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PRODUCTIVE MANAGEMENT OF RUMINANT LIVESTOCK FOR FARMERS AND HERDERS IN DEVELOPING COUNTRIES

TECHNICAL SERIES BULLETIN
NO. 29

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I. Introduction: The Importance of Ruminant Livestock in Developing Countries

A. The Role of Livestock in Developing Countries

Ruminant livestock now occupy an important economic role in the agriculture of developing countries. However, there is good evidence that the present economic benefits from the livestock sector could be greatly improved by adoption of management practices that are feasible for present livestock managers. The governments of individual developing countries would also be strengthened by improved management of livestock to meet national food needs, and to substitute for the heavy financial burdens of importing larger and larger amounts of dairy products and meats to satisfy growing market demands.

B. Present Numbers of Livestock in Developing Countries

Ruminant livestock include cattle, buffaloes, goats, sheep, and camels. The present farmers and herders are concerned first, with survival in terms of family subsistence; second, with dependability of production; and third, with the need to earn cash income by producing a surplus for sale of livestock and livestock products. The current abundance of the several species of livestock is shown in Table 1, for Africa, Latin America and the Caribbean, and Asia. There has been a modest increase in total livestock numbers in most regions between 1979 and 1981, but this increase has not kept pace with human population growth. Nevertheless, the present livestock herds and flocks may serve as the base for much greater profitability to the rural family units, to provide market supplies.

Table 1. Ruminant Livestock Numbers in the Tropics and Subtropics. (Data from FAO 1981 Production Yearbook)

Livestock Types	Thousands of Animals					
	Africa		Latin America & Caribbean		Asia	
	1979	1981	1979	1981	1979	1981
Cattle	167,368	170,930	263,152	267,494	355,583	362,771
Buffalo	2,321	2,347	482	558	114,571	117,943
Goats	144,220	148,936	29,430	28,567	254,044	271,608
Sheep	177,109	184,301	114,895	114,687	310,723	335,035
Camels	12,064	12,311	0	0	4,180	4,257

*Excluding China and Japan.

C. Present Status of Livestock Products in the Tropics and Subtropics

There is general consensus that ruminant livestock are a major component of most farming systems of developing countries; but statistical reporting of livestock products is quite incomplete. Much of the output is locally consumed by rural family units and rural villages, which is unrecorded. The movement of livestock and livestock products to urban centers is usually recorded, as well as production by commercial livestock enterprises.

The recorded data are presented in Table 2. Such data indicate a modest increase from 1979 to 1981, but far less than the growth of human population (see Table 4 on imports). This report will undertake to identify constraints, and outline practical and rewarding means of increasing productivity and profitability of the livestock sector. One of the factors that limits livestock products for rural consumption is the general lack of cold storage or other preservation for fresh meats and milk in rural areas. Prompt local consumption currently avoids the need for preservation in rural areas. Methods of compensating for this lack of cold storage will be described later in this report.

D. Agricultural Populations of the Tropics and Subtropics

The extent of the rural consumption of fresh milk and meat by farm family units may be estimated from the relative size of national populations that are engaged in agriculture. Thus, the average percent of total national human population that is engaged in agriculture was 64.7% for developing countries in Africa; it was 33.6% in Latin America and the Caribbean countries, and 60.0% in Asia, as shown in Table 3. To the extent that consumption of livestock products by rural populations is not adequately reported, the statistical

Table 2. Recorded FAO Data on Ruminant Livestock Products in Developing Tropical and Subtropical Regions

Products	Africa		Latin America & Caribbean		Asia*	
	1979	1981	1979	1981	1979	1981
	(Thousands of Metric Tons)					
A. Indigenous Meat Production						
Beef & Buffalo	2,989	2,965	8,163	8,361	2,330	2,378
Sheep & Goat	1,219	1,297	381	386	1,960	2,092
B. Dairy Production						
1. Fresh Milk						
Cow	9,259	10,516	41,716	33,869	24,503	25,970
Buffalo	1,227	1,303	0	0	23,823	25,127
Goat	1,365	1,434	351	463	3,212	3,390
Sheep	654	697	34	35	2,786	3,084
2. Processed Milk						
Evaporated, Condensed & Powders	73	73	772	777	477	542
Cheese	356	320	631	625	423	443
Butter & Ghee	168	162	222	225	1,086	1,164

*Excluding China and Japan.

NOTE: Much of the reported data are derived from commercial type enterprises that enter the market economy. The production and consumption of livestock products in rural families and villages is largely unrecorded. These rural quantities are related to the total agricultural population in each country.

Table 3. Agricultural Populations of Developing World Regions. (Data from 1981 FAO Production Yearbook)

Africa		Latin America & Caribbean		Asia*	
Agricultural Population		Agricultural Population		Agricultural Population	
Thousands of People	Percent Agricultural is of Total Population	Thousands of People	Percent Agricultural is of Total Population	Thousands of People	Percent Agricultural is of Total Population
303,832	64.7%	125,285	33.6%	899,243	60.0%

*Excluding China and Japan.

reports (shown in Table 2) are incomplete. The logical conclusion is that actual total production of livestock products is much greater than recorded by census data in developing countries.

A missing component in effective use of the present livestock herds and flocks is the development of successful methods for collection and delivery of livestock products to the urban centers of consumption. This objective must include realization of economic rewards to the livestock farmers and herders of each nation. Greatly improved livestock management practices must become economically rewarding both to farmers and herders, as well as to the national governments concerned with meeting urban food needs. This requires more efficient livestock management combined with equitable "farm gate" pricing for livestock products.

E. The Extent of Existing Imports of Meat Animals and Meats in Tropical and Subtropical Regions

The extent of current market demands for both meats and dairy products is indicated by actual national imports to meet market demands.

The average regional imports of meat animals and meats are presented in Table 4 for 1978 and 1980. The greatest increases in meat animals and meats occurred in the developing countries of Africa and Asia. For those regions, the increases greatly exceed the 2½ to 3% per year growth in human population. These growing market demands are not satisfied by domestic production; and nations are meeting these growing demands by exhausting foreign exchange reserves by means of national borrowing. The substitution of imports by domestic production will become possible through improved management of existing herds and flocks. This should produce larger offtakes from the additional feed resources on present land acreages, using superior management.

Table 4. Total Imports of Meat Animals and Meats.
(Data from 1980 FAO Trade Yearbook)

Commodities	Thousands of Dollars					
	Africa		Latin America & Caribbean		Asia	
	1978	1980	1978	1980	1978	1980
A. Live Meat Animals	$459,531	$593,155	$245,360	$228,429	$796,230	$1,169,771
% Change		+27%		-7%		+47%
B. All Meats	$431,407	$653,088	$575,771	$723,497	$1,590,395	$3,607,111
% Change		+51%		+26%		+39%
C. Animal Oils & Fats (excluding butter)	$185,601	$249,304	$256,586	$293,113	$357,966	$403,027
% Change		+34%		+14%		+13%

NOTE : These imports constitute market demands not satisfied by domestic production.

Table 5. Total Imports of Dairy Products by Developing Countries

	Thousands of Dollars 1978	1980	Percent Increase
A. All forms of Milk (fresh, evaporated, condensed, powder)			
Africa	411,599	961,251	+134%
Latin America	277,889	772,125	+178%
Asia*	581,485	1,371,565	+136%
B. Butter			
Africa	110,580	227,052	+105%
Latin America	72,895	79,835	+ 10%
Asia*	165,528	455,829	+175%
C. Cheese			
Africa	44,809	109,037	+143%
Latin America	41,237	157,429	+282%
Asia*	192,840	497,240	+158%

*Excluding China and Japan.

G. The General Status of the Livestock Sector in the Farming Systems of Representative Countries

The agricultural resources now available in representative developing countries are summarized in Table 6. These data report the areas of permanent grazing lands, their relation to arable lands, the numbers of ruminant livestock, the numbers of farm family units for each nation, and the present number of livestock units per farm family unit. It is obvious that there are great differences between countries at the present time. These data do not reveal the potential for economically rewarding livestock enterprises, since the national and international focus has traditionally been directed to crop production, rather than to livestock production.

A pervading weakness in present farming systems is failure to utilize the by-products and crop residues from crops on arable lands, as an important feed resource for ruminant livestock, to supplement native grazing land forages.

These data show increases in family livestock, which is the traditional situation. This report deals with beneficial changes made possible by application of proven methods of livestock management.

The livestock enterprises in farming systems contribute to family welfare in the following ways.

1. They provide the principal means of utilizing non-arable permanent grazing lands. More than 2/3 of the total agricultural lands of the tropics and subtropics now harvested by livestock would otherwise contribute very little to the support of man.

Table 6. Ruminant Livestock in Farming Systems of Representative Developing Countries (1980 FAO Data)

Countries	Total Area of Permanent Grazing Lands (000 Ha.)	Ratio of Grazing Land to Arable Land	Ruminant[1] Livestock: Numbers of Animal Units (000)	Estimated[2] Number of Farm Family Units (000)	Livestock Animal Units per Family Unit (Total)
AFRICA					
Botswana	44,000	32.4 to 1	3,630	51	71
Cameroon	8,300	1.2 to 1	3,812	527	7
Ghana	3,480	10.0 to 1	1,660	366	5
Kenya	3,770	2.1 to 1	13,220	802	16
Liberia	240	1.0 to 1	114	79	1
Malawi	1,840	0.8 to 1	990	383	3
Mali	30,000	14.7 to 1	7,240	517	14
Niger	9,668	3.0 to 1	5,435	241	23
Senegal	5,700	1.4 to 1	3,391	290	12
Sudan	56,000	3.2 to 1	28,180	720	39
Swaziland	1,250	8.3 to 1	710	31	23
Tanzania	35,000	10.9 to 1	16,840	988	17
Togo	200	0.1 to 1	567	125	5
Upper Volta	10,000	2.4 to 1	3,610	498	7
Zaire	9,221	4.4 to 1	1,856	1,476	1
Zimbabwe	4,856	2.0 to 1	6,940	237	29
NORTH AFRICA & MIDDLE EAST					
Egypt	0	0	5,297	1,000	5
Jordan	100	0.1 to 1	304	33	9
Lebanon	10	Negligible	242	14	17
Morocco	12,500	1.7 to 1	7,920	456	17
Syria	8,274	1.6 to 1	2,456	175	14
Tunisia	2,550	1.0 to 1	2,262	103	22
Yemen	7,000	4.6 to 1	3,462	205	17

(1) Animal Units: 1 cow or buffalo = 1 Animal Unit (A.U.)
5 sheep or 5 goats = 1 A.U.
1 camel = 2 A.U.

(2) Family units estimated from "Economically Active Agricultural Population" (FAO Data) and the assumption that 6 adults constitutes 1 Family Unit.

Table 6 continued.

Countries	Total Area of Permanent Grazing Lands (000 Ha.)	Ratio of Grazing Land to Arable Land	Ruminant[1] Livestock: Numbers of Animal Units (000)	Estimated[2] Number of Farm Family Units (000)	Livestock Animal Units per Family Unit (Total)
ASIA					
Bangladesh	600	0.1 to 1	35,682	4,219	8
Burma	361	0.03 to 1	9,468	1,216	8
Indonesia	12,000	0.8 to 1	11,097	5,090	2
Nepal	1,700	0.7 to 1	11,968	1,044	11
Pakistan	5,000	0.3 to 1	38,355	1,989	19
Philippines	1,000	0.2 to 1	5,220	1,350	4
Sri Lanka	439	0.4 to 1	2,564	459	6
Thailand	308	0.2 to 1	10,368	2,681	4
LATIN AMERICA & CARIBBEAN					
Bolivia	27,100	8.4 to 1	6,330	151	42
Costa Rica	1,358	5.5 to 1	2,072	43	48
Dominican Republic	1,500	1.7 to 1	2,235	146	15
Ecuador	2,560	1.5 to 1	3,037	189	16
El Salvador	610	1.2 to 1	1,371	126	11
Guatemala	880	0.6 to 1	1,710	202	8
Guyana	999	2.7 to 1	316	11	29
Haiti	510	0.9 to 1	1,277	323	4
Honduras	3,400	1.3 to 1	1,803	113	16
Jamaica	210	1.0 to 1	365	26	14
Nicaragua	3,400	2.5 to 1	2,848	58	49
Panama	1,161	2.6 to 1	1,424	37	38
Paraguay	15,200	15.4 to 1	5,313	80	66
Peru	27,120	8.7 to 1	7,482	326	23

2. Livestock are important contributors to subsistence of family units and rural villages, by supplying meats and milk products, which not only are important foodstuffs, but also contribute the essential dietary needs for animal proteins.

3. The living animal populations constitute an economic reserve, controlled by the farm families, to exchange for other necessities, by either sales to urban markets, or by barter to crop growers (for cereal grains, legume grains, oil seeds, etc.).

4. Cattle (oxen) and buffaloes are the major source of animal power in farming systems. Animal power is a practical method of meeting power needs for land tillage, for crop culture, and transport of farm inputs, harvesting and outputs of the farm. The initial transport to markets of crop products is accomplished by use of oxcarts. Estimates in Asia have been made that a team of oxen will augment at least 4 to 8 times as much power as unit of human labor alone. In fact, much of the farm power needs can not be made by human labor; particularly tillage of heavy soils.

   Draft animals may be grown on the farm; they may be adequately fed with farm forages; and provide independence of petroleum powered machinery.

5. The growing market demands for meats and milk products in developing countries require substantial increases in rural production of these substances in each country. Not only do

human diets require that 10 to 15% of the total protein be supplied by animal proteins for balanced nutrition, but meats and milk products already are in growing demand by urban populations as standard foodstuffs.

II. Productive Management of Cattle and Buffaloes by Farmers and Herders in the Tropics and Subtropics

A. The Elements of Management

The management of these large ruminants has certain features that apply to all sectors of the family livestock population; but each sector has specific management practices that should be applied for relatively effective results, at low cost. The common components are: (1) adequate nutritious feeds and feeding practices on a year-round basis; (2) adequate supplies of clean stock water readily accessible to meet all livestock needs; and (3) prevention of livestock diseases and parasites by timely action of the family leader responsible for decisions on animal management. These aspects of good management will be discussed for each livestock sector in the following discussion.

There are three major groups or sectors of the family (or village, or tribal) large ruminant herds. These are:

1. The breeding group of female animals;
2. The growing young stock from time of weaning, until maturity; and
3. The mature group from about 2 years old until marketed (both sexes all ages).

The breeding group of females is the most important sector of total livestock herds under family control. Successful management of the breeding females of cattle and buffaloes should result in reproduction with minimum losses, to increase the numbers of "matures" for market, and, with the same dams, to produce the milk for family subsistence, and for barter with other villages; or for delivery to local systems of milk collection and delivery to urban areas.

4. Animal Power.

B. Management of the Breeding Group of Livestock

1. Planned benefits

The more productive management should achieve the following goals, by skillful timing of practices, to utilize fully the available feeds and water resources, without degrading the lands. This type of management usually involves very little in additional costs, but focuses on the following objectives:

(1) Increasing the conception rate of all females to about 85%, or greater per year;

(2) Increasing the successful birth of live healthy calves to 85%, or more of the bred females;

(3) Reducing the mortality of suckling calves to 10% or less of total;

(4) Production of strong healthy calves at time of weaning, that are capable of sustained growth on nutritious forages.

2. Controlling size of breeding group

It is essential that the number of breeding females in the breeding herd be no greater than the available feed resources. There is no profit to the family from intermittent starvation of livestock, particularly of the breeding herd. The group of cows included in the breeding herd must be selected to provide those animals to be managed for the greatest productivity, so as to most effectively utilize available feeds and water to produce offspring. Cows that fail to reproduce under good management should be moved promptly to the group eligible for market. Their replacement by young heifers of breeding age should be the offspring of the more productive cows in the cow breeding herd.

3. Principles of heredity

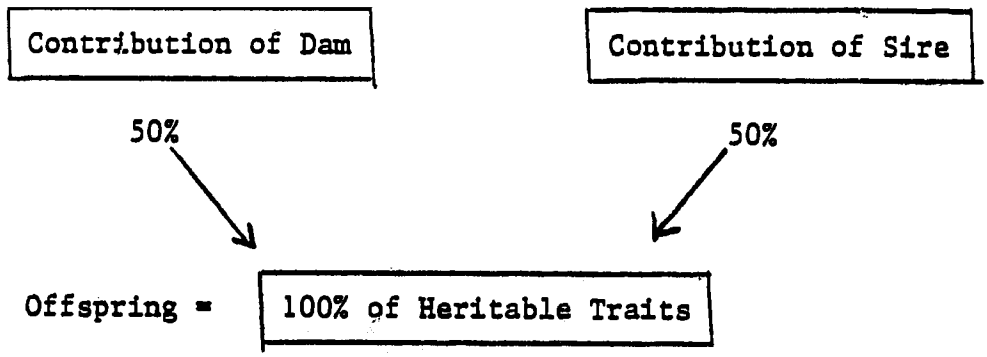
Maintenance and improvement of the cow breeding herd, requires selection of the young replacements that show greatest promise of productivity on the basis of performance of their respective dams. Livestock improvement in indigenous cattle and buffaloes should be controlled by the leader of each family unit. The full utilization of the heritable traits for tolerance of heat and drought, for effective utilization of available feedstuffs, and for tolerance of endemic diseases and parasite pests is one aspect of effective livestock management. Those animals that are most productive under local conditions should constitute the breeding herd of cows.

The livestock manager of the family herd may foster improvement by both selection of outstanding hereditary traits in cows, combined with equally rigorous selection of the herd bulls. Selected males to serve as herd sires should have desirable physical traits, but also be the offspring of strong, productive cows. All bull calves not selected to be herd sires must be castrated before one year of age, or otherwise be emasculated, to prevent any breeding. These castrated males should be moved to the "mature" group for market, or designated as future work oxen. Not more than one selected herd sire is needed for the breeding herd; and all mating with selected cows should be limited to the season that will result in calf delivery when feed supplies are most effective. The common practice of castrating all males selected to become work animals is appropriate.

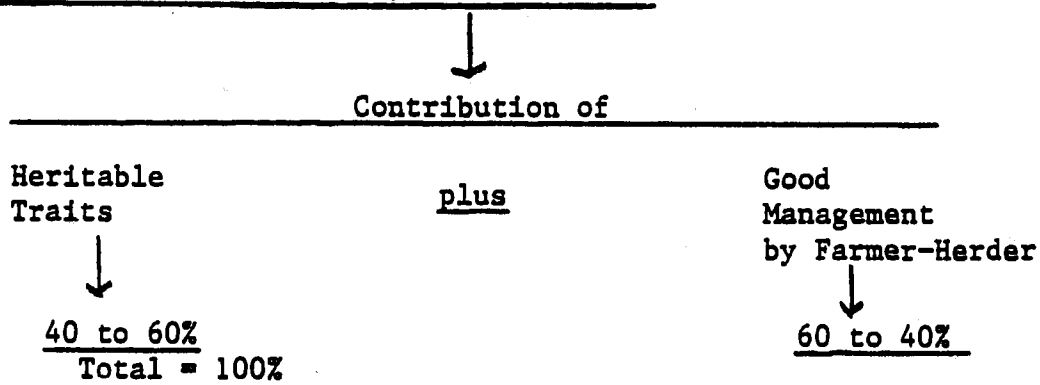
The principles of heredity are shown in the following chart. This chart also indicates the relation between hereditary traits and the effects of good management responsible for productivity.

LIVESTOCK IMPROVEMENT

A. Inheritance of Physical Traits (Appearance) and Productivity



B. Physical Vigor and Productivity of Each Animal



Vigorous productive livestock depend on the combined contribution of heritable traits, plus productive (profitable) management by the farmer-herder.

There are substantial opportunities in family livestock herds for rapid improvement in productivity (and profitability) without costly inputs. Managerial skill is required to more fully utilize the capabilities of the indigenous livestock now present in family herds.

4. Feeds and feeding of cows in the breeding group

The breeding cow herd should be no larger than anticipated supply of feeds on a year-round basis. Yearly feed sources may include a feasible combination of (a) native pasture or rangeland in the season of plant growth; (b) any seeded pastures; (c) crop by-products from cereal grains (millet, sorghum, maize) whose stalks and green leaves are harvested and stored after grain harvest; (d) tops and vines of food grain legumes (peas, beans, groundnuts, etc.) after seed harvest; and (e) planted forage crops grown in rotations on arable lands for soil improvement. These feed sources must also support growing young stock, as well as the combined herd of marketable livestock consisting of non-breeding females, all males not selected as herd sires, and all other animals in excess of available feed supplies. The average feed requirements of breeding cows are as follows*:

Per cow in breeding herd, for full year

- Stored dry forages: 2,700 kg for year
- Average daily ration: 8.0 kg

When green crop feed is used, consider that 4 kilograms of fresh weight equals 1 kilogram of dry forage. Also, 3 kilograms of silage equals 1 kilogram of dry weight.

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*For more details see Technical Bulletin No. 27, "The Production, Storage and Feeding of Herbaceous Forages to Support Ruminant Livestock in Developing Countries," issued by Office of Agriculture, Bureau of Science & Technology, Agency for International Development, Washington, DC.

It is vital for successful gestation, as well as for milk flow of lactating cows, that about ½ of the forage feed be supplied by forage legumes from pastures, or as tops and vines of leguminous crops (peas, beans, groundnuts, etc.), to ensure enough feed protein and minerals for a balanced ration.

For larger animals, particularly buffaloes, the daily feed requirement may be about 20% greater; totaling 9.5 kg of dry forage per day.

The yearly feed requirement to be met by supplying stored dry forage or equivalent may be calculated on the basis of the number of days when the cows do not have access to adequate permanent pastures or grazing land.

An additional feed allowance should be provided for lactating cows, with higher daily milk output. This may be as great as 30% more feed to sustain higher milk flow. Without this additional feed, the milk flow will rapidly decline.

5. Management of lactating cows that are nursing calves

In many regions, calves are allowd to nurse their dams during the day, but are separated during the night. For the morning milking, the family takes 1/2 to 3/4 of the milk, and allows the calf access to the remainder. This is a doubtful arrangement in which the calf may be chronically undernourished, and makes unsatisfactory growth, or does not survive. Unless the dam is a strong milker, it is most desirable to allow the calf the full milk yield. Only for higher milk producing cows is this automatic limitation of milk for the calf a satisfactory practice. Thus, only the milk from high producer cows should be taken for family subsistence or for marketable milk.

It should be recognized that milk production by cows requires additional feed protein and minerals from feeds than is needed for maintenance of marketable mature cattle. Unless the more nutritious feeds are provided in the daily ration, milk production rapidly declines, and will not again be elevated until the following lactation occurs. An adequate feed ration must be continuous for sustained productivity of the breeding herd.

6. Water requirements for the breeding group

Although stock water is generally recognized as a necessity for livestock production, the special requirements for the breeding herd often are not met. The non-lactating breeding animals must have a minimum of one adequate watering each day as a general maintenance practice; but during the latter part of gestation period, abundant water must be provided twice daily during the dry season. For milk producing cows, water must be provided twice daily. Milk is about 87% water; and failure to water adequately will promptly and permanently reduce milk flow. Where water supplies cannot be augmented to meet dairy animal needs, the number of dairy animals must be reduced to those that can be adequately watered daily. Second priority on water supplies must be given to growing young stock; and the lowest priority to the herd of "matures" being managed for market.

7. Selection of Herd Sires

A more adequate exploitation of the hereditary traits of indigenous livestock requires a sound method of selecting herd sires. (See chart on page 17.) One-half of hereditary traits are supplied by the sire, and the other half by the dam. By selection of vigorous, apparently productive dams and sires, the offspring (calves) should benefit from desirable inheritance from both parents.

The practice of castrating or emasculating all male calves, except the outstanding individual males, will largely eliminate the indiscriminate mating that occurs in local herds. The selected males for development as sires should be identified during the period following weaning, and confirmed at one to two years of age. These young bulls should reach breeding age when about two to three years old; and they should be mated with selected cows. The selected cows may be those females that have already produced strong calves of desired conformation, and that are obviously strong milkers. If the selected male (sire) was produced by a dam with a strong performance record, the superior traits of the sire should be evident in his calves. The full expression of those desired traits will be made possible by good feeds and feeding practices, accompanied by standard methods of preventing diseases and controlling parasitic pests.

8. Possible danger of inbreeding

To prevent any undesirable inbreeding, such sires should be replaced by newly selected bulls, after three years of breeding. A convenient exchange with a bull from another village, where the same system of selection is followed, would be feasible in many instances, without additional cost. The possible hazard of undesirable inbreeding will probably be very small in the first 10 years of selecting from the local herd. To protect against accidental loss of the herd sire, a younger replacement may be added to the herd.

The above system should quickly replace the unproductive practice of allowing all males to mate indiscriminately with all cows in the herd. Progressive animal improvement is impossible by uncontrolled mating.

9. Special considerations for Water Buffaloes

Buffaloes are most abundant in the Asiatic countries. The cows are important sources of milk, used mostly for family subsistence. The bulls are commonly used as draft animals for field work on rice production, and for local transport.

Buffalo cows are allowed free grazing on natural pasture in the daytime, including waste lands and road sides. Established pastures have proven profitable where lands are available. Feeds include forage crops cut and fed green, and some by-products from milling rice. Rice straw and chaff is fed; but no rice hulls that have very low digestibility.

Lactating cows may produce four to five liters of milk daily. Buffalo milk is quite rich in butter fat. Much of the milk is consumed by local families and villages.

Calf mortality is reported to be very high, as a result of inadequate sharing of the daily milk for the nursing calf to meet its growth requirements.

Water buffaloes are social animals; particularly the cows. The presence of each cow's calf is said to be important for stimulating milk flow by the dam. The bulls used for animal power are managed as individuals but are strongly attached to the human manager.

Buffaloes are adversely affected by restricting their access to water. Daily wallowing in water sources is widely practiced in the Far East. It is reported that wallowing plays a crucial role in the buffalo physiological mechanism for reducing the effects of high temperatures.

For reproduction, the first calving of young female buffaloes is about 45 months of age. Subsequent breeding may require some five to six months interval before conception takes place. Conception is affected by the adequacy of feed quality, as well as total amounts of feeds.

C. Management of Young Ruminants; from Weaning to 2 Years of Age

1. Weaning

Weaning is a sensitive period for all nursing calves. The change from mother's milk to sole dependence on forage may be eased when calves nurse their mothers during the daytime (although separated at night), since the calves gradually learn to feed on forage when accompanying the mother. When the calf reaches three to four months of age, and the access to mother's milk has produced normal development of the calf, a gradual transition may be made by allowing evening nursing on alternate days for a limited period.

It is important that the initial placement of weaned calves be on nutritious pasture, along with continuous access to water. This will minimize the shock that may severely damage newly weaned calves.

The temptation to prematurely enforce weaning before the calves are sufficiently developed should be avoided. The productivity of the entire livestock herd may be severely damaged by unwise management of weaner calves that are actually the basis for reproduction and growth of the herd. A satisfactory survival rate of weaner calves during the initial separation from the dam is necessary for the total livestock enterprise. Weakened calves have high incidence of disease and high death rates; and, if survival is difficult, the subsequent growth will be slow. Premature weaning to provide

the family with milk is self-defeating. The calf has much greater value than the additional milk that may be provided.

2. The prevention of calf diseases

The prevention of calf diseases and protection from parasitic pests should follow the principles outlined in the following section (p. 30). Separation of the young stock from other livestock is desirable; but effective vaccination for prevention of common diseases should follow the recommendations of the veterinary service of the nation.

In providing suitable forage feed on pastures, the younger stock should be given priority of grazing ahead of more mature stock that follows. Calves up to one year of age require highly digestible forage, if they are to make satisfactory growth. Periods of feed shortage, and inadequate stock water are highly undesirable. Older stock are somehwat more tolerant of inadequate feed an water, than young stock. If feasible, it would be useful to make two or more groups of young stock. The weaner calves should be given preference on feed for the first few months after weaning. Calves that appear weak or unthrifty should be given separate attention until they recover.

3. Young stock from six months to two years of age

All males should be castrated or emasculated, except the few outstanding bull calves identified as possible candidates to be saved for service as herd sires. This treatment should occur before age of one year, at the season when the national veterinary service recommends it.

As the calves grow, they will require additional feed, particularly in the "dry season" when harvested and stored dry forage is needed to support continued growth. At two years of age, the average feed ration per day may

amount to 4 kilograms of dry forage, or its equivalent in forage cut and fed green, silage, or mixed grass and legume hay. During the grazing season, the available standing forage should support steady growth. The acceptable goal of producing mature meat animals for market when animals reach three or four years of age is feasible when feed supply remains adequate.

4. Selection of females for breeding

Female calves should be selected from the young stock at about two years of age, for replacements in the breeding group of cows. These should be strong animals, capable of being bred for calving at three years. All other heifers should be promoted to the mature group at two years of age, for finishing and marketing.

In addition, suitable castrated males should be selected at about two years of age for training in the duties of animal power. These young males are not yet ready for full-scale field work or transport; but training at this age is desirable. Actually some limited work may be performed as part of training (see later section on animal power).

D. Management of the "Mature" Group of Large Ruminants

1. Available feed supplies

This group may include all animals above three years of age--all males, and those cows not suited for breeding (barren, or unthrifty), or that are excess animals beyond the permanent feed supply. In many regions with extended "dry seasons" of five months or longer, the number of stock is greater than the available pasturage or harvested feed. Prompt marketing of all older and unthrifty animals should take place at the earliest opportunity, to reduce the number of mature animals to be fed. There is abundant evidence that overstocking beyond available feed supplies causes live weight losses, and the disposal of excess animals is necessary so that those remaining

are adequately fed. This a more profitable system of management. The practical goal is to bring the "mature" animals to market at about three to four years of age. Actually, it has proven feasible to bring animals to marketable state in three years of sufficient management.

The greatest emphasis must be placed on providing sufficient feed at all seasons to prevent loss of weight. To achieve this goal of preventing starvation at any season, there is the requirement that the year-round feed supply be estimated to include all grazing land that may be used, all forages available as by-products of grain crops, forages from legume crop vines and tops salvaged after seed harvest, any forages grown in rotation with crops on arable lands and available as hay, silage, or fresh cut. It is feasible to estimate the forages that are available from such sources, expressed in terms of total dry forage. On the basis of such yearly estimates, the manager may determine the number of animals that can be adequately fed through the entire year. Any animals in excess of those that can be fed adequately should be marketed as soon as possible.*

2. Adjusting livestock numbers to available feed supplies and water

The practice in many regions of allowing animals to starve for any period is wasteful and self-defeating. For instance, mature stock that do not become marketable until five, six or seven years of age because of recurring feed shortages are actuall losing income for the producers. Sustained adequate feeding for all seasons should bring livestock to marketable state at three to four years of age; thus conserving the extra feed otherwise utilized to compensate for dry seasons when little or no feed is available and losses in weight occur.

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*For additional information on feed requirements, see Technical Bulletin No. 27, "The Production, Storage and Feeding of Herbaceous Forages to Support Ruminant Livestock in Developing Countries of the Tropics and Subtropics."

As noted in previous sections, all mature livestock must have adequate water on a daily basis, if feeds are to be efficiently used by these animals. They may survive under inadequate watering, but this practice wastes feed, and prevents livestock weight gains.

E. Managing Work Animals--Oxen and Buffaloes

1. Feeding and training work animals

As noted in preceding sections, animals selected for animal power by rural families may be chosen from the young stock group at about two years of age. Mostly these will be males, castrated, and having strong bodies. The additional factor of temperament must be determined by their responsiveness to training on carts, plows, and other tillage implements. The role of animal power in support of agriculture is rapidly increasing, and trained oxen should have good market value. Animal power is a practical substitute for machinery that must be petroleum powered. Animal power is far less expensive than petroleum powered machinery and vehicles; the animals may be grown by the family at low cost; and the feeds necessary for good performance are available on the farm (irrespective of size of farm). The training of oxen and bullocks may be accomplished satisfactorily in seasons when human field labor is not required. A well-trained, strong team may satisfactorily replace two to six human laborers. Also, this power permits farming heavier soils than can be effectively tilled by human labor.

2. Feeding work animals

Feeding work animals must be handled as a special activity. Beginning with young animals to be trained, regular feeding and watering is essential. These animals may be stall-fed, or kept loose in fenced pens, with a feeding rack and drinking water.

Freedom of movement is necessary; and adequate water must be provided. All rationed feed must be supplied when animals are penned.

3. Maintenance ration

When not actively working, a maintenance ration of about 6 kilograms of dry forage per day is usually sufficient to maintain animal weight.* When actively working, the feed supply must be increased about 50%, including at least 2 kilograms of dry matter per day that has substantial protein content. Tops and vines of peas, beans, groundnuts, etc. are suitable protein feeds. However, any mixed grass-legume hay, or green cut mixed forage may be used. The protein supplement is needed to maintain strength of the work animal. Should loss in line weight occur when the animal is being worked, this is a strong indication of inadequate feed rations.

4. Protecting health of work animals

The work animal is a valuable property. The health of these animals should be protected by vaccinations and other practices recommended by the national veterinary service.

5. The method of yoking work animals, and the kinds of hitches for field machinery are important. Improper or wasteful yokes and hitches may greatly reduce the amount of work that can be performed. The skillful manager avoids excessive demands on work required of animals.

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*About 4 kilos of fresh green feed, or 3 kilos of silage is the equivalent of 1 kilo of dry forage.

F. Mineral Nutrient Requirements of Ruminant Livestock

1. Salt is a continuing need of all ruminant livestock: (a) for reproduction, (b) for production of healthy offspring, (c) for abundant production of milk, (d) for growth of young stock, (e) for maintenance and weight additions of mature stock being maintained for market, and (f) for resistance to livestock diseases and parasitic pests. It is an uncommon situation for animals subsisting on forages to obtain sufficient salt in those forages to meet livestock nutritional needs. Thus, regular provision of salt in adequate amounts is essential for profitable livestock production.

2. It is less commonly understood by livestock managers, that forages may be seriously deficient in other minerals. Phosphorus is widely deficient in many regions. In addition to phosphorus deficiencies, which has been widely observed in ruminant livestock, preliminary evidence from localities in the tropics and subtropics indicate that one or more of the following mineral deficiencies may be adversely affecting livestock health and production:

Magnesium

Sulfur

Cobalt

Iodine

Iron

Manganese

Molybdenum

Selenium

Zinc.

As research confirms local specific mineral deficiencies, prompt correction will provide prompt benefits.

3. Some of these deficiencies have already been identified in specific regions by animal nutritionists and veterinarians. In those regions mineralized salt containing the identified deficient minerals is recommended. Research is needed to identify such regional significant deficiencies. The possibility that mineral deficiencies are causing unthriftiness, weight losses, unusual susceptibility to diseases and parasitic pests, etc. should be diligently studied to determine causes, and the best means of correcting such deficiencies in feeds available to those livestock.

G. Prevention of livestock Diseases and Parasites

Much can be done by managers* of livestock by family and village leaders to protect their herds and flocks from animal diseases and such parasites as ticks. The following practices are feasible and effective.

The managers of livestock flocks and herds should serve as the major factor in prevention of diseases. The following common sense management practices describe the various ways of protection against serious disease losses in all domestic livestock:

1. Malnutrition of livestock makes animals more susceptible to infectious diseases. (a) Malnutrition may result from inadequate feed to meet animal needs, particularly in "dry seasons" when plant growth ceases. Efforts must be made to balance available feeds against the number of animals in the herd or flock. (b) At some seasons, standing forages (pastures and rangelands) may be seriously deficient in protein content. This deficiency can be predicted, and corrective action taken. (c) The available feeds may be notably deficient in available essential minerals for livestock health.

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*The livestock manager is the person with responsibility for decision making in all aspects of livestock management.

These deficiencies are generally common in a region and may be predicted by studies by livestock specialists of the region who offer recommendations on mineral supplements.

2. Seasonal husbandry practices should adjust to the most favorable times for mating, so that calves and kids will be borne when forage is adequate to sustain milk flow by the dams. This means control of mating, by exclusion of sires at unfavorable periods. Also, young stock should be given access to sufficient feed (after weaning for some months or a year) so they are not expected to compete with older animals for feed and water. Deprivation of young stock increases susceptibility to diseases.

3. Clean, unpolluted stock water. Inadequate or polluted stock water places stress on all livestock, and makes them more susceptible to infectious diseases and may be a direct source of disease causing agents. Water must be available within reach of livestock feed sources. Young stock and lactating dams, as well as sheep and goats, have more need for readily available stock water than the more mature cattle. The accessibility of water may be a major factor in choice of livestock type suitable for a specific region.

4. Temporary care of unthrifty or sick animals is essential to assist in recovery, or observation as to possible disaase. If disease becomes evident in a herd or flock, segregation and isolation of unthrifty or sick animals will prevent spread throughout the herd or flock.

5. Diseased or sick animals should not be slaughtered for meat, or marketed. Some livestock diseases are deadly to people. Seek advice of a veterinarian if dangerous disease is suspected.

6. Prompt diagnosis of infectious diseases should be sought from a qualified veterinarian; and the specialist's recommendations should be followed to minimize animal losses.

7. Prompt burial or burning of all dead animals is a responsibility of the manager. Eliminate the possibility of wild animals feeding on the carcass, and spreading infectious diseases; or dissemination by wind or water.

8. Compliance with the established animal health control regime, as to vaccinations and other treatments, such as tests and quarantine should be followed as promptly as possible, to avoid needless losses of livestock. The livestock specialists of the national government should advise on such programs.

9. Spread of infectious diseases from herd to herd, is a constant hazard for livestock being trekked to market. Trekking* exposes animals to parasites that transmit disease, as well as transmission of infectious diseases from local infected herds to the moving herd or flock. To the extent feasible, it is desirable to exclude contact of family flocks with all other livestock.

10. The livestock market may be a source of infectious diseases. Animals purchased in markets or from other flocks should be held in local isolation long enough to provide assurance that they are not infected with any contagious disease, before being intermingled with local livestock.

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*Trekking - driven or trailed to market, or to distant grazing lands.

2. Adjustments for body weights

The body size of small ruminants is an advantage in providing meat for the producing family. Without any refrigeration, a large animal (cow or buffalo) will not be slaughtered for local consumption since the excess meat cannot be saved. The carcass of an individual sheep or goat can readily be consumed within a family or village. Sacrificing kids or lambs for meat is often practiced for special occasions, thus permitting the use of the mother (dams) for family milk production.

3. Adaptation to limited lands

Because of the smaller size of sheep and goats, they are feasible for situations of limited farm size (for arable crops), and limited grazing areas of browse. The effective use of forages by small holders is adapted to livestock enterprises based on small ruminants.

4. Unique values of sheep and goats

Small ruminants have a short period of development--usually about a year from birth to full maturity. This permits more rapid adjustments in the agricultural system caused by climatic changes, market opportunities, unforseen constraints, etc.

5. Although sheep and goats may be trekked (walked) to market, the general trend is to serve markets in nearby urban areas or sizeable villages. The producing family is generally in control of such movement.

6. Adjustment of goat numbers to available feed

Although goats are sometimes blamed for destruction of vegetative plant cover in regions of limited rainfall, this is not a weakness of the goat

species. Rather, it is a failure of the farmers and herders to maintain supportable stocking rates, by reducing numbers of goats to the feeds available. The aggressive foraging habits of goats, and their capability for thriving on browse of brush, small trees and weeds, permits them to thrive where large ruminants are unsuccessful. Goats excel in milk production when well managed, as well as in meat production. Goats are amenable to human control, and appear to be less susceptible to local disease and parasites than large ruminants.

C. Managing Sheep and Goats

1. Management of the breeding group

a. Feed requirements per mature animal. When subsisting on dry harvested forage (hay, or dry chopped stalks and leaves of harvested grain crops, etc.), the maintenance ration should equal 1.0 kg of dry forage per day. For lactating females, an additional protein-rich feed must be added to support milk flow, as follows:

Green legume forage - 1.4 kg/day, or

Dry legume forage - 0.4 kg/day, or

Green mixed grass/legume forage - 3.0 kg/day, or

Dry mixed grass/legume forage - 0.8 kg/day.

NOTE: These are average values and adjustments are required for larger animals. For example, where the grazing season is about 200 days per year, and harvested feed is provided for 165 days, the total harvested feed required per mature sheep or goat will be about 165 times the daily requirement.

The feed supplying capacity of the grazing lands must be estimated separately to determine the number of sheep and/or goats that can be adequately sustained during the grazing season. The grazing lands must not be overstocked. Each grazed area (whether for browse or consumption of forage grasses and legumes) must be rested for a portion of the growing season to permit recovery of the grazed species. Every system of grazing, and the selected stocking rates must avoid intensity of grazing that destroys vegetative cover. Such controlled protection will actually increase livestock take-off, above that of uncontrolled or unregulated grazing. The economic value of grazing land is the product of human management to maintain a balance between grazing flocks and vegetative growth.

It should be recognized that milk producing females (sheep or goats) have substantially greater feed requirements than those not lactating. The greater the milk flow, the greater is the need for feed supplement above simple maintenance. This supplement should be a high protein forage such as vines and tops of food grain legumes, or mixed grass/legume crops grown as soil improving crops on arable lands. Such higher protein feed should be supplied for three weeks or more before giving birth to the young lambs or kids, to insure strong offspring. The high protein supplement should be continued throughout the period of lactation, to produce rapid growth of young stock, and to maintain milk flow.

b. Stock water requirements. Sheep and goats must be adequately watered each day; and milk producing females should be watered twice daily if milk flow is to be maintained. This requirement is

feasible to satisfy, since these small ruminants are maintained near villages by the family owners. The important point is that stock water supplies must be accepted as necessary for effective production. For regions having a dry season with little or no rainfall for more than two months, the establishment of wells or other water sources for livestock water in dry periods is fully as important as adequate feed.

Lambs and kids of the breeding flock must have become accustomed to watering before they are ready for weaning. Also, these nursing young should be learning from their mothers the consumption of forages as a supplement to milk.

c. Breeding for flock improvement. Flock improvement is feasible in every family production unit. The manager should identify those dams that appear vigorous, and that frequently have multiple births. When the multiple lambs or kids grow rapidly, they have the hereditary capability of thriving on the milk flow of their mothers. Such outstanding dams should receive special attention in feeding and watering, and general supervision. The young females from such mothers should be the group from which selection is made of replacements for old or weak females in the current breeding flock. Rejected young females may be marketed.

The young males from such strong mothers should be the group from which future sires should be selected for the family flock. Final selection of sires may be made at about one year of age, and all other males should be castrated, or marketed (or slaughtered).

Careful selection of strong, well-formed males and females, combined with controlled mating, constitutes the method for sustained flock improvement, to more fully utilize the local situation as to feed, water, and adaptation to the environment. Sustained breeding programs of this sort are feasible for any family unit; and in fact, this has been the means of developing superior breeds in various regions of the tropics.

Mating should be managed so that birth of kids or lambs will occur about two to four weeks after regrowth of pastures and grazing lands that will provide abundant feed. Harvested forages should be reserved for feeding in seasons of low rainfall.

2. Weaning of kids and lambs, and growth to maturity

In general, it is not practical to extract milk from lactating sheep or goats, while these dams are nursing kids or lambs. Sheep milk and goat milk are nutritious human foods and may contribute strongly to family subsistence. In the event that the dam can bring her offspring to weaning before her milk flow ceases, this provides milk for the family. Also, when kids or lambs are sacrificed for meat, these dams may contribute milk to the family. Early weaning should be limited to those dams that are strong milk producers and foster rapid grwoth of kids and lambs. When these nursing offspring begin to feed on nutritious green forage, they may be weaned early with safety.

The important point is that the current crop of kids or lambs must not be retarded by unwise management. These kids and lambs are the principal means of maintaining the family flock, and of improving its productivity.

The weaned offspring should be given access to the most nutritious forage available; and such pasturages should be supplemented with harvested feed as necessary for sustained continued growth.

3. Yearly rejuvenation of flocks

The mature animals of each flock may include all castrated males not reserved as flock sires, and all weak or unproductive females not selected for reproduction. These "matures" should be marketed or slaughtered for family subsistence as soon as practical, so as to save the feeds otherwise consumed. Protection of the breeding group of the flock should have the highest priority in accessibility to feeds and water. Castration of all males not selected for flock sires is necessary to avoid indiscriminate mating with the breeding group of females.

The dams in the breeding group that have been most productive and are apparently strong milk producers when well fed should be retained as long as they are productive. In general, barren dams, or those that appear unthrifty, should be replaced by young females that are offspring of highly productive dams. This process of rejuvenation is a continuing practice to increase productivity.

4. Mineral nutrition of sheep and goats

There is a general belief that goats and sheep are less subject to those deficiencies in mineral nutrients that affect cattle. This has not been adequately proven by research, but it seems plausible because of the widespread feeding of small ruminants on browse. The tender shoots and leaves of perennial brush, trees and plants other than grasses and legumes may have higher content of minerals essential for livestock, since they are deep rooted

and extract minerals in deeper horizons of soils and lands. These unique sources of feeds for sheep and goats may provide some assurance for higher content of minerals in those feeds.

However, it is necessary for sheep and goats to have adequate amounts of salt, and to meet the same requirements as cattle for phosphorus, as well as such mineral nutrients as magnesium, iodine, cobalt, etc. Wherever deficiencies in specific mineral nutrient supplies are determined for cattle, it is prudent to assume the sheep and goats are likely to be suffering from the same deficiencies.

5. Prevention or control of diseases and parasites of sheep and goats

The standard practices presented in Section II-G of this paper are fully applicable to sheep and goats. The farmers and herders have a major responsibility for protection of the health of the flocks, which they manage. Very substantial benefits will be realized from such practices. These practices are the first line of defense against disastrous epidemics when these occur.