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ECONOMIC CONSIDERATIONS FOR SMALLHOLDER CATTLE MILK AND MEAT PRODUCTION AND MARKETING: II. PRODUCTION-RELATED ASPECTS

by

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Introduction

1. African livestock producers have been relatively successful with their traditional systems of low-input, low-output per head. Despite low per animal productivity, return to investments in livestock is not low in most traditional African livestock systems. Animals are held because they usually provide high and secure economic return relative to other investment options. Depending on the species, returns are realised in the form of milk, draught power, meat, dung for fuel and manure, hides and skins, and wool and hair. Livestock are often the most important and secure form of investment and savings available. Livestock do not necessarily require land ownership and as investments or savings, livestock provide security and can be drawn on for food purchases, family emergencies, school fees, ceremonies, and social events.

2. However, output of meat and milk in sub-Saharan Africa is low and growth has been disappointing, lagging behind population growth rates. As a consequence, the trend in per caput output of livestock products has been negative. (Anteneh, 1984a; Anteneh et al, 1988).

3. Livestock production can be increased by increasing numbers or by increasing output per animal. Increased productivity per animal usually involves increasing one or more inputs. Much is known about ways of increasing output per animal. However, in Africa, more often than not, it is found that the cost of increased inputs exceeds the value of the increased output per animal. Moreover, low input systems are usually low risk systems relative to high input systems especially where purchased feed or exotic animals are involved. Risk can pose a major constraint for low income, near subsistence producers who can ill afford to jeopardise their subsistence.

4. Finding technologies appropriate to African conditions will require more investment in adaptive research focusing on economical ways of increasing livestock output. Perhaps equally as important, is the development of a more favourable economic environment to make some of the currently available technologies viable. This may require policy changes, and investments in facilitative institutions and marketing systems to provide the services necessary to support technological change.

5. ILCA (1987) has classified the main constraints to increased livestock production in two broad categories. The first is socio-economic and institutional which involves government policies on exchange rates, commodity prices, imports, land tenure, manpower (e.g. for extension and animal health services), and marketing infrastructure. The second category is technical which involves feed and nutrition; genetics; health and disease; and other constraints, including such things as water shortage, toxicity, and poor management. These technical constraints also involve economic considerations.

6. ILCA's economics program in the Cattle Milk and Meat Thrust (CMMT) focuses on both broad constraint categories and includes the following breakdown of major activities:

   i. Identifying constraints to and opportunities for improved meat and milk production; specifically to examine commodity price policies, the supply of inputs and marketing systems.

   ii. Investigate marketing strategies, quantifying present and future demand for milk and meat products, and analysing credit policies for smallholder cattle producers.

iii. Assessing new technologies from an economic viewpoint. This will enable us to determine how much productivity needs to be increased or what risks need to be reduced, to insure adoption. We will also need to determine the benefits of new technologies in terms of output, income stability and welfare and to whom such benefits accrue.

7. These considerations are addressed in two parts. Considerations relating to economic policy, supporting institutions as well as marketing and consumer demand (Part I) were addressed in ALPAN Network Paper No. 26 (Brokken and Williams, 1990). This network paper deals with economic considerations of the technical aspects of cattle milk and meat production by smallholders and constitutes the second and final part.

Economic Efficiency and the Complexity of Livestock Production

8. The fundamental economic problem is efficiency in both the short- and long-term. The (on-farm) test for any new technology is first, does the value of the output exceed the cost of the inputs used in its production; second, is there an alternative use for the same inputs which will yield an even greater value of output? Economic efficiency requires that the first test be affirmative, and the second test negative. If a new technology involves greater risk in terms of variability in output (income), the impact on food/income security as well as farmers' willingness to accept more risk in exchange for higher expected income must be considered.

9. In making these tests one should also be assured that the technology is presented in its best economic light. That is, inputs should be presented in their most efficient combination and the production process carried to its

economic optimum (to the point that obtains the maximum difference between the total value of all output and the cost of all inputs). In addition, the risk implications of any new technology must be understood and addressed in terms of the producers' ability to bear risk and their willingness to accept greater risk in exchange for higher expected returns. Technologies that reduce risk may be particularly welcome.

10. As stated earlier, livestock production may be increased by increasing output per animal, or by increasing the number of animals, or a combination of these. The economic efficiency problem in livestock production is, however, very complex. A single species may produce many products under a wide array of systems varying in time rates of input use and production. Inputs such as labour, capital, land, and different feedstuffs can be used in different ratios to obtain a given output though perhaps a different rate of output per unit time. Feedstuffs can also be used in different ratios and combinations including pasture, crop residues, and forage crops, each used singly or in combination with cereal grains, pulses, and/or industrial by-products from crop and food processing.

11. The problem is further complicated by the fact that different livestock species and even crops may use the same inputs. At the same time, some livestock outputs (e.g. draught power and manure) are important inputs in crop production while the output of feedstuffs from crops and crop residues are inputs in livestock production. Thus, while our main focus is on cattle milk and meat, interactions with other cattle products, or with other livestock and crops cannot be ignored in addressing the full range of economic considerations in cattle production.

12. Complexities in dealing with the economic efficiency problem

also emanate from the interactions and trade-offs among or between the technical constraints enumerated in paragraph 5 above. Such interactions and trade-offs are important aspects which economic considerations should address.

13. The subsequent discussions in this paper mainly focus on the economic aspects of mitigating the major technical constraints. These deal with the economic aspects of: increasing the quantity and quality of feed; improved nutrition; genetic improvement; and animal disease prevention or control and health. The part dealing with genetic improvement (including the annex) presents an illustration of how to consider interactions and trade-offs between technical constraints. A separate section briefly deals with risk which is not a technical constraint in the above sense but which, as pointed out earlier, is an important element in producers' acceptance of technical solutions.

Economic Considertions of Production Constraints

Increasing the quantity and quality of feed

14. The seasonal variability in supply of feedstuffs and the poor quality of feed is regarded as the main constraint to increased livestock production in much of sub-Saharan Africa.

15. The trend in livestock and cattle numbers has been upward throughout most of the cattle producing areas. However, in most cases, since the 1950s, livestock numbers have increased at a lower rate than human populations. Apart from improved disease control and health care, there is some question as to whether these increases have mostly followed increased utilization of existing annual feed supplies or whether they followed increases in forage/fodder production. There is some evidence that both have played a role in

supporting increasing livestock numbers.

16. Increased cropping in the semi-arid and subhumid areas has provided increased fodder from crop residues and increased crop aftermath for grazing. While some of these increases have come at the expense of grazing, it is thought that, on balance, total feed supplies have increased, rather than decreased, from expanded cropping. As cropping activities are extended through bush clearing by farmers and increasingly by sedentary herders, tsetse populations are reduced sufficiently to permit expanded grazing territories. Further, exchange arrangements between herders and farmers permit herders greater access to crop residues and aftermath forage production. Depending partly on the cropping patterns adopted, the expansion of cropping areas reduces range feed supply in the rainy season, but increases feed from crop residues for the dry season.

17. In addition, several important new technologies have been developed which show considerable promise for increasing fodder and forage for cattle. Three of these are alley farming, fodder banks, and zero grazing. For example, alley farming in Nigeria, Ghana, Côte d'Ivoire and Togo has demonstrated the potential to provide increased animal feed, directly through use of trimmings from the leguminous trees and indirectly, through increased crop yields providing greater production of crop residues (Sumberg, 1985). However, the trimmings also have an alternative use in providing mulch and green manure for crops and the economic trade-off between this use and use for livestock feeding must be tested. Studies by ILCA suggest that up to 25% of the total leaf matter can be used as fodder without adverse effects on the yields of crops that are associated with the system (Sumberg and Cassady, 1985).

18. Fodder banks in northern Nigeria and Mali were designed originally to provide fodder during the dry season. The fodder banks are fenced areas planted with a legume for grazing during the dry season. The legumes provide several special benefits. First, they provide a high protein supplement which enhances the feeding value of lower quality roughages. Second, they add nitrogen to the soil which has been shown to increase the growth and yield of both the volunteer grasses emerging in the legume stand and the cereal crops which follow it in the rotation. Finally, the improved soil tilth, resulting from the legume in the fodder bank, makes soil tillage easier which is very important under hand-hoe tillage. In addition, livestock productivity may be enhanced in terms of an increased number of conceptions and a reduced calving interval, reduced seasonal weight loss and reduced mortality.

19. Farmers adopted different strategies in utilizing the fodder banks in the dry season. In areas where cropping intensity is high, there might be a wet season nutritional problem which may be overcome by grazing the fodder bank in the wet season. There may thus be merit in supplementary feeding during the wet rather than the dry season. There are some possible benefits in support of this strategy which, however, needs further testing. First, the total yield of digestible nutrients (especially energy and protein) is greater if harvested during the wet season. Second, the proportion of the nutrients utilised for production will be greater if utilized during the wet season when the animals are already in a positive energy balance. Thus, the total contribution of the fodder banks to animal production may be greater if they are used in the wet season rather than in the dry season (Otsyina et. al, 1987). The result of this strategy is perhaps even greater where seasonal imbalance is compensated by mobilization of body reserves during the dry season

"harvested" in the form of weight gain in the wet season.

20. Increasing the quantity and quality of feed is only one of several constraints which needs to be overcome in the smallholder zero grazing (or cut-and-carry) dairy systems in Kenya and Malawi. Other important constraints included capital, labor, market outlets, animal health and disease, acquisition of suitable breeds and management. Proper management of all aspects of the zero grazing system (including proper harvesting of the forage, manure management, sanitation and feeding) was essential to its viability and this was achieved through an intensive and effective extension and farmer training effort. Economic viability of the system required that every component of the entire system be managed properly.

21. The three systems just described, particularly the zero grazing system, represent relatively high-input, high-output systems. Proper management of the zero grazing system (a very big extension problem) makes it possible to increase greatly the production and utilization of cattle feed on small farms. Most of these operations supplement cut-and-carry green fodder with concentrate feeds. Risk aspects related to farmers' financial ability to acquire purchased inputs on a regular basis, including substantial amounts of feed, are mitigated by continuous daily sales of milk. However, regular availability of marketed inputs remains a problem.

22. Reducing the export of by-product feeds is another potential source for increasing both the quantity and quality of livestock feeds. In 1984, the latest year for which FAO figures are available, West Africa exported 25,000 metric tons of molasses valued at US $1 million; 246,650 metric tons of high protein oilseed cake or meal valued at US $37 million; and 24,616 tons of fish meal valued at US $10

million. For sub-Saharan Africa as a whole the figures are 312,200 metric tons of molasses at US $10.8 million; 365,000 metric tons of oil crop cakes or meal at US $53 million, and 26,616 tons of fish meal at US $10.9 million (Bedingar, 1989). While the trend in utilizing these high quality ingredients for domestic livestock feeding is on the increase, there remains a substantial tonnage of exports. The question of whether utilizing these by-product feeds domestically would contribute more to national incomes than exports needs to be investigated country by country.

23. While there are many technically feasible ways of increasing the quantity and/or quality of livestock feed, finding economically efficient ways to do so remains problematic. The main problem seems to be the high opportunity cost of land and labor which must be diverted from other crop commodities. For example, in the Ethiopian highlands, oats is a crop which potentially can produce high quality hay. However, it is often not harvested at its peak feeding value because of the conflict in the use of labour with other cropping activities. This results in lower quality although lower cost fodder. Another example in Ethiopia is hay harvested from bottom lands, which is frequently done late because of labor shortage, resulting in rapidly declining hay quality (Gryseels et al, 1988).

24. On very small-scale subsistence farms, the opportunities to introduce forages for livestock are very limited. However, intercropping cereals with legumes, which is a common practice in southern Nigeria, offers some potential for increasing the quantity and quality of feed output per unit area. The opportunity cost of labor and land in producing forage is reduced by interplanting with cereals.

Improved nutrition

25. The economics of nutrition is very complex. An animal's quality and value, or the amount and value of animal products (e.g. growth, milk, progeny, draught power) may be varied by alternative feeding/nutritional regimes which also vary in costs. Thus, choice of a least cost set of feedstuffs for a given output is of interest. But the question is which is the best output? And if we establish the best level of, say, milk output, what are the trade-off implications for the output of calf production (including calving interval, calf survival, and calf growth) or of traction? Thus, optimum nutritional regimes can often be determined only in the context of the whole system.

26. One important issue throughout sub-Saharan Africa concerns the optimum utilization of low quality roughages in feeding cattle and small ruminants. It is recognized that one way to increase the feeding value of low quality roughage is to supplement it with high protein feedstuffs. This results in an increase in both the digestibility and the dry matter intake of the low quality roughage. However, increasing the protein level alone may still leave the supplemented roughage low in energy resulting in low daily energy intake. Economical utilization of low quality roughages in milk production, or in accelerated growth and/or fattening usually requires further supplementation with high energy concentrates.

27. Brokken (1979) and Brokken and Bywater (1982) illustrate the methodology for analysing the technical and economic trade-offs between roughages and concentrates in cattle feeding. Further analysis (now underway) using this methodology with African data for goats, sheep and cattle, confirms the limited usefulness of low quality roughages when the goal is

to produce weight gain.

28. Low quality roughages are very often over-priced in terms of their feeding value relative to higher quality roughages and concentrates for use in producing liveweight gain or milk (except perhaps at minimum roughage levels). Low quality roughages are important for maintenance, or for use as an economical input in negative energy balance feeding strategies. It is probably due to this that they are priced relatively higher. That is, one seeks the cheapest way to sustain an animal between wet seasons.

29. In this connection, ruminants, and especially cattle, are well adapted to seasonal variation in feed supplies. They can endure extended periods of weight loss during periods when their nutritional requirements for maintenance and production exceed nutrient intake, and then rapidly regain their condition during a relatively short period of compensatory growth following the return of the rainy season. Thus, cattle are very well adapted to minimum input grazing systems utilizing low quality roughages which provide the least cost means for survival of the animals between wet seasons.

30. In cases where animals have good quality grazing, but are limited in the amount of time they are allowed to graze, supplemental feeding with low quality roughage may prove very beneficial. If the protein value of the pasture is high, the feeding value of the low quality roughage will be enhanced. The animals may benefit from increased daily energy intake in terms of a reduced anestrous period, increased weight gain and milk production, among others.

31. Selective or strategic feeding, concentrating on particular animals or supplementing at particular times of the year, has

been suggested as a possible way of increasing productivity in pastoral systems. Examples include: supplemental feeding of calves to increase growth rates, to reduce mortality and morbidity, possibly to reduce the age of sexual maturity; and, supplemental feeding of heifers and/or cows to reduce nutritional anestrous, or to increase milk production with resultant positive effects on calf production.

32. In the first case, on-going ILCA calf feeding tests in the Sidamo Region of southern Ethiopia show improvements in weights from pre-weaned supplementation, but this advantage is not sustained after weaning (ILCA, 1990). In the second case, tests to determine the economics of supplementing the most productive cows or the worst ones, von Kaufmann and Blench (1989) found that it was more economical to preserve capital by supplementing the worst cows than to increase the productivity of the best animals. Pastoralists in Nigeria tend to supplement their worst cows when they manage their sown legume pastures.

Genetic improvement[1/]

33. In an economic context, genetic improvement means increasing productivity in ways that increase the value of all animal products of a particular species above the costs of inputs. This definition introduces the concept of relative prices of multiple inputs and products as well as of technical input-output relationships, i.e. technical efficiency parameters. The efficiency parameters include milk yield, fertility rates, calving interval, growth rates, survival rates, etc.

1/ This section does not deal with certain important issues such as trypanotolerance (ILCA/ILRAD, 1988), resistance to other diseases, problems of maintaining desirable crosses, and AI services.

34. Increasing the potential output per animal is one avenue that, under some circumstances, may increase output per unit of inputs (feed, labor, land, capital) and therefore result in reduced costs per unit of animal product. In the case of milk yield or growth rates this usually involves increasing the animal's capacity to ingest feed at rates above its maintenance requirements to enhance traits related to increased milk yield, or in the case of meat, increased growth rates. However, in cases where feed supplies are very limited, or high quality feeds are very costly, it may be infeasible or impractical to provide rations that are of sufficient quality to capitalize on the full genetic potential of high producing animals. This is often the case in African situations where feed supplies are inadequate to be able to capture the full genetic potential of even low potential breeds.

35. In low input systems where the genetic potential of the indigenous breeds is not a limiting factor, increasing the genetic potential for growth or milk output will not result in greater output per animal. In any case, increasing output per animal may reduce output per hectare of land. For example, Jones and Sandland (1974) demonstrated that the relationship between stocking rates and output per animal are such that output per hectare (output per head times animals per hectare) continues to rise as stocking rates increase beyond that which achieves maximum output per head (i.e. at stocking rates that do permit full genetic potential to be expressed). Therefore, in cases where genetic potential is not a limiting factor but adequate feed (both quantity and quality) is, upward genetic change may not result in increased output either per head or per hectare. On the other hand, in cases where both genetic potential and adequate feed supplies are limiting factors, selecting for higher milk yielding or faster growing animals may actually

be associated with reduced fertility, reduced disease resistance, and increased mortality rates. Thus enhancing genetic potential under these conditions could make matters worse instead of better.

36. It is thus important to consider the relationship between technical constraints such as between genetic potential and feed/nutrition. It is even more important to consider, even if at a general level, the economic consequences of pursuing a single technical solution which could be ineffective without being combined with another. Detailed comparisons of the efficiency of feed use between animals of different levels of genetic potential entail more complex analysis, but it is probably more useful for site specific research to be able to offer optimal techno-economic solutions to extension staff and potential adopters. Annex I presents an example of what considerations to take in such comparisons. The example is an extreme one to be sure, but it serves to highlight the problem.

37. The gist of the example in Annex I is that the appropriate genetic potential to target is dependent on input prices. Under less constrained feeding, high potential animals become much more efficient in energy utilization. At the same time, high output per animal is required to minimize labour and capital per unit of output in high input systems. Indeed, as feed quantity and quality become less limiting, it is imperative to utilize animals of appropriate genetic potential in order to minimize input costs per unit of product.

38. Very high potential dairy cows are usually kept in drylot and stall fed. High producers may consume up to 3 times their maintenance requirements. While most of the energetic efficiency is reached at close to 2 times maintenance,

feed costs per kg of output continue to decline significantly up to 3 times maintenance. Such high energy intake requires supplementation with high energy concentrates which in most of the developed world are cheaper per calorie than roughages. Thus, as concentrates are added to the diet, daily energy intake increases, energy requirements per kg of milk decrease, and cost per unit of feed energy decreases. All of these factors are mutually reinforcing and favour maximizing utilization of concentrates.[2/] This is further reinforced by the increasing efficiency of labor and capital as output per head increases. When concentrates are not cheaper per calorie than roughages, one must consider the trade-off between the reduction in energy per unit output and the increase in cost per unit energy as the proportion of concentrates in the diet increases. Optimum daily energy intake will frequently fall between 2 to 3 times maintenance requirements. This will very likely be the case under African conditions for the foreseeable future.

Health and disease

39. While the fundamental economic consideration (economic efficiency) is unchanged, there are some special complicating problems arising in economic analysis of animal health delivery systems and disease control. These relate to the justification of public expenditure for animal health programs, and the extent to which these services should be publicly or privately financed.

2/ While exact limits on levels of grain in the diet are not specified, safe levels are generally thought to be limited to approximately 60% of dry matter intake.

40. The economics literature dealing with public finance distinguishes between public goods and private goods. Pure private goods are those from which the service provider can exclude those who do not pay for them and from whose use a specific benefit accrues to only one individual at a time. Pure social goods are the opposite of these: one cannot exclude others from enjoying the benefits which the services create and consumption of these goods by one person does not reduce the benefits available to others.

41. In the real world, there are few examples of purely private or purely social goods. In the case of livestock services, Anteneh (1984) illustrates that AI services are essentially a private good because the benefits almost totally accrue to an individual cattle owner in terms of increased milk production and subsequent own consumption and sales. In contrast, he notes that dipping services used by an individual livestock owner always generate both private and social benefits. Private benefits accrue to the owner in terms of protection against tick-borne diseases. At the same time, other cattle owners benefit because the danger of tick infestation from potential hosts is reduced. Both those who dip their animals and those who do not, benefit from Mr. A dipping his animals.

42. Thus, the dipping activity of one individual generates external benefits to nearby cattle keepers: a phenomenon recognized in the economics literature as an externality. An externality arises any time a production or consumption activity generates a beneficial or detrimental effect on some other individual who is not a party to the activity (Rowley and Peacock, 1975). In Anteneh's example summarized above, Mr. A's dipping gives rise to external benefits to those who do not dip. So dipping is an example of a partly private and partly social good where, in economic terminology benefits

are partly "externalized" and partly "internalized".

43. The main methodology for dealing with efficiency questions in animal health and disease control is cost-benefit analysis. The cost-benefit methodology usually involves one of three approaches: cost/benefit ratios, net present value (NPV), or internal rate of return (IRR). It is important to include both private and social costs and benefits (and account for both positive and negative externalities) in making the cost-benefit calculations.

44. Briefly, these methods involve calculating the stream of future costs and benefits expected from a specific health care practice or package, properly discounted in each future period for opportunity returns that could be earned by employing capital in the best alternative investments. For more detailed information on these methodologies see Mishan (1976). For methodology specific to economic analyses of animal health services and disease control see Putt et al (1988), and Sere (1979). Economic evaluations of various animal health projects are provided by Sere (1979), Anteneh (1983, 1984 and 1985), Leonard (1987) and many references therein.

45. More specifically, disease has direct costs in terms of its effects on all productivity parameters through both mortality and morbidity. Losses due to morbidity are expressed through infertility, abortion, extended calving intervals, delays in reaching maturity (for reproduction or sale), lowered milk output, lowered draught power, increased culling rates, and lowered weight of fattened or culled animals (Putt et al, 1988; Sere, 1979). Thus, losses are realized in terms of lowered output and/or wasted inputs.

46. In addition, there are indirect costs in terms of potential

production lost in cases where a disease threat inhibits or prevents cattle production. Putt et al (1988) mention two examples. First, in eastern Africa, tick borne diseases, particularly East Coast Fever, may prohibit introduction of improved, exotic breeds of cattle except under extremely efficient tick control. In passing, it is worth noting, that an important aspect of the small-scale, zero grazing dairy systems is that they permit relatively efficient tick control. Apparently, confinement is an important key to control of tick-borne diseases as well as trypanosomiasis in this system.

47. The second example is tsetse-transmitted trypanosomiasis which often prevents access of livestock to large and potentially very productive land resources, also limiting the potential employment and productivity of labour. The loss of potential markets, resulting in lowered prices is another indirect cost affecting some producers as happens for example when export markets are lost due to outbreaks of foot-and-mouth disease.

48. Like other investments, the decision to invest in disease control is based on the level of net benefits. Investment is justified as long as the flow of future benefits exceeds the flow of future costs (properly discounted to account for the investment opportunity costs). In cases where the investment decision maker does not fully bear all costs and/or does not fully capture all benefits, the level of investments are not likely to be socially optimal. Having discussed the methodology for dealing with efficiency questions in animal health and disease control, it is worthwhile to briefly examine some of the issues involved in the implementation of health and disease programs.

49. Veterinary services can be classified as preventative,

curative, and promotional. The terms preventative and curative are more or less self-explanatory, though the term promotional perhaps needs explanation. Promotional veterinary service refers to extension and educational efforts toward improved animal care and husbandry. Leonard (1987) argues that preventative and promotional services are public (social) goods and are appropriate governmental activities under virtually all circumstances. But curative practice is a private good, suitable for government support only in cases involving support for the very poor. Leonard argues that evidence suggests that commercialized practice will actually deliver a greater quantity of clinical care more equitably than a highly subsidized public service does.

50. Anteneh (1983, 1985) has analyzed animal health services in 20 countries in West, Central, East and Southern Africa. He found that in most of these countries, animal health services are provided by government departments. He found that the main factors necessary to effectively provide these services include: (i) availability of adequate finance; (ii) availability of trained manpower, and (iii) an appropriate organizational and management set-up for supporting the delivery system.

51. In most cases one or more of these necessary factors was missing. In many cases the problem was inadequate and declining financing. Often funding for non-staff recurrent expenditures on livestock services, e.g. i.e. for medicines, transport, etc. was too little, in one case as low as 5%, of total recurrent expenditure. As funding declined, the organizational set-up deteriorated, becoming increasingly top heavy with senior level staff.

52. Sere (1979) notes that the structure and intensity of veterinary services required by an animal production system

are determined by :

a. The production pattern
b. The diseases prevailing
c. The resources available
d. The costs involved
e. The technical control strategies available
f. The external effects caused by the diseases and their control measures.

Thus, the need and demand for veterinary services varies by system. Our concern here being smallholder systems, review of health inputs required for nomadic/migratory systems and smallholder/sedentary systems is in order.

53. In the nomadic systems, herds migrate over large areas, grazing communal lands. This system favours exposure to contagious diseases such as rinderpest and contagious bovine pleuropneumonia (CBPP) as herds migrate over wide areas and intermingle with other herds while grazing and at watering points. Sporadic outbreaks of these diseases cause varying levels of mortality. Productivity impairing diseases such as internal parasites, tuberculosis and mastitis are of less importance. The main demand for veterinary services is for preventative measures, mainly vaccinations to reduce cost and risk of high mortality owing to outbreaks of contagious diseases. The returns to curative practices are limited because of the very low per animal productivity while the costs of such measures are quite high owing to the low density of the livestock population and high transport costs.

54. The demand for veterinary services is somewhat different in the smallholder, mixed farming and intensive dairy systems. The density of livestock tends to be much greater where mixed farming systems prevail, but the livestock are held in small

herds which tend to be relatively isolated from each other. Sere (1979) notes that in the small mixed farming situation, infectious diseases tend to linger continuously throughout the population rather than to recur as epidemics. Prevalence of productivity impairing, parasitic, diseases is favoured by poor hygiene and poor nutrition. As a result, veterinary costs in these systems tend to be high, while per animal returns tend to be low, for example, compared to intensive dairy systems. This situation favours mass vaccination campaigns, low density veterinary posts conducting extension activities and marketing drugs (antihelmintics, trypanocides).

55. The disease pattern in the small-scale intensive dairy systems is similar to that in the mixed farming systems. However, productivity tends to be much higher and therefore supports a higher demand for veterinary inputs and services. Highly intensive services become viable: vaccinations, trypanocidal treatments or tsetse control, communal tick control and individual clinical treatments. At the same time Sere (1979) notes that intensive dairy schemes in the tropics are totally dependent on veterinary services. Important production problems include parasites, nutritional deficiencies, mastitis, brucellosis, and tuberculosis. Brucellosis and tuberculosis pose important public health hazards and, therefore, their control constitutes an important <u>social good</u> justifying public support.

Risk

56. Risk is a constraint to increased productivity. It is associated with producer behaviour toward technical and policy solutions which can increase or decrease the level of risk producers are prepared to accept in adopting them. It is therefore extremely important that producer risk be taken

as a major consideration in the process of technology development or policy formulation if the ultimate acceptance by producers is seriously taken as an objective.

57. Cattle milk and meat production is a risky business. Production takes place under highly variable economic, institutional and environmental conditions. In sub-Saharan Africa, producers face a variety of price, disease and resource risks which make their incomes fluctuate from year to year.

58. The types and severity of the risks faced by producers will vary depending on the production system, climate, policy and institutional setting. For example, in semi-arid areas risks linked to environmental variability pose a serious threat to herd survival, while in humid areas the risk of disease outbreak is of overwhelming importance. Nonetheless, production and marketing risks seem to be prevalent throughout sub-Saharan Africa and do have, at least, two important implications for small holder producers.

59. First, numerous empirical studies have demonstrated that farmers typically behave in risk-averse ways (e.g. Lipton, 1968; Dillon and Scandizzo, 1978; Binswanger, 1980). As such, farmers often prefer production plans that provide a satisfactory level of security, even if this implies sacrificing income on average. Achieving a secure livelihood may involve engaging in less risky enterprises, diversifying into a greater number of activities to spread risks, using well tried techniques rather than venture into new tehnologies, and retaining a larger share of the farm output for family subsistence. The risk-averse behaviour of farmers suggests that improvements to animal management practices that increase productivity but involve an increase in income variability may not be acceptable to smallholders

unless the expected increase in income is substantial.

60. The second point relates to the differential ability of various groups of producers to bear risk. Initial resource endowments in terms of herd size, land, labour and capital and the level of investment in non-agricultural enterprises all serve to determine the risk bearing ability of a household. The distinct differential impact of risk on smaller and larger producers that have been reported in semi-arid areas suggests that production strategies, herd composition and offtake decisions, and the adoption of new technologies will differ between various classes of producers. Recognizing the varying impact of risks on producers would call for an array of interventions to satisfy the risk bearing abilities of different categories of producers. More importantly, price stabilization and effective marketing information can help to reduce the price risk confronting livestock producers. In addition, suggested interventions to increase production should be such that they would not put household survival in jeopardy.

Conclusion

61. Finding technologies appropriate to African conditions will require more investment in adaptive research focusing on economically viable ways of increasing livestock output. Equally important is the development of a more favourable economic environment to make some of the currently available technologies viable. This may require changes in economic policies and greater investment in facilitative institutions, marketing systems and infrastructure to provide services necessary to support technological change in farm-level production.
62. Successful technological development and adoption depends importantly on the economic environment provided by:

(i) economic and broader development objectives and the policies pursued by a country to secure these objectives;

(ii) the adequacy of supporting institutions and services including provision for extension and training, credit, land reform, and animal health services and veterinary supplies;

(iii) the level of supporting infrastructure including roads and communication services; and

(iv) the efficiency of markets for inputs to and outputs of the livestock sector.

ANNEX I

Comparison of Feed Use Efficiency Between High and Low Potential Animals

In this example, we discuss the daily metabolizable energy (ME) requirements in relation to daily milk output and the corresponding ME requirements per kg of milk output for a high and a low potential animal. The basic relationships are presented in Figures 1A and 1B. In this example, the daily metabolizable energy (ME) requirements in relation to daily milk output and the corresponding ME requirements per kg of milk output are shown for a high and a low potential animal. Figure 1A shows the relationship between daily feed energy requirements and daily milk output for a 450 kg holstein producing 3.5% butter fat (BF) milk and a 275 kg zebu producing 5.4% BF milk. The equations used area[a/] :

Holstein : Mcal ME[b/] per day = 15.59 + 1.16 (kg milk) @ 3.5% BF (1)

Zebu : Mcal ME per day = 9.33 + 1.462 (kg milk) @ 5.4% BF (2)

Adjusting equation (2) to correct for BF level at 3.5% obtains equation (3):

Zebu : Mcal ME per day = 9.33 + 1.16 (kg milk) @ 3.5% BF (3)

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a/ Requirements for the holstein were taken from the National Research Council (1978, Table 2) with maintenance increased 20% to $0.15964W^{.75}$ Mcal ME per day to adjust for sparse grazing (NRC p. 3). Maintenance requirements for zebu were taken from King (1983, table 25) at $0.481W^{.75}$ MJ ME = $0.1152W^{.75}$ MCAL ME. An additional 20% was added to correspond to the adjustment made for holsteins, increasing the maintenance requirement to $0.1382W^{.75}$. An additional adjustment is warranted for walking (grazing) but will not alter the general analysis or conclusions to be drawn. Requirements for milk are 1.16 Mcal ME/kg of 3.5% BF and 1.462 Mcal ME/kg milk for 5.4% BF milk.

b/ Megacalories (Mcal) of metabolizable energy (ME).

Equations for Figure 1B are derived by dividing equations (1), (2) and (3) by kg milk or by simply dividing each daily energy requirement level from Figure 1A by its corresponding milk output level. Thus, Figure 1B shows how the energy requirements per unit of output vary in relation to the level of daily output.

In Figure 1A, the daily ME requirement for maintenance is shown at the intercept or where the milk output is zero. Maintenance requirements for the zebu are lower than for the holstein because the zebu requires less energy per unit metabolic weight and is lighter in weight. However, the energy requirement line is steeper for the zebu than for the holstein because of the higher BF content of its milk. The lower dashed line shows the equivalent requirement for 3.5% BF milk for a given daily output of milk in kg.

In this example, maintenance requirements for the holstein are 1.67 times the maintenance requirements for the zebu. An ME intake of 1.67 times the maintenance requirement for the zebu corresponds to a milk yield of 4.28 kg of 5.4% BF milk per day or 5.39 kg of 3.5% BF content milk per day (Figure 1A). The ME required per kg of milk at this level of daily ME intake is 3.66 Mcal ME/kg milk @ 5.4% BF or 2.91 Mcal ME/kg of 3.5% BF milk (Figure 1B)[c/].

To produce at the same level of efficiency of feed energy (the same ME per kg of 3.5% BF corrected milk), the holstein must produce 9 kg of 3.5% BF milk per day (Figure 1B). This would require 26.04 Mcal of ME/day or 1.67 times its daily maintenance requirement (Figure 1A).

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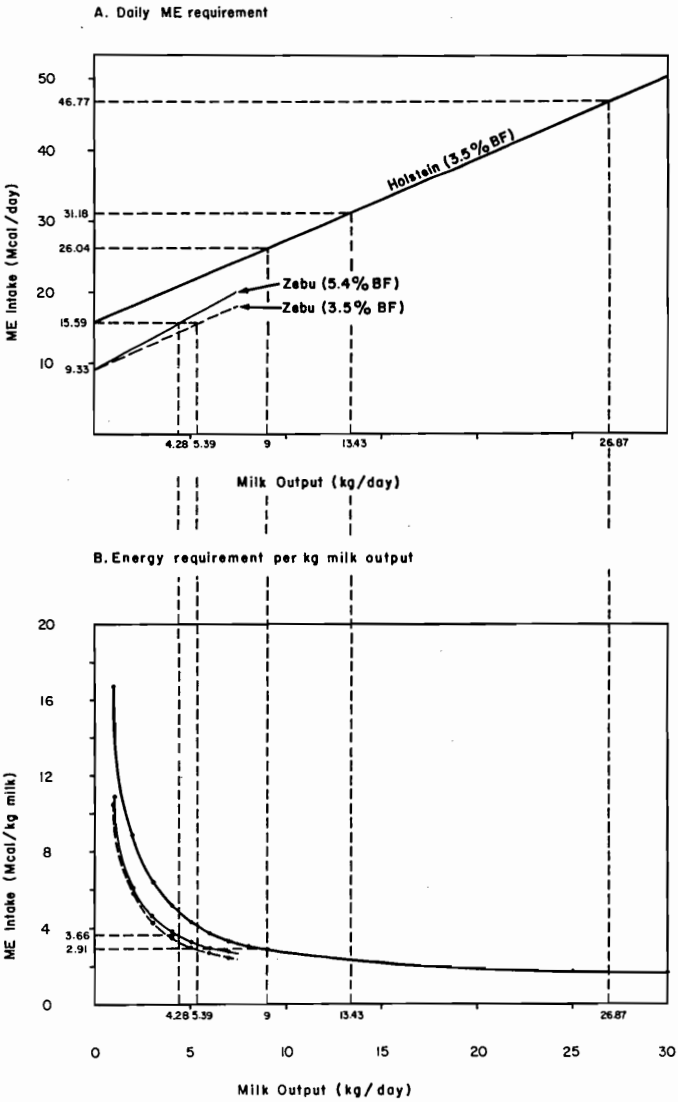
c/ The milk production potential of many zebus is well below 4.28 kg of milk per day, thus an ME intake of 1.67 times maintenance may be divided between milk and weight gain for such low milk producers.

Kiwuwa et al (1983) reported average milk yield of zebu cows of 929 kg per 303 day lactation (3 kg/day) at the Asela Experiment Station in the Ethiopian highlands. While these animals may not have represented the best producing zebu available, they were supplemented during the dry season, 4 months prior to parturition and during lactation. Thus, perhaps the 3 kg average milk output per day represents a maximum that might be achieved under good range conditions. Hence, normal energy intake of zebu cows may be well below maintenance requirements for a very high producing cow. And under poor grazing conditions a high producing cow may do well to survive: a more or less permanent state of nutritional anestrous would be very likely, reducing output to zero or less.

In the present example, the energy required by the zebu to produce 3 kg of 5.4% BF milk daily is 13.72 Mcal of ME. The corresponding ME requirement per kg of 5.4% BF milk is 4.57 Mcal (13.72/3). The equivalent amount of 3.5% BF milk is 3.78 kg per day at 3.63 Mcal of ME per kg of 3.5% BF corrected milk. To obtain the same feed energy efficiency (i.e. 3.63 Mcal ME/kg milk), the holstein would produce 4.31 kg of milk, requiring 22.91 Mcal of ME per day. Because of its higher maintenance requirement the holstein in this example must consume 1.67 times as much feed per day as the Zebu to attain the same level of feed efficiency. With the same total feed intake as the holstein, 1.47 zebus can produce the same quantity of milk adjusted to 3.5% BF.

At very low output per head the low potential animals can utilize feed more efficiently than high potential animals. However, low potential animals reach their maximum efficiency at very low outputs. With adequate feed supplies, the higher potential animals can attain much greater levels of feed efficiency. Thus, while the zebu is able to achieve its genetic potential under very limited feed availability, and under conditions with standard deviations in feed supply dipping below survival standards for high potential animals, the high potential animal becomes more efficient after only modest increase in assured feed supplies.

Figure I. Relationship between daily rates of milk output and energy requirements



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