats have no serious competition as meat producers and excel all farm animals in India. With this in mind the Government of India has recently encouraged goat research and extension activities throughout the country. Projects already operating include:

- All India coordinated project on milk production —

  Objective: to produce a stall fed, high milk producing goat by crossbreeding local stock with Saanen and Alpine bucks.

  Results: The half-breeds surpassed the native breeds in body weight from birth to yearling. Alpine crosses do better than Saanen with increased milk fat and reduced dry period and age of maturity.

- All India coordinated project on goats for mohair/pashmina production —

  Objective: To produce breeds with fine lustrous fiber by crossing local goats with imported Angoras (U.S.A.) and Predonskayas (U.S.S.R.).

  Results: Improved pashmina in quality and quantity; half-breeds did not produce mohair but the hair quality was improved. The 3/4-Angoras are expected to produce mohair.

- All India coordinated project on goats for meat production — A new project for which information is not available yet.

Goat Production in Mexico

A. Juarez

The present goat population of Mexico is about 9 million. Goats rank third in total numbers of farm livestock after cattle and swine and rank 5th in economic value. Goats are distributed primarily throughout the Northern and Central regions of Mexico (Figure V. 1).

In 1970 annual milk production from goats was estimated at 241 million liters or 66 liters per doe. Total meat production was 27.6 million or 7.7 kg average carcass weight per doe. Considering the value of both products, meat represents 45.5 percent and milk 41.5 percent of the total value of goat production in Mexico.

Breeds — Little is known on the early history of goats in Mexico; however, there is evidence that the first flock was introduced in the 16th century. According to the phenotype, the breeds introduced included Granadina, Murciana, Pirenaica, Malaguena, Blanca Celtiberica, Castallana de Extremadura, and the African or Nubian goat. Early this century several breeds such as Saanen, French Alpine, Toggenburg, and Anglo-Nubian were introduced.

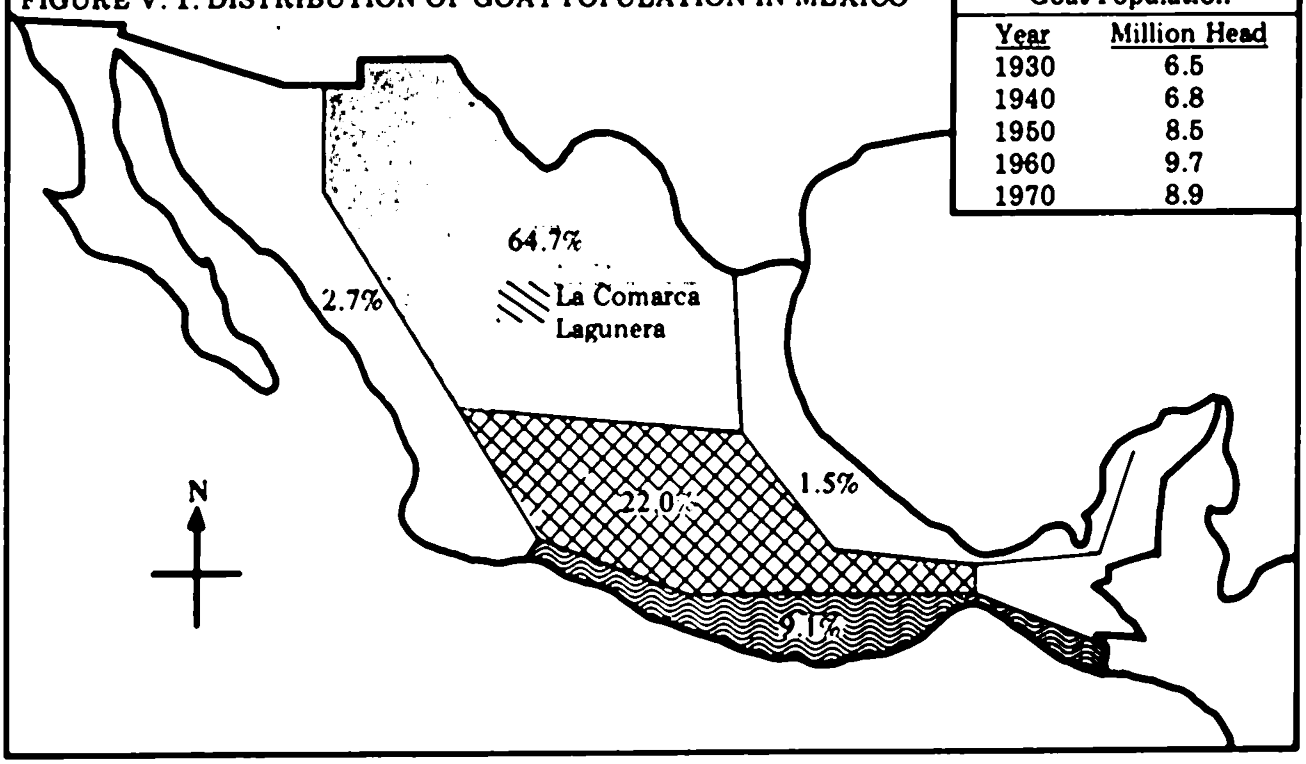
Production Systems — Generally, goats are raised by peasants or "ejidatarios". The number of animals in each herd varies between 50 and 400 with the average being around 100. The predominant production system is of the extensive type, frequently nomadic in nature. Low productivity under this system is due to low planes of nutrition, disease (primarily external and internal parasitism) overall inadequate management and husbandry practices, and lack of objective criteria for selection.

Other factors constraining extensive goat production systems include: the lack of marketing organization among producers; the unavailability of credit to small producers for goat production; the absence of professionals to provide research, teaching and extension services; the association of goats with poverty and deforestation; and the increasing shortage of shepherds.

Intensive systems of goat production are however being encouraged by the Government in states such as Durango and Coahuila. In the region of "La Comarca Lagunera" emphasis is being placed on intensive dairy goat production. An industrial dairy goat complex, milking approximately 3500 does of 5 different breeds, has operated successfully in this area for the past 9 years. Eight more goat farms owned by ejidatarios and a government goat raising center operate in this area with a total of 7,300 goats. The entire region has about 275,000 head. The success of the goat industry in this area when compared with national averages is attributed to: government support; credit availability; adequate breeding stock; use of cultivated forages plus availability of crop residues (from nearby irrigated lands) and agricultural by-products; adequate facilities to process the milk and meat; partial disease control practices; and the introduction of some modern husbandry and management practices.

Despite the increased productivity of goats in the Tlahualilo herds, it is estimated that meat and milk production can be further increased about 48 percent by (1) increasing milking persistence (21 percent), (2) reducing reproductive failures (14 percent) and (3) increasing replacement rates (13 percent).

FIGURE V. 1. DISTRIBUTION OF GOAT POPULATION IN MEXICO



Goat Population	
Year	Million Head
1930	6.5
1940	6.8
1950	8.5
1960	9.7
1970	8.9

Production Systems in East Africa and the Sahel

E. W. Allonby

The Sahel is an ecological zone where rainfall varies from 5-20 inches per year, and is not a fixed geographical region. It lies between the Sahara desert and the Sudanese agricultural zone. The Sahel, East Africa and South Africa contain much of the domestic livestock of Africa.

Vegetation in these regions is very much dependent on local climatic conditions, which are the deciding factors in determining production systems. The seasonal pattern of rainfall results in an annual cycle of nomadic movement of people and their livestock. There is a symbiotic relationship of nomadic people and agriculturalists, to the mutual benefit of both groups. The variable rainfall pattern influences the vegetation, which has an extreme range of types. Where rainfall is very high, cash crops are dominant and little livestock is kept. Animals tend to be concentrated in arid and semi-arid zones. The variations in vegetation productivity, with varied rainfall, give rise to a complete range of ecological zones; and management practices cover the whole spectrum of breeds, feed resources, and other factors.

In high-altitude areas (7,000-9,000 ft.), below the high rainfall cash crop zone of East Africa, sheep (for example, Corriedales and Romney Marsh) are kept on improved pastures of subterranean clover and are successful despite the fairly heavy rainfall. Cattle and milk goats, in which there has been a lack of interest hitherto, are also found in this zone. Such high-altitude areas still have great potential which needs to be developed. There is a place for exotic breeds at this altitude, keeping in mind their additional disease susceptibility. More research needs to be carried out, particularly with imported dairy goat breeds.

Merinos, together with other exotics and their crosses, are utilized in the medium rainfall areas. A bimodal rainfall distribution leads to poor pasture conditions for much of the year. Single lambs appear to be better, economically, in these marginal zones than are twins. Extensive crossbreeding is being carried out with breeds, such as the Dorper and Red Masai, to discover the best combination to exploit this type of area. Selection for twins in these crossbreds is being carried out in the regions of better rainfall. Production of wool-type sheep will likely decline in the short term as larger ranches are being subdivided into smaller units.

Over much of this part of Africa, local conditions such as climate and disease are severely restrictive; and the use of adapted, indigenous breeds cannot be overlooked. The benefits of using improved management systems with such livestock can be enormous, but may take several generations (up to 2 or 3) to really reveal themselves. Various options on the best way to utilize pasture production in terms of frequency of lambing and time of weaning have been studied. Productivity has been measured as kg liveweight produced per unit of pasture per year, with an open breeding season over the whole year (provided nutrition is adequate). A program of lambing 3 times in 2 years has given as much as a 40 percent increase in production. Programs utilizing meat-type goats are also being developed.

Special problems of livestock production in these areas of Africa include the transfer of disease from wild livestock and predation that necessitates fairly elaborate night-time production systems for stock.

The potential for increasing production in this region of Africa is vast despite the fact that results of improved nutritional management and disease control are often not immediately obvious. They can, however, have a crucial effect on food production in the marginal areas of Africa and elsewhere in the world.

The low rainfall regions of East Africa and the Sahel provide an environment that is predominantly utilized by camels and goats. Livestock production systems are essentially nomadic and systems of movement of flocks and herds between grazing areas and waterholes are generally very sophisticated. Any development plan must include consideration of the consequences of disturbing such local systems. The people of this region are totally dependent on livestock; and have no cash crops. Development is, however, hampered by the lack of knowledge of, and data on, native livestock populations. Data on skin and hide production appear to indicate that the goat and sheep are increasing in numbers, but much more information is needed.

Governments are concerned about the increasing pressure on land use as reflected in the available figures. The rate of human population increase is high, and animal numbers have increased comparatively. Taken with the fact that there has been no change in vegetation resources, this indicates more intensive land usage. It is hoped that increased offtake from the land reflects improvements in production, which ideally should be achieved without an increase in breeding herd numbers. The goat and sheep are becoming more important than cattle in many areas, and their numerical increase reflects the dependence of the local populations on the products of small ruminants.

There is much scope for management improvement. Many native flocks contain as much as 45 percent adult males, and there is potential for improving the marketing of these. Attempts are being made to establish improved marketing and management methods in these areas of Africa. Overstocking is the disastrous result of animal numbers being allowed to increase out of control. Disease outbreaks used to give pastures a chance to recover, but vaccination programs keep animals alive and grazing land under constant pressure. Management programs to optimize land utilization are urgently needed, and their development should include consideration of the potential contribution of wild game animals to overall productivity.

Production Systems of Small Ruminants in Europe

B. Vissac

Production systems for small ruminants in Europe vary according to:

- **The needs and traditions of the populations** — including meat with specific slaughter weights and carcass quality; fresh milk or special kinds of cheeses; and wool.
- **Feeding systems** — involving variations existing among ecological zones (oceanic, alpine, continental and mediterranean) and among types of enterprises which use sheep and goats in intensive or extensive systems.

Sheep Production Systems

Sheep production systems in Western and Mediterranean Europe can be divided into two zones: the center North zone and the Mediterranean zone.

The center north zone is chiefly under oceanic climate conditions and sheep are raised for meat (85 to 95 percent of total income) and wool (5 to 15 percent of income). British and Irish production is mostly under the control of large specialized enterprises operating in a sedentary system utilizing the best available technology. Due to the large consumption of sheep meat per inhabitant, production is for average quality lambs of 20 kg carcass. Similar specialized sheep enterprises are found only in the westcentral part of France. In other areas, where cropping and cattle are more profitable, sheep are used as a by-product in the following systems: (1) grazing with dairy cows in the littoral zone; (2) grazing poor pastures and marginal lands of dairy and beef farms; (3) grazing on common lands in the North East of France and in Germany with ambulatory flocks; and (4) feeding on crop residues on large cereal farms. Lambs marketed in this region are of medium size (18 kg carcass) and often of the top quality grade demanded by the Paris market.

The Mediterranean zone includes Southern France, Northern and Central Italy, Spain, Portugal and Greece. This a dry, mountainous area with various sheep production systems as well as breeds of local origin. In this zone, sheep are kept for milk and meat production.

Dairy flocks — more than 60 percent of the ewes in this zone are totally or partially milked with 90 percent of the milk being converted into high quality cheeses. Dairy flocks (80 to 100 head) are concentrated around cheese processing facilities. In Central and Northern Italy ewes are reared in small flocks and milked for local consumption while in Southern Italy and Lazio large flocks (200 to 500 head) are being converted to dairy or meat flocks. Under the above systems, lambs are slaughtered at 8 to 10 kg carcass.

Meat flocks -- Mediterranean Zone meat flocks vary according to:

- **Genetic origin**: Merino or local breeds when milking has been stopped due to lack of nearby efficient processing units.
- **Size of flock**: Small in Venezia and Lombardia, and large in Provence with the Merinos d'Arles.
- **Feeding system**: Sedentary with or without intensification; transhumant between low lands (winter), and Alpine conditions in summer with or without intermediate grazing areas for spring and fall.
- **Lambing seasons**: Generally fall for transhumant flocks and spring and fall for intensive systems.
- **Lamb carcass weight**: Varies from 8 to 10 kg in Northern Italy and in France from 10 kg (winter lambs) to 15 to 18 kg for fattened spring lambs.

Dairy Goat Production Systems

European goats are distributed primarily throughout the southern part of the Mediterranean countries and the islands (Cyprus, Malta). With few exceptions, European goats are milked.

Greece is the principal goat producer in Europe. Around 20 percent of the Greek goats are fed in sedentary units of low lands and semi-mountainous areas where Saanen and Saanen crosses to local breeds are predominant. The rest of the national herd (80 percent) is made up of range goats from local breeds reared in systems of nomadism and chiefly transhumance from low lands to high lands from spring to fall. Kidding takes place in the low lands where goats remain until kids are weaned so that most of the milking period takes place on the range. The herd size is variable, from 1 to 20 for family consumption to more than 100 for commercial purposes.

Similar production systems exist in Italy, Spain and Portugal with the more intensive units using improved breeds like the Saanen and the more extensive systems using local breeds (e.g. Murciana, and Malaga breeds in Spain). The difference between Greece and other Mediterranean countries is that more milk is devoted to cheese in Greece (75 percent of the total milk). In all of the countries where extensive systems of rearing goats are dominant, the value of goat meat represents about 50 percent of the milk income.

Due to the traditionally high demand for pure goat cheese in France, cheese processing and marketing have been organized industrially. This has led to intensive dairy goat production on cultivated pastures. The main areas for this activity are the Center-West and South-East of France where dairy goat units are dominant (80-150 head).

General Trends in Production Systems

Some general trends that can be observed in the evolution of small ruminant production in Europe include:

- A decrease in the overall population similar to that of other developed areas of the world (North America). This decrease is particularly true for the goat population.
- An increase in meat or milk production per head greater than in any other part of the world.
- An overall replacement of transhumant and nomadic extensive systems of small herds and flocks by intensive sedentary systems with larger herds using cultivated pastures and winter reserves.
- Specialization of southern sheep flocks and goat herds either for meat or for milk; and the fattening of kids and particularly of lambs in specialized units.
- Social problems are causing the decrease of sedentary units, which represent a secondary production in cropping areas, but flocks belonging to small or medium size dairy or beef farms are increasing. In this situation sheep are more efficient than beef cattle, in terms of returns on capital investment, in changing a dairy into a meat unit when there is a shortage of labor. This evolution is very important in France.

Research Strategy

The primary aim in rearing small ruminants is to use resources coming from marginal lands where their place in the corresponding ecosystems will not be competitive with other farm animals. The use of small ruminants requires the study of: various ecological zones (natural grasslands, forests, and cultivated lands where small ruminants can use crop residues); the location of the zones (in the same farm, valley or region); and the required transfers (feed transport, animal transport, change of management system, etc.) necessary to adjust feed requirements to animal production.

Several interdisciplinary projects are now developing in France, under the leadership of the Ministry of Science, to study principles related to the use of trophic relations between plants and small ruminants in the ecosystem; and the geographical strategies of production, processing and marketing in relation to human needs. These projects can be divided into (1) projects involving experimentation and (2) projects based on surveys. The projects involving experimentation include:

- **Causses area** — Different types of transfers of energy are compared from intensive clay zones to extensive chalk zones in the same farms. The dairy and sheep meat production systems are involved.
- **Landes area** — The objective is to compare the efficiency of production systems involving different grazing intensities and different levels of fertilization of the overall pine forest.
- **Maquis and Garriques areas of Languedoc** — Studies are devoted to the influence of continuous sheep grazing after burning or mechanical cleaning of the natural vegetation on this area.

The projects based on surveys describe, at the regional level, the attitudes of farmers concerning production systems as they relate to transfers or associations within the ecosystems. These projects include:

- **Pyrenees area** — Exchanges between lowlands and highlands in production systems.
- **Alps area** — grazing and social behaviour and ways to optimize grasslands utilization during the summer.
- **Margeride** — Attitudes of people towards the use of grass and by-products under natural pine forest conditions.
- **Corsica** — Description of land use by four species of farm animals in the Mediterranean saltus.

Discussion of Papers Presented by Devendra, Sengar, Juarez, Allonby, and Vissac

Tropics and Subtropics. — Considerable attention was given in this discussion to the role of planners in the development of the goat industry as a source of animal protein for smallholder or landless farmers. It was pointed out that under many circumstances planners in the developing countries have shown a bias against goats. This is evident in view of the lack of support in the areas of marketing, processing, veterinary, extension services, and credit for goat production. It was generally agreed that the bias against goats has developed partly because of misunderstandings of the habits of goats. Goats have been unjustly blamed for deforestation and the subsequent degradation of the environment since they usually inhabit barren areas unsuited for agricultural purposes or areas overgrazed by other species. Under proper feed and husbandry practices, however, goats can be an invaluable asset in grazing systems. In order to correct this bias against goats, adequate information regarding goat production systems must be disseminated so that planners and their advisors can appreciate the potential benefits of goat production.

The potential use of goats and sheep as grazers in plantation crops (coconut and rubber trees) was debated. It was concluded that this system would be beneficial in many areas provided adequate feed is available to avoid possible damage to trees. Research is needed to establish grazing patterns and preferences of goats.

India. — Discussion on the necessity for housing for sheep and goats indicated that housing was necessary only in the extreme of climates and for protection against predation. Goats suffer more from cold than warm weather so protection is often necessary in the months of November-February in India.

Because of the importance of goat meat in India, its marketing systems were discussed. Apparently, the goat is the simplest animal to be sold for meat. Brokers or contractors routinely visit the villages where they purchase the goats and take them to the urban areas where they are sold to butchers who slaughter and distribute them to the retailers. There is no organized market for goat's milk since the fresh milk demand is low. The marketing of fresh milk is limited to those amounts consumed by infants, invalids and convalescents.

On the subject of vaccinations, Dr. Sengar pointed out that goats tested on his station for Brucellosis have been reported negative. Presently there is widespread use of goat pox, haemorrhagic septicemia and enterotoxemia vaccines but not for Brucellosis.

There was general agreement that data are lacking regarding the contribution of goat's milk towards the general health of infants in poor families. It appears, however, that the contribution of goat's milk has been largely understated.

Mexico. — The higher milk production (and persistency) of the Saanen breed as compared to the Nubian and Granadina breeds was discussed. Emphasis was placed on the causes of abortions in goats. Apparently, there is high incidence of abortions throughout the Northern region of Mexico, including the intensive goat farms. Specific causes for abortions have not been identified but it is believed that a combination of poor nutrition, inadequate management and husbandry practices, and disease are major contributors. A program to eradicate Brucellosis (through Rev-1 strain vaccination) has been in effect for the past five years but the rate of abortions has not been considerably reduced.

It was pointed out that the relative success of commercialized intensive dairy goat production in the region of "La Comarca Lagunera" was due to the availability of goat milk processing facilities. Most milk is processed locally into cheese and "cajeta", a type of caramel candy, for distribution throughout the country. The demand for goat's milk is high and prices fluctuate considerably. The average price of goat's milk is slightly below that of cow's milk. In the near future, the economic efficiency appears to favor goats over cows in this region since, in addition to milk, goats can produce two offspring per year. The meat of young goats is in high demand and its price per kg is twice that of beef.

Training, directed by Dr. Juarez, is currently carried out on a limited scale at the center. More emphasis will be placed on training in the future, particularly on intensive goat production practices.

East Africa and the Sahel. — The differential response of plant species to the effects of grazing was discussed. Some plants benefit from being grazed, others do not. Overstocking and climatic effects influence pasture productivity, and the relative effects of these are presently being studied.

It may prove advantageous to drastically reduce livestock numbers on pasture land at times when it would normally regenerate. Drouth, for example, can lead to catastrophic losses when animal numbers remain high. Current systems of land tenure and communal grazing can be a problem in developing improved management systems. The accumulation of stock as a sign of wealth, and as a precaution against total loss during unfavorable climatic times, also works against management systems aimed at reducing animal numbers and preventing overstocking.

A point to consider is the potential of wild game to produce food. Thompson's gazelle, for example, is cropped at a rate of 25 percent of the population in one area of Africa, without noticeably influencing total numbers. Disease resistance and adaption to the local environment are important factors influencing the productivity of such livestock.

Europe. — Much of the discussion that followed Dr. Vissac's presentation concerned artificial insemination. Experiments using artificial insemination techniques are being conducted in a cooperating project by Sardinia, Spain and France to compare seven breeds of rams for terminal crossings in six different environments. Many artificial insemination centers in France are now interested in artificial insemination of sheep, goats and pigs because there is a decline in artificial insemination in cattle, particularly in the South of France.

There was no general agreement on the relationship between percent fat in sheep milk and total yield. It was pointed out, however, that work is being carried out in France with the objective of analyzing the relationship between the weight of ewes each month, milk production, and fat percentages.

SHEEP AND GOATS AS FOOD AND FIBER RESOURCES—CURRENT AND FUTURE

H. A. Fitzhugh

The approximately 1.5 billion sheep and goats of the world are the major single commercial source of animal fiber—wool and hair. Their relatively small carcasses and daily milk yields are an asset in regions where food preservation technology is still primitive. A family can fully utilize these "handy-sized" portions of milk and meat the same day they are harvested. Free from taboos, sheep and goats often provide the major, if not only, source of meat protein in the diet.

Production efficiency of sheep and goats is high and their full potential has not been realized. Shorter gestation periods (approximately, five months) and higher frequency of multiple births contribute to the higher annual fertility of sheep and goats compared to cattle. Lambs and kids tend to be earlier maturing than calves, allowing them to reach desired slaughter weights and condition at earlier ages and often on lower energy rations. Feeding trials suggest that sheep are 5-6 percent more efficient than cattle in use of energy for maintenance and growth. Production of wool and hair is an additional advantage, especially in light of decreased supply and increased cost of petroleum derived synthetic fibers. The petroleum energy cost of producing one kg of scoured wool is 18 Mcal versus 45 Mcal per kg of synthetic fiber (Cook, J. Range Mgmt. 29:186, 1976).

Between 1970 and 1974, world cattle populations increased while sheep and goat populations showed little change (Table VI. 1). However, with the recent decline in value of beef and increased values of wool, hair and sheepmeat, these trends have probably reversed in recent years.

Annual per-head turnoffs of food and fiber from regional sheep and goat populations suggest room for substantial improvement (Tables VI. 2 & 3). The relatively high proportion of the regional sheep population slaughtered each year in North America and Western Europe results from the combined effects of higher fertility, lower mortality and earlier maturity. These same factors plus use of larger, faster growing genotypes and some grain finishing yielded the higher carcass yields in the same two regions. Perhead yield of wool is highest in Oceania, especially Australia, which is the major source of fine quality apparel wool.

Milk yields from sheep and goats were highest in Western Europe. Certainly, the commercial value of sheep and goat milk for cheese making is most significant in Western Europe, a region noted for developing dairy breeds such as the East Friesian sheep and Saanen goats. The importance of home consumption of sheep and goat milk (at best, only approximated for FAO statistics) to improving diets of poor families in the developing regions should not be underestimated.

Tables VI. 4 and VI. 5 indicate the productivity of regional sheep and goat populations as percentages of world totals for 1972. Small ruminant populations in North America, Europe, USSR and Oceania tended to produce more than their share of food and fiber compared to populations in the developing world. For example, Oceania produced 21 percent of the world's wool. Important exceptions can be noted. Sheep and goat populations in Northern Africa and the Middle East produced relatively high proportions of the world's milk supply from sheep and goats. Mohair production statistics from Angora goats were not provided in the FAO statistics. Devendra and Burns (Goat Production in the Tropics. Farnhan Royal, U. K., 1970) reported that in 1968 approximately 27,000 metric tons of mohair were produced. Most of this production was from Turkey, Union of South Africa and the USA (primarily, Texas).

Sheep and goat meat are combined in the trade statistics given in Table VI. 6. North America, Western Europe and Japan account for 90 percent of the net importations and Oceania provides 92 percent of the net exports. Relatively little trade of sheep and goat meat exists among the developing regions of the world where most of the sheep and goat meat is consumed within the household or in the local area.

Looking to the future, the expected world populations of sheep and goats in the year 2000 (Table VI. 7) may be estimated from projected consumption statistics, which are based on the United Nations medium projected population increase and the expected increases in per capita consumption of sheep and goat meat associated with increased disposable income. If the 1972 carcass meat turnoff values (Tables VI. 2 and VI. 3) and local production/consumption statistics (Table VI. 5) do not change, then increased demand for sheep and goat meat in 2000 will require a world population of 2003 million sheep and 919 million goats. It seems unlikely that such increased populations can be supported in competition with the increased human populations.

The major opportunity is for increased turnoff rate so that fewer individual sheep and goats are required to meet the expected demand for meat and other products. Increases can be obtained through better nutrition, improved herd health and improved breeding practices. Examples of the impact of such improvements are illustrated by the projections from the Winrock Ruminant System Simulation Model.

This input-output model was developed to simulate feed energy flow through ruminant production systems. Some of the specified input and output variables are shown on Tables VI. 8 and VI. 9, respectively.

The effect of changing percent birth rate was simulated for sheep and dairy goat herds in "good" and "poor" production environments. Primary differences between these environments are the growth, lactation and mortality parameters (Table VI. 10) and differences in proportion of high energy-protein concentrate supplementation available and in roughage quality. For example, all systems were assumed to have 10,000 Mcal of GE available. Of this 10,000 Mcal GE, approximately 60 percent was assumed from roughage sources in the "good" environment vs. 93 percent in the "poor" environment.

Improving percent birth rate consistently improved efficiency of production of both sheep and goat systems (Tables VI. 11 & VI. 12). At higher birth rates, a smaller proportion of animal feed resources was required for herd maintenance, freeing more nutrients to support reproduction and production of meat, milk and fiber. Harvesting milk from the dairy goats (compared to only meat from sheep) increased human food NE yield nearly eightfold. Sheep flocks did yield wool (not counted in the NE/GE efficiency) and would not require the labor intensive management necessary for the dairy goat operation.

Trends for production efficiency with improved birth rates are similar in both good and poor environments. The deleterious effect of the poor environment on turnoff is obvious. Higher mortality, lower growth rate and older age of slaughter combine to lower yield of food and fiber and decrease the proportion of nutrients available for harvestable production.

These comparisons illustrate the opportunities for use of better management, nutrition, herd health and reproductive control to improve turnoff. It will not be necessary to double and triple inventory to meet projected demand for food and fiber from sheep and goats if we develop and implement more efficient systems of production.

Table VI. 1. Cattle, Sheep and Goat Populations, 1972[1]

Region	*Cattle*		*Sheep*		*Goats*	
	No. head[2]	% annual[3] change	No. head[2]	% annual[3] change	No. head[2]	% annual[3] change
North America	130.1	3.3	19.3	-5.3	1.5	-12.0
Middle America	39.1	2.8	6.4	-2.2	10.4	1.8
South America	190.5	2.0	115.2	-1.6	27.4	1.4
Western Europe	89.4	1.7	84.4	2.1	9.7	- .2
Eastern Europe	35.2	2.8	41.0	-1.5	2.2	-8.3
USSR	102.4	2.3	140.0	1.1	5.4	2.5
China	63.3	.1	71.3	.8	58.2	1.0
No. Africa — Mid. East	43.6	1.1	145.0	1.4	70.5	- .7
Central Africa	115.8	-1.3	68.0	2.5	89.2	.4
Southern Africa	15.9	.3	37.0	-1.3	8.0	-3.2
India	179.0	.5	40.4	-1.6	68.0	.8
So. & So. East Asia	75.0	.8	39.3	.7	36.2	3.6
Japan	4.0	2.7	—	—	.2	-7.8
Oceania	37.0	6.0	234.0	-4.0	.2	3.6
Rest of World	11.2	1.3	14.0	2.7	4.5	1.9
World Total	1131.0	1.5	1043.4	- .6	391.6	.5

[1] FAO Production Yearbooks 1974
[2] Total inventory, millions
[3] Annual change between 1970 and 1974

Table VI. 2. Annual Per-head Turnoff from Sheep[1,2]

Region	Head slaughtered (%)	Carcass meat, (kg.)	Milk, (kg.)	Scoured wool, (kg.)
North America	2.9	12.0	—	1.82
Middle America	.3	2.5	—	.40
South America	5.1	2.4	—	1.16
Western Europe	13.2	8.9	23.9	.96
Eastern Europe	5.0	5.8	30.2	1.32
USSR	15.1	6.5	.6	1.85
China	5.7	4.6	6.0	.51
No. Africa — Mid. East	12.1	5.5	18.3	.55
Central Africa	5.1	3.2	2.0	.02
Southern Africa	4.0	4.8	—	1.42
India	3.3	2.7	—	.52
So. & So. East Asia	3.5	4.1	11.6	.79
Japan	—	—	—	.90
Oceania	23.8	6.1	—	3.03
Rest of World	.9	5.9	3.6	.88
World Average	36.2	5.4	6.7	1.45

[1] 1974 FAO Production Yearbooks
[2] Turnoff expressed as average per all animals in 1972 herd

Table VI. 3. Annual Per-head Turnoff from Goats, 1972[1,2]

Region	Head slaughtered %	Carcass meat (kg)	Milk (kg)
North America	—	—	—
Middle America	1.3	2.4	21.0
South America	4.6	2.4	4.7
Western Europe	4.9	5.4	132.6
Eastern Europe	1.0	7.0	103.6
USSR	1.8	6.9	73.2
China	13.7	4.7	4.6
No. Africa — Mid. East	12.8	3.2	28.0
Central Africa	24.0	3.0	6.6
Southern Africa	2.0	4.2	.2
India	22.7	3.9	9.5
So. & So. East Asia	10.4	4.5	27.0
Japan	—	5.2	25.4
Oceania	—	9.6	—
Rest of World	.8	4.8	8.4
World Total	32.6	3.7	17.3

[1] FAO Production Yearbooks, 1974
[2] Turnoff expressed as average per all animals in 1972 herd.

Table VI. 4. Relative Productivity of Regional Sheep Populations, 1972[1]

Region	No. head	No. head slaughtered	Carcass meat	Milk	Scoured wool
North America	1.9	2.9	4.4	—	2.5
Middle America	.6	.3	.3	—	.2
South America	11.0	5.1	5.3	.4	9.3
Western Europe	8.1	13.2	12.6	28.5	5.3
Eastern Europe	3.9	5.0	4.2	18.2	3.7
USSR	13.4	15.1	15.4	1.2	16.4
China	6.8	5.7	5.6	6.0	2.3
No. Africa-Mid. East	13.9	12.1	13.2	36.8	5.2
Central Africa	6.5	5.1	3.4	1.6	.1
Southern Africa	3.5	4.0	3.1	—	3.7
India	3.9	3.3	2.0	—	1.4
So. & So. East Asia	3.8	3.5	2.7	6.6	2.1
Japan	—	—	—	—	—
Oceania	21.4	23.8	26.5	—	47.0
Rest of World	1.3	.9	1.3	.7	.8
World Total	1043.4	378.0	5757.0	7148.0	1532.1
	...... Millions		...... Thousand Metric Tons		

[1] Regional totals expressed as a percent of world totals.

Table VI. 5. Relative Productivity of Regional Goat Populations, 1972[1]

Region	No. head	No. head slaughtered	Carcass meat	Milk
North America	.4	—	—	—
Middle America	2.6	1.3	1.5	3.2
South America	7.0	4.6	4.4	1.9
Western Europe	2.5	4.9	3.7	19.0
Eastern Europe	.6	1.0	1.3	3.3
USSR	1.4	1.8	2.5	5.9
China	14.9	13.7	18.4	4.0
No. Africa-Mid. East	18.0	12.8	16.4	29.2
Central Africa	22.8	24.0	18.8	8.9
Southern Africa	2.0	2.0	2.6	—
India	17.4	22.7	18.6	9.6
So. & So. East Asia	9.2	10.4	10.4	14.4
Japan	—	—	—	—
Oceania	—	—	—	—
Rest of World	1.2	.8	1.4	.6
World Total	391.6	127.7	1424.0	6774.0
	.... Millions	....	.. Thousand Metric Tons	..

[1] Regional totals expressed as a percent of world totals.

Table VI. 6. World Trade Statistics for Sheep and Goat Meat[1]

Region	% of World Totals Net Import	Net Export
North America	13	—
Middle America	—	—
South America	—	7
Western Europe	55	—
Eastern Europe	—	0.6
USSR	4	—
China	—	—
No. Africa; Mid East	—	0.2
Central Africa	0.5	—
Southern Africa	0.2	—
India	—	—
So. & S. East Asia	—	—
Japan	23	—
Oceania	—	92
Rest of World	4	—
World Totals[2] (Thousand Metric Tons)	774	774

[1] Average for years 1969-71.
[2] Carcass weight

Table VI. 7. Current and Projected Human[1], Sheep and Goat Populations[2], Millions

World Population	1972	2000
Human	3,758	6,321
Sheep	1,043	2,003
Goats	392	919

[1] U. N. population projections, medium variant.
[2] Sheep and goat numbers in 1972 from FAO production yearbook; numbers for 2000 are those required to meet projected consumption demand assuming no improvement in sheep and goat meat turnoff.

Table VI. 8. Input Variables to Winrock Model

Birth and Mature Wts.	% Milk Harvested[1]	Age, 1st Conception
Daily Wt. Gain[1,2]	% Fat in Milk[1]	Postpartum Interval
Daily Fiber Growth[1,2]	% Protein in Milk[1]	Gestation Interval
Daily Travel[1,2]	% Mortality[1,2]	Male: Female Births
Daily Work[1,2]	% Sales[1,2]	Longevity
Daily Milk Yield[1,2]	% Conception[2]	Days Per Season[1]

Digestible dry matter, Digestible protein, Metabolizable energy in concentrates and roughage[1,2]
Concentrate/Roughage in Daily Ration[1,2]

[1] Allowed to vary in each of four seasons of the production year.
[2] Allowed to vary for each of 15 age-sex classes.

Table VI. 9. Output Variables From Winrock Model

Equilibrium herd composition
Requirements for ME and DP[1,2]
maintenance, weight gain, activity, work, fiber growth, lactation, pregnancy
Total and digestible dry matter intake[1,2]
Turnoff — animal, liveweight, milk, fiber, work[1,2]

[1] Output for each of four seasons.
[2] Output for each of 15 age-sex classes.

Table VI. 10. Some Defining Characteristics of Modeled Sheep and Goat Production Systems

Production System	Mature wt., kg Male	Mature wt., kg Female	Male sl. produce Gain kg/day	Male sl. produce Sl. wt. kg.	Male sl. produce Sl. age Days	Mortality 1 yr. %	Mortality Mature %	Lactation Days	Lactation Kg.	Lactation % Harv.[1]
Sheep										
Good env.	90	65	.20	60	10	13	4	120	180	0
Poor env.	80	55	.15	58	13	21	7	150	120	0
Goats										
Good env.	70	55	.16	48	10	15	4	240	950	100
Poor env.	50	40	.11	45	13	24	7	150	270	100

[1] Percent of milk harvested for human consumption.

Table VI. 11. Effect of % Birth Rate on Productivity of Sheep in Good and Poor Environments[1,2]

Variable	Good environment % birth rate 90	120	150	Poor environment % birth rate 70	90	120
Herd composition						
% breeding males	2	2	2	3	2	2
% breeding females	57	47	40	60	52	43
% slaughter produce	41	51	58	37	46	55
ME utilization						
% for breeding females	71	64	58	66	58	50
% for herd maint.	58	55	52	63	60	57
Annual turnoff/herd						
No. slaughter, %	34	38	41	23	26	29
Lv. wt., kg.	21	23	25	14	15	17
Fiber, kg.	2.8	2.6	2.6	2.0	1.9	1.9
Food NE, Mcal						
Meat	126	145	164	59	65	77
% food NE/feed GE	1.3	1.4	1.6	.6	.6	.8

[1] Birth rate is number young born/female exposed.
[2] Gross energy (GE) available to all systems standarized to 10,000 mcal.

Table VI. 12. Effect of % Birth Rate on Productivity of Goats in Good and Poor Environments[1,2]

Variable	Good Environment % birth rate 90	120	150	Poor Environment % birth rate 70	90	120
Herd composition						
% breeding males	3	3	2	3	3	2
% breeding females	57	47	41	61	52	43
% slaughter produce	40	50	57	36	45	55
ME utilization						
% for br. females	75	70	67	71	65	58
% for breeding females	46	46	43	65	61	57
Annual turnoff/head						
No. slaughter, %	34	38	40	22	25	28
Lv. wt., kg.	17	19	21	10	11	12
Milk, kg.	196	218	233	67	74	81
Food NE, Mcal						
Meat	111	125	132	54	63	71
Milk	791	881	942	304	337	371
% Food NE/feed GE	9.0	10.1	10.7	3.6	4.0	4.4

[1] Birthrate is number young born/female exposed.
[2] Gross energy (GE) available to all systems standardized to 10,000 Mcal.

LIST OF PARTICIPANTS—NAMES AND ADDRESSES

E. W. Allonby
Veterinary Research Laboratories
Kabete, Kenya

F. Bell
Winrock International Livestock
Research and Training Center
Morrilton, Arkansas 72110

G. E. Cooper
Winrock International Livestock
Research and Training Center
Morrilton, Arkansas 72110

C. Devendra
Senior Research Officer
Head, Animal Science Programme Branch
Mailbag 202
P. O. Universiti Pertanian
Serdang, Selangor, Malaysia

H. A. Fitzhugh
Winrock International Livestock
Research and Training Center
Morrilton, Arkansas 72110

W. C. Foote
International Sheep & Goat Institute
Utah State University
Logan, Utah 84321

R. Galun
Head, Department of Entomology
Israel Institute for Biological Research
Ness-Ziona
P. O. B. 19
Israel

H. Glimp
Winrock International Livestock
Research and Training Center
Morrilton, Arkansas 72110

A. Juarez
Director Tecnico
Centro de Cria Caprino
Tlahualilo, Durango, Mexico

R. H. Khouri
World Bank
1818 H Street, NW
Washington, D.C. 20433

N. M. Konnerup
USAID/Department of State
Washington, D.C. 20523

A. Louca
Director, Department of Agriculture
Nicosia, Cyprus

A. Martinez
Winrock International Livestock
Research and Training Center
Morrilton, Arkansas 72110

I. L. Mason
29 Via S. Anselmo
Rome, Italy

E. A. Oltenacu
Animal Science Department
Cornell University
Ithaca, New York 10036

J. A. Pino
The Rockefeller Foundation
1133 Avenue of the Americas
New York, New York 10036

N. S. Raun
Office of Agriculture, Bureau of
Technical Assistance
USAID
Washington, D.C. 20523

R. W. Rice
Head, Department of Animal Sciences
University of Arizona
Tucson, Arizona 87521

O. P. S. Sengar
Department of Animal Husbandry & Dairying
R. B. S. College
Bichpuri, Agra, India

M. J. Shelton
College of Agriculture
Texas A&M University
Route 1, Box 950
San Angelo, Texas 76901

G. M. Smith
U.S. Meat Animal Research Center
P. O. Box 166
Clay Center, Nebraska 68933

H. H. Stonaker
6529 E. Highway 14
Fort Collins, Colorado 80521

C. E. Terrill
ARS-USDA
National Program Staff
Beltsville, Maryland 20705

J. C. Trail
International Livestock Center for Africa
P. O. Box 5689
Addis Ababa, Ethiopia

H. N. Turner
CSIRO
Box 90
Epping, N.S.W., 2121
Australia

B. Vissac
Department Genetique Animale
Institute National
de la Recherche Agronomique
78350 Jouy-en-Josas, France

R. O. Wheeler
Winrock International Livestock
Research and Training Center
Morrilton, Arkansas 72110