MEASURING THE BENEFITS OF SUBSISTENCE VERSUS COMMERCIAL LIVESTOCK PRODUCTION IN AFRICA

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INTRODUCTION

Farming Systems Research projects are predicated on the attempt to increase the welfare of small farmers (Norman and Gilbert, 1981). In practical fact, these attempts usually promote technical interventions which would increase farmers' cash incomes while increasing their dependency on agricultural input and output markets (Baker et al, 1983: 6; Norman et al, 1982: 131). With regards to African livestock development, the tendency within FSR to promote commercial production is reinforced by national policy goals which stress the need to produce marketable livestock commodities in order to generate export earnings, provide meat for urban populations, and reduce the number of animals using "over-stocked" pastures (Shapiro, 1979; Jahnke, 1982; Sandford, 1983).

It is therefore imperative that FSR develop quantitative techniques for assessing the relative benefits of commercial versus subsistence livestock production, for at least two reasons.[1] First, these assessments will be a critical aspect of project evaluation and estimations of project success in meeting the goal of increased producer welfare. Second, such comparative studies will be a tool for predicting whether farmers and herders will actually benefit and hence be prone to adopt technical innovations requiring increased commercialization.

The present paper examines three different methods for measuring the benefits of commercial versus subsistence forms of livestock husbandry:

1. One can assess animal performance through the use of biological measures of herd productivity.

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[1]This analysis pertains only to extensive pastoral and agro-pastoral production systems based on natural grazing resources in arid Africa. Small-scale livestock farming primarily dependent upon fodder and crop residues may present complications which have not been examined here.

ii. One can seek economic measures of the profitability of the herding enterprise.

iii. Finally, one can compare the dietary and nutritional status of human populations engaged in different forms of livestock production.

This analysis will show that each system of evaluation has its own strengths and weaknesses, and that the various systems do not necessarily produce comparable results. As a practical rule, therefore, we should favor a combination of measurement techniques whenever possible, and when this is not possible, exercise considerable skepticism in evaluating the results of any unidimensional comparison. A second less obvious but equally important conclusion will emerge from the following analysis. In a cross-cultural setting, it is impossible to insulate the apparently "objective" task of measuring productivity, profit or welfare from the supposedly "subjective" task of assessing farmers' goals and motivations. Each of the measurement techniques examined here portrays a limited segment of the total environment which conditions producer decision-making. These measurements will have predictive value only to the extent that they mirror criteria farmers themselves employ in reaching decisions. Like technical interventions, methods of measurement must be attuned to the needs and circumstances of the agricultural community being served.

BIOLOGICAL MEASURES OF HERD PERFORMANCE

The difficulties of using a strictly biological, herd performance approach are clearly illustrated in the case of a comparative study of ranch and pastoral herd performance carried out in Botswana. From 1970 to 1976 a unit within the Agricultural Research Station, Ministry of Agriculture, conducted a series of studies which compared the productivity of experimental ranches run by the research station and neighboring, privately-owned African herds. The methods used in these studies are explained in detail in Rennie et al (1977) and in numerous government reports from that period (Animal Production Research Unit [APRU], 1975, 1976, 1977). Basically, calves were purchased from cattle posts--the local English name for indigenous African livestock operations--and subsequently raised on research ranches in the same area. The research station paid above-market prices for the purchased calves, and in return herd owners permitted the eartagging of other calves which were born at the same time as those purchased for the ranches. These eartagged calves remained behind at their natal cattle posts, and the dams of all purchased and eartagged calves were also eartagged. Both calf growth and cow reproductive performance were then monitored at regular intervals at both the ranches and cattle posts, and the results were compared.

These results were apparently unequivocal: "The ranch management system is twice as productive as the cattle post system" (Buck, 1978: 251), or more precisely:

> Research has shown that the productivity per cow under the ranch system of management can be twice that achieved under the cattle post system (APRU, 1980: 8).

These conclusions are embodied in the following table which--with minor variations on the values given here--reappears in the course of almost any technical discussion of animal performance in Botswana (see Table 1).

Three separate methodological problems cast doubt, however, on the conclusions that have been drawn from this table. Taken in combination, these problems suggest a vast underestimation of the productivity of the traditional African system of animal husbandry. Since these problems are not peculiar either to this study or to Botswana, they merit our close examination.

Experimental Ranches versus Private Producers

In the comparative study examined here, the biological potential of fenced ranching was established by monitoring the performance of ranches operated by research personnel. Given the problems and resources of the majority of Batswana cattle owners, these ranches constituted a radical departure from normal management conditions. The ranches were capital-intensive and dependent upon skilled and disciplined labor; in addition to ample grazing, the ranches provided disease control, mineral supplementation, and fully adequate water supplies. Although these ranches turned a profit (depending on the techniques used to separate research costs from management costs) research was their primary purpose. They therefore existed in an economic environment peculiar to experimental stations, an environment which stressed optimal biological productivity irrespective of short-term profits and the need to fulfill the economic expectations of a private ranch owner. Something would be fundamentally wrong with an experimental ranch of this kind which did not outproduce the herds of the average African livestock producer.

While the limitations of on-station agricultural research were not fully appreciated when the Botswana study was initiated, these limitations are now generally recognized by farming systems researchers. In retrospect, a more relevant comparison of commercial and subsistence productivity can be obtained only if we compare private pastoral producers with private fenced ranchers, as would presumably be the case in an FSR on-farm research project. Table 2 undertakes such a comparison of productivity on adjacent ranches and cattle posts operating under similar environmental and market conditions in western Botswana. According to these figures, the ranches were marginally more productive than the cattle posts, but the results were by no means clear-cut. Calf mortality was lower on the ranches and weight gains were higher, but

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overall mortality was the same, and the calving percentage was higher on the cattle posts. Much the same results emerged from a second, later study which compared newly "developed" ranches and cattle posts in two additional areas of Botswana. The results of this study are not conclusive because only seven ranches were examined, their performance was monitored for only a short period of time, and the ranches themselves had been in existence for only a couple of years. Given this note of caution, the study nonetheless indicated that:

> The results of herd performance from the ranches do not, in general, indicate significant differences from those of the communal area survey [the cattle post herds], in fact they are in many respects very similar to the performance of the herd sizes 101-150 and over 150 [head] (CARL BRO, 1982: 4.38).

These findings are confirmed on a wider geographical scale by an excellent analysis of national livestock statistics from Botswana (Hubbard, 1982). Instead of looking at the productivity of newly-created ranches designed for occupancy by African owners, this study examined the productivity of long-established freehold ranches which had been created for European colonists during Botswana's Protectorate period. As long as the comparison was restricted to herds of roughly comparable sizes, Hubbard found that there was a significant difference in the recorded propensity of ranch and cattle post owners to sell their animals. However, with respect to biological performance measured in terms of herd mortality and calving rates, the ranches out-performed the cattle posts with reasonable consistency, but at a modest margin (see Table 3).[2]

In sum, the three studies of private ranch productivity cited here demonstrate the extent to which experimental station data distorts the results of any comparison of subsistence and commercial production, irrespective of additional problems of measurement bias which have yet to be discussed.

Production per Hectare and per Head

Whether they have been carried out on experimental ranches, private ranches, or cattle posts, all existing assessments of pastoral productivity in Botswana suffer from a common limitation. In all cases productivity is expressed on a yield per animal basis without any control of stocking rates. If we are to appreciate the fundamental nature of this problem, we must first obtain an understanding of the

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[2]See Cruz de Carvalho (1974) for a similar comparison of ranching and indigenous pastoral production in Angola.

variable productivity of animals and land at different stocking rates. Simply stated, the problem is as follows: Within limits, on natural range higher livemass gains per hectare are obtained from high stocking rates, that is, from a high density of animals per unit of land. There is, therefore, a trade-off between productivity per animal and per unit of land, and within reasonable parameters the two are inversely correlated. This relationship can be displayed graphically following Mott (1960) (see Figures 1). As the graph indicates, yield per animal is highest at the lowest stocking rate, and does not immediately begin to fall as animals are added to the range. At stocking rate A (see Figure 1), however, the productivity per animal begins to decline as the range resource is more completely used. At the same time, productivity per hectare continues to increase since reductions in animal productivity have been more than offset by the increasing number of animals. As the stocking rate is further increased, however, the system reaches a breaking point at stocking rate B (See Figure 1) where the pasture resource is badly overtaxed and everything collapses--the range is degraded and yield both per animal and per hectare declines. Short of this threshold, maximum weight gain per hectare occurs at heavier stocking rates than maximum weight gain per animal (Barnes, 1978: 41, 42; Jones and Sandland, 1974).

With this conclusion in place, we may profitably return to an examination of the specifics of the Botswana study (Rennie et al, 1977). No information was given concerning stocking rates on the cattle posts and adjacent ranches compared in this study. Nevertheless, available evidence indicates that the stocking rates on the ranches were very low--much lower than even a conservative commercial rancher would have stocked them (CARL BRO, 1982: volume 2, 3.16). On the other hand, the tribal lands outside the ranches are described in official government reports as "overstocked" although, again no empirical evidence has been given to support this assertion (Lightfoot and Behnke, 1982). Could it be that the cows on the ranches were living in a bovine Garden of Eden, but not making very efficient use of the Garden?

More generally, most African pastoralists live under considerable human and animal population pressure given the harshness of the areas they inhabit (Jahnke, 1982: 99-103). In response to these pressures, pastoralists have evolved a system of animal husbandry capable of sustaining high stocking rates. They do this by engaging in highly sophisticated, short and long-distance pasture rotation systems involving shepherding and nomadism (Horowitz, 1979; Dyson-Hudson and Dyson-Hudson, 1969; Behnke, 1980). They herd animal breeds that can utilize substandard pastures and survive periods of climatic stress. By minimizing the water intake of their animals, they may inadvertently increase the physiological efficiency with which the animals use nutritional inputs (McDowell, 1983; Pratt and Gwynne, 1977). Finally, pastoralists tend to own herds of predominately older animals which may require less feed because they are no longer growing (Ellis et al, 1979). Under these conditions, productivity per hectare would seem to be at least as relevant a measure of herd performance as productivity per animal.

Measuring Productivity

It is sometimes assumed that measures of animal productivity are inherently objective simply because they are based on "hard" biological data. The kinds of biological measures which are employed can, however, seriously bias relative estimations of the productivity of animal husbandry systems designed to produce different kinds of products. In Botswana both experimental and private ranches produce one product--slaughter cattle. On the other hand, Batswana-operated cattle herds, like the herds of most African pastoralists, produce a wide variety of products including milk, meat for home consumption, animals for sale, and traction power for plowing or haulage. Measures of productivity based on the production of red meat will, therefore, be consistent with the management objectives of commercial ranches, but will bear no relation to the diverse productive uses of indigenous African herds.

The research unit which conducted the comparative cattle post and ranch study operated under a clear research mandate--to examine the problems and potentialities for beef production in Botswana. Accordingly, estimates of post and ranch productivity were based on "weight of beef produced per cow per year" (APRU, 1975; 38) and calculated according to the "the four traits of major economic importance in beef cattle production...calving percentage, viability, pre-weaning and post-weaning growth" (Rennie et al, 1977: 3). In sum, all of the produce of the ranches was compared to part of the produce of the cattle posts. It seems only reasonable, therefore, that the productivity of the indigenously-managed African herds should be found wanting.

There is, nonetheless, a mitigating argument in favor of the Botswana research program. Many of the measures of herd performance in this and similar studies do not measure herd output so much as they measure the health and vigor of the herd. To what extent, we may justifiably ask, do these measures assess factors of concern to all livestock owners regardless of their production objectives?

In order to answer this question we must examine more closely the way in which commercial ranchers and subsistence pastoralists manage their herds. A recent study of commercial Colorado cattle ranching and cattle keeping among the Karamojong of Uganda is based on a comparison of energy flow in the two systems (Ellis et al, 1979). Drawing on analogies suggested by plant and animal ecology, the study concludes:

> The Pawnee [Colorado ranching] situation can be viewed as a predator-prey relationship, with the people being the predator, while that in Karamoja can be seen as a parasite host relationship, with herders as the parasites (Ellis et al, 1979: 148).

This conclusion is applicable both to Botswana in particular and to an understanding of the difference between commercial ranching and subsistence pastoralism in general. Ranching is a predatory system in that it exploits animals by killing them, but does everything possible to insure their well-being up to the time of slaughter. Subsistence herders, on the other hand, live like parasites on their herds in that they rely on the harvesting of live-animal products and treat meat as a residual benefit to be realized only at the end of an animal's productive career. In this way herders postpone slaughtering their animals and extract a good deal of value from them in the long term. They do so, however, at some cost to the health and vigor of the animals. Calves, for example, will have to share their dam's milk with human children, oxen used for plowing will lose weight, etc. Subsistence herders, therefore, stress their animals continuously, while ranchers stress them only once--at the slaughter house. Thus, the comparison of commercial and subsistence herd performance may be irrelevant from the point of view of the subsistence herder, for by these measures under-used (and consequently, unstressed) herds may "perform" better than their heavily-used and highly productive counterparts. This is not to say that pastoral producers do not value lower rates of mortality, higher rates of live birth, or increased weight gain. These measures of herd health and vigor will not, however, be meaningful unless rates of live-animal resource extraction are held constant, which is unlikely given the nature of the two systems under comparison.

The attempt to minimize these measurement biases is exemplified by the work of Penning deVries and Djiteye (1982) on pastoral production in Mali (reproduced in Table 4). Here biological productivity is calculated in terms of production of animal protein, a measure which encompasses both milk and meat, and stated in terms of yield per unit of land area. Whereas the Botswana experimental ranches appeared to be twice as productive as their local indigenous counterparts, these calculations suggest that Malian pastoral systems achieve rough parity with industrial ranching systems in similar rainfall zones. It is, of course, impossible to know how much of the differences in the two sets of results arises from real differences in technical efficiency between Mali and Botswana, and how much is merely an artifact of different measurement techniques.[3]

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[3]Due to the kinds of measurement difficulties discussed here, animal scientists have developed complex indices of herd productivity which incorporate a number of different biological measures into a single overall productivity score. These more sophisticated techniques have been used to simulate the impact of technical innovations on pre-existing systems of production (Sullivan et al, 1980; International Livestock Centre for Africa, 1978) or to model the relative productivity of localized pastoral production systems in Africa (de Leeuw and Konandreas, 1982, based on Trail and Gregory, 1981). To the best of my knowledge, however, these scoring procedures have not yet been used to assess the actual productivity of alternative systems of subsistence and commercial production.

ECONOMIC ANALYSIS

The limitations of the Botswana experimental ranch and cattlepost comparison spring from a common source--the attempt to make a single, commodity-oriented research program serve antithetical objectives. The research on the experimental stations constituted a perfectly adequate investigation of commercial beef production under Botswana conditions. It could not, however, be transformed into a valid comparative analysis simply by extending the scope of data collection to include subsistence producers and by analyzing their operations within a framework appropriate only to a commercial beef operation. Given this basic limitation in research orientation, the addition of economic analysis to the research agenda will not transform a misleading comparative study into an adequate one. Economists can (and in the past frequently have) measured pastoral output solely in terms of marketed offtake of live animals; they have expressed the results of their analyses in terms of income per animal irrespective of the stocking rates of the systems under examination; and they have compared the economies of private subsistence enterprises to the pseudo-economies of experimental ranches. In all these cases, however, economic analysis merely expresses in cash equivalencies the same misconceptions that had previously been measured according to biological criteria. In the following discussion of economic analyses, I will assume that these more egregious errors have been rectified, or that they can be dismissed with the same arguments that have already been adduced. In this way we will be free to undertake a more detailed examination of the issues peculiar to the economic analysis of subsistence and commercial animal husbandry.

As Zandstra has noted, "at this day and age few agricultural researchers will formulate recommendations based on maximum yield or biological efficiency," but rather compare alternatives "by some economic performance measure--generally returns over variable costs" (1983: 36). Less widely recognized is the extent to which competitive markets make possible quantified economic analysis by assigning numerical values, i.e. prices, to goods and services. But subsistence production cannot, by definition, be valued in this way, and this is our problem. It is, moreover, a critical problem to the extent that production for home use constitutes an important proportion of total production in many contemporary African livestock economies. Some examples:

i. Danckwerts calculates that for certain tribal areas of Zimbabwe (then Rhodesia) over 80% of the total value of cattle were ascribable to arable inputs and home consumption, in an area with a 2.7% sales rate (Danckwerts, 1973 : 9-16).

ii. Jahnke (cited in Ruthenberg, 1980: 337-339) ascribes to in-kind production the value of 32% and 37% of gross return to livestock keeping among, respectively, the Nyabushozi and Karamoja, two pastoral societies in Uganda.

iii. Based on a combination of estimates and field data, a recent study in Botswana concluded that on average income from Batswana cattle herds was divided about evenly--47% in-kind and 53% in cash output (CARL BRO, 1982: 4.126-4.132).

iv. Among Kenya Maasai operating on communal land, betweeen 41% and 47% of all production was in kind, depending on the extent to which particular areas had been commercially developed (White and Meadows, 1981 cited in Sandford, 1983: 125).

Leaving aside for the moment the question of how in-kind production should be valued, these ratios clearly document the importance of in-kind production to the total output of semi-commercialized livestock economies. As a consequence, the results of any calculation of economic costs and returns will be highly sensitive to any changes in the way subsistence production is valued.

The cash value to be attributed to subsistence production is, however, a contentious issue. At least two different procedures have been advocated, and these two procedures would lead to significantly different imputed values. On the one hand, there is the standard approach adhered to by most agricultural economists and explained as follows by Gittinger:

> In agricultural projects, the point of first sale at which it is generally desirable to value new production (or production forgone) is the "farm gate" price--the price the farmer receives when he sells the product at the boundary of his farm (1972: 33).

He continues:

> In some cases it may be extremely difficult to determine just what is a realistic farm gate price for a crop produced primarily for home consumption because rather little of it really appears on markets. This is the case, for example, for manioc and cocoyam in Africa where some argue that the true value of the crop is overstated if the market prices are used as a basis for valuation. Even so, home consumed production should be valued at your best estimate of a valid farm gate price...(1972: 34).

In opting for a farm gate price, Gittinger clearly believes that he is ascribing a generous cash value to such production. Nevertheless, several arguments can be adduced to support the position that producer

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prices are not too high but rather too low an estimation of subsistence value. This will be the case whenever trade is infrequent precisely because the exchange value of a particular item does not equal its use value in the domestic setting.

A clear ethnographic instance of such undervaluation is provided by the economics of mixed sheep and goat pastoralism and wheat and barley cultivation in Eastern Libya in the early 1970s (Behnke, 1980: 44-47). The analytical problem in this case was to comprehend the continued involvement of most households in both crop farming and animal husbandry. The interest of producers in crop farming did not at first appear reasonable since the cash returns to that activity were negligible compared to those of herding--something on the order of one to twenty for an average holding in a normal year. The problem with this calculation lay in the valuation of unsold grain at farm gate prices. The solution to the muddle lay in realizing that the domestic use value of the grain as an animal fodder far exceeded its farm gate value. As a result of this discrepancy, very little grain was in fact sold by producers until they had an opportunity to convert it into a more valuable market commodity--meat. In this case, to value unsold grain at farm gate prices would have both distorted the apparent utility of different productive activities and obscured the strategy behind household involvement in and withdrawal from the marketplace.

Similar considerations may also obtain in the case of agricultural produce grown for human rather than animal consumption. In a semi-commercialized economy, local market demand for basic foodstuffs may be slight precisely because food self-sufficiency is a primary objective of household economic activity. Low producer prices in this situation may not reflect the fact that a commodity is valueless, but to the contrary, may indicate that households value it highly enough to commit much of their internal resources to its production. If the object of our analysis is to assess the utility of subsistence produce from the farmers' point of view, producer prices may persistently underestimate its worth.

A second line of argument is based on explicitly theoretical considerations. With respect to subsistence agriculture, rural farm households are dual-purpose institutions. Like the business firms of classic micro-economic analysis, they produce; like the households of classic micro-economic analysis, they consume. To afix a producer price to subsistence production is to construe these units as producers, but it is equally justified to view them as consumers. In this case, the relevant market price to assign to home consumption/subsistence production is the price that producers would have to pay to replace home

produce with purchased equivalents.[4] As Mellor has expressed it:

> The farmer correctly attaches a higher price to production for home consumption than to production for sale since he in effect pays the retail price for what he buys and receives the wholesale price for what he sells (Mellor, 1966; 200; cited in Chibnik, 1978).

A clear case of the operation of such a pricing system in a semi-commercialized livestock economy is provided by Doughty's discussion of the value of camels in North Arabia in the late 19th century. According to Doughty, camels had two very different cash values. On the one hand, there was their desert value--the price the Bedouin would have accepted for their animals had they bought and sold them among themselves. This price was widely accepted among producers and real in the sense that Doughty tried to buy a camel and found that the Bedouin would sell for nothing less than the quoted value; but the price was also hypothetical in that the Bedouin might raid or steal camels from each other, but they rarely sold them. In contrast to this desert price, there was the actual sale price of the beasts after they had been transported out of the interior deserts and disposed of at auction in the coastal market towns. The object of this trade by the Bedouin was to obtain rice imported by Indian merchants. Like tobacco, weapons, cloth, and coffee, rice was one of the essentials of a Bedouin way of life that they could not produce themselves and had to obtain through trade. The paradoxical aspect of this trade was that the market price received for camels was nearly <u>half</u> their desert value, despite the considerable transport costs borne by the Bedouin in bringing the animals to market (Doughty 1979: 438). In this case it is clear that camels had a reasonably low exchange value given their utility to Indian merchants, and they had a much higher use value for the Bedouin given their pastoral way of life dedicated to the efficient exploitation of the beast. Although the exchange value of the animals was considerably lower than their domestic use value, richer Bedouin continued to sell a <u>limited</u> number of animals in order to meet their perceived essential rice requirements (Doughty 1979: 438).

In situations of this kind the accurate valuation of herd wealth must necessarily employ two distinct pricing systems. Camels sold will be valued at their empirically observed sale price. Camels retained for home use will, in contrast, be valued at their replacement cost, that is, at (i) either the amount of money it would take to purchase replacement animals from other producers, or (ii) the amount of money it

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[4]The valuation of subsistence production in terms of replacement costs was suggested to me by Carol Kerven, and the following discussion of this subject is based largely on her published (1979, 1982) and unpublished research on this issue.

would take to purchase consumables equal to those generated by the beast given local techniques of animal exploitation. In sum, sold beasts are valued at the farm gate price; unsold beasts are valued at the opportunity cost (their best alternative use in another production process) of their sale (Kerven, 1982). As Chibnik (1978) has noted, this process of double valuation may at first seem counterintuitive. It is, however, no less reasonable than the analogous process of valuing the output of an industrial plant according to the market in which it is sold, giving that portion of the output which is sold to domestic markets, for example, a lower value than that which is sold on more lucrative export markets.

This dual pricing policy has the added advantage of providing a potential explanation of the observed marketing behavior of pastoralists, especially their unresponsiveness to minor fluctuations in producer prices. In the Bedouin case just presented, producers are target sellers in the sense that they are selling to meet definite consumption objectives, not in order to make a profit. In order to explain this phenomena we need not invoke a camel complex, economic irrationality, or pastoral conservatism. We need only note that producers cannot profit from additional sales beyond consumption needs, given the relative use and exchange values of the animals. Small increases in producer prices are, therefore, unlikely to elicit higher rates of sale, and may permit lower rates of sale consistent with meeting stable consumption goals. Employing a parallel line of reasoning, Chibnik provides tentative evidence that the price elasticity of supply for subsistence agricultural crops is somewhat less than that for commercial crops, all else being equal (1978: 372).

The preceding remarks justify the ascription of replacement cost as the cash value to be placed on subsistence produce. It remains to be shown that this valuation technique significantly alters the outcome of economic assessments of the advantages of subsistence versus commercial production. As an illustration of the potential effect of revaluing subsistence production, Table 5 presents the results of a comparison by Ruthenberg of Ugandan ranching and pastoralism; the original results are then contrasted to new estimations of pastoral and ranch income which result from substituting replacement costs for Ruthenberg's valuation of in-kind produce. With some justification Ruthenberg could use the original table as evidence for the following conclusion:

> Most types of semi-nomadism are economically wasteful. In comparison with large-scale production on ranches, the productivity per hectare, per man-equivalent, and per animal is usually low (Ruthenberg, 1980: 340).

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There is, on the other hand, litle in the recalculated table which would sustain these generalizations.[5] These new results show income per hectare on the ranches as half of that for the pastoralists, while income per animal is a third less for the ranchers than the pastoralists. Only in terms of income per unit of human labor do the ranches achieve clear superiority, as they did in the original calculations. Based on this exercise, there can be little doubt that a re-estimation of the value of subsistence production would have a significant impact on the results of economic analyses of semi-commercialized livestock production systems.

Problems and Cautions

The pricing of subsistence production is in principle quite simple: ascribe to home production and consumption a cash value equal to its replacement cost. With respect to livestock-based economies, however, the calculation of replacement cost demands the solution of several practical problems including changing patterns of food consumption in the commercialization process, instability of pastoral/non-pastoral terms of trade, and the issue of crop-livestock interactions in agro-pastoral production systems. There follows here a brief discussion of how we might approach the solution of these problems.

Changing Consumption Patterns:

The shift from subsistence to commercial animal production is accompanied by predictable shifts in food consumption patterns (Behnke, 1980: 87, 88; 1983). This facet of the commercialization process complicates the calculation of replacement equivalents since meat or milk foregone for sale is not replaced by comparable quantities of meat or milk, but usually by cheaper purchased grain. The economics of this substitution process is similar to that documented by Hodder (1969, as reported by Chibnik 1978) for the substitution of food crops in West Africa:

> In certain areas of Nigeria most farmers do <u>not</u> grow most of their food. However, Hodder also reports that most (about 60 percent) of the crops these farmers sell in local markets are foodstuffs...What appears to be happening is that many farmers sell food crops with high market prices (usually yams) and buy for home consumption crops with comparatively low retail prices (usually cassava in the form of gari)...Such behavior seems economically sensible (Chibnik, 1978: 571, 572).

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[5] Ruthenberg's analysis has been recalculated in order to illustrate a methodological issue. The recalculation is based on several necessary but tenuous assumptions, and may not reflect the real terms of choice for Ugandan pastoralists contemplating increased market involvement.

In commercializing livestock economies, high-protein animal products are exchanged in most cases for high-caloric food grains at favorable rates if substitution costs are calculated solely in terms of caloric equivalencies. The nutritional incommensurability of these exchanges will be considered in a later section of this analysis.

Price Instability:

Figure 2 shows the terms of trade for animals versus millet over a more than thirty year period of a region in Niger. Although there is no clear secular trend in the terms of trade, these data do document precipitious, major, recurrent price shifts caused by drought and bad harvests (Sutter, 1982). At the very least, any accurate economic estimation of the relative benefits of commercial versus subsistence livestock production must take these price fluctuations into account by examining a run of good and bad rainfall years. The violence of these fluctuations casts serious doubt, however, on the capacity of routine cost/benefit analysis to model the utility for livestock producers of various levels of commercial involvement. For example, calculated in terms of their replacement cost in grain, cattle values fluctuated by a factor of over four to one for different years in the 1970s, by slightly less than three to one in the 1960s, by about two to one in the 1950s, and again, by a factor of four to one in the 1940s (Figure 2, based on Sutter, 1982: 48, 49). For small holders operating on the margins of economic viability, the fact that commercial production may be extremely lucrative in some years (or even in most years, or in the mythical "normal" year) may be less important than the probability that a commercially-managed small herd would be unlikely to survive the climatic fluctuations of a decade, and still sustain the family. In this case, the real utility of subsistence production for the small producer may be somewhat higher than the cash replacement cost as set by local markets.

Livestock-Crop Linkages:

In mixed farming-livestock systems many products generated by a family's livestock enterprise are neither consumed nor sold but rather are invested in the household's cropping enterprise, while the reverse holds true for the cropping enterprise vis-a-vis the herd. Crops or crop residues used for animal fodder, manure used for fertilizer, or animal traction used for plowing are common examples of such intermediate agricultural products whose value is only realized after the addition of other inputs or processes. Determining the value a sensible farmer would place on these home-produced inputs is, in principle, no different from determining the cash value of subsistence consumables. In all cases, the appropriate value of a subsistence input or terminal product is the cash cost of purchasing its replacement, i.e., the cash cost of buying fodder to replace crop residues, of purchasing fertilizer to replace manure, or of purchasing plowing services in lieu of using the family animals.

The Limitations and the Utility of Economic Analysis

If we accept the methodological strictures laid down here, the economic literature on African pastoralism reveals a curious situation. There exist very few methodologically adequate comparative studies of subsistence and commercial production, despite the strong views that observers tend to have regarding the relative merits of the two systems. The closest approach to an adequate comparative study is probably provided by the recent work by White and Meadows on the Kenya Maasai (1981). The results of this study (as summarized in Sandford 1983) are presented in Table 6. These results run directly counter to accepted wisdom regarding the dysfunctional economic nature of subsistence livestock production (see Ruthenberg's remarks cited previously). The more closely and accurately we quantify the gap between subsistence and commercial production, it would appear, the more the two systems seem to achieve rough economic parity. This result has important implications for how we conduct future economic studies of pastoralism, not to mention the issue of whether greater commercial involvement is in the best interests of African livestock producers.

The methodological innovations called for in this analysis are analytically defensible and operationally feasible; nevertheless, the application of these principles would require more empirical data, more sensitivity to the ethnographic situation, and more plain field experience than is usually deemed necessary by economic analysts. In the past, faulty economic analysis has perpetuated the myth of its own adequacy by exaggerating the advantages of commercial forms of production. Why attempt a more sensitive but expensive analysis, these studies seemed to suggest, when the manipulation of available statistics immediately revealed the superiority of the commercial alternative? By closing the apparent gap between commercial and subsistence production, more appropriate comparative methods tell us something unexpected about the economics of African pastoralism, and provide clear justification for further careful and precise attention to a problem once thought to be beneath serious consideration.

NUTRITIONAL STUDIES

The following discussion examines the rationale for the monitoring of the human nutritional impacts of livestock development. This discussion will be more hypothetical than the preceding analyses for the simple reason that I have been unable to locate a quantified study of this kind for any pastoral societies in Africa.

The potential conflict between profit and production versus human nutrition is particularly acute in commercializing pastoral economies, and requires that we clearly distinguish between biological yield, income, and human welfare. The shift from a subsistence to a commercial production strategy demands the abandonment of a multipurpose pattern of animal use in favor of what has been labeled the "mono-husbandry of a single cash-crop species" (Teitelbaum, 1980: 40). The problem is that these changes in production strategy are inextricably linked to changes in food consumption patterns. Milk deflected from family use and

invested in increased calf growth, for example, must be replaced by purchases funded by the proceeds of animal sales. We can place money values on these conversions and monitor them economically, as noted previously. What economic analysis cannot easily model, and may even obscure, is the simple fact that grain and livestock products are not nutritionally equivalent, and that herders may "profit" from such exchanges by undercutting their long-term health and that of their children. This is in fact the conclusion reached by a recent USAID evaluation of the nutritional impacts of livestock development schemes in Africa:

> In many cases, project failures were attributed to noncooperative pastoralists. As we shall see, there is reason to conclude that many of the implementation difficulties came about not because pastoralists were uncooperative, hostile or too conservative as have been suggested by range management technicians. Rather, the problems may have arisen because in large part livestock/range management project design contradicted the existing subsistence food systems of the herds and threatened to undermine the nutristructure of the pastoral populations without developing effective alternatives (Teitelbaum, 1980: 60).

This report also makes it quite clear that it is inadequate to conduct a study of herd productivity or enterprise economics and subsequently convert the results of these studies into units of nutritional accounting. The Penning deVries and Djiteye study cited previously remains a study of herd performance, not human nutrition, despite the calculation of herd performance in terms of units of protein, and likewise with the Ruthenberg comparison of Ugandan pastoralism and ranching (Table 5), in spite of my conversion of their results into caloric equivalencies. At least four separate reasons can be given for rejecting these studies as bona fide nutritional analyses, and for undertaking a direct examination of the diet, health and vigor of commercializing pastoralists.

i. Ingested in the correct ratios and at the correct times, food grains and livestock products have a synergistic effect on each others' protein value, i.e., in certain combinations they can be worth more than the simple sum of their values. Part of the value of a food, therefore, is not inherent in the food itself but is contingent upon its mode of preparation and consumption (Teitelbaum, 1980: 26).

ii. In a subsistence economy, the value of a particular food source will reflect the relative abundance of alternative foods. Thus, food available during "hunger months" of seasonal scarcity will be of more value to sustaining human life than comparable amounts of food at another time (Teitelbaum 1977; Whelan, 1983). Much the same point can be made with respect to agricultural labor demands during peak and low periods of food availability. Despite obvious technical and economic advantages, increased work during hunger months may be rejected by farmers or herders as an unattractive alternative.

iii. The shift from subsistence to commercial production may precipitate shifts of power within the household regarding control over food supplies. For example, through the provision of their labor in milking and the processing of milk products, women may have direct control over the household food supply in a subsistence context; the marketing of live animals for cash, on the other hand, may reinforce the power of adult males to dispose of, control and invest the wealth generated by the herd. Assuming that the economic goals of the two sexes are not identical, these shifts in power may alter consumption patterns even at stable levels of income (Dyson-Hudson and Dyson-Hudson, 1980).

iv. Nomadic settlement (if it accompanies commercialization) will also have an impact on effective levels of nutrition:

> Sedentarized nomads have increased intestinal parasite loads, which consume ingested nutrients; vector-borne and filth-spread infectious diseases increase in incidence among sedentarized pastoralists due to the "closing circle" impacts of reduced mobility of man and beast (Teitelbaum, 1980: 44).

In sum, nutritional analysis and monitoring can contribute at two different levels to an understanding of the commercialization process. First, if FSR is serious about improving farmer welfare (rather than simply increasing agricultural productivity and commercial offtake) then nutritional monitoring will be a critical aspect of project evaluation. Second, if herders themselves can foresee the negative nutritional implications of certain technical and economic innovations (and Teitelbaum's work suggests that they can), then nutritional studies will be a critical part of the overall effort to predict farmer behavior. Given the imponderables of economic modeling, such a nutritional study may provide the most direct and empirical method to investigate the real concerns of the poorer producer.

CONCLUSIONS

This paper has presented a number of technical recommendations which either expand or modify the usual repertoire of procedures used to evaluate livestock development. These recommendations confront a fundamental issue for international agricultural research: the problem of cross-cultural objectivity. Historically, this is a problem which has been handled differently by different academic professions.

Those professions which specialize in comparative social research have long adhered to a scientific method which assumes that specific institutions, customs, values, or behaviors take on different meanings according to the social environment in which they are embedded. In this analytical framework, objectivity is relative and is arrived at by adjusting the concerns of the scientific community to the concerns of the community under study. On the other hand, in the biological sciences, and to a lesser extent in economics, objectivity is insured by adherence to a disciplinary tradition which predetermines the nature of data and analysis. In this realm, facts are facts irrespective of the

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capacity of local farmers and herders to perceive them or to appreciate their significance.

The preceding analysis has emphasized the limitations of this latter approach for an applied branch of agricultural science like FSR in which farmer adoption rates are one critical marker of the cogency of research recommendations. For the practitioner of FSR, or for an inter-disciplinary research team, to be technically correct but largely ignored by the surrounding farming community is an unacceptable and professionally damaging outcome. The objective of the foregoing recommendations has been to avoid this outcome by bringing our technical measurement criteria into line with the criteria farmers and herders use in reaching decisions.

Once this step has been taken, our calculations tend to point in a new but not an unexpected direction. The existence of the rational farmer is one of the philosophical underpinnings of FSR. Today almost all subsistence pastoral economies in Africa have been penetrated to some degree by commercial relations, and the option to sell or to use a particular animal product is a dilemma that is before most livestock producers. When these putatively rational farmers defy our expectations and reject increased commercial involvement or "modern" techniques of animal management, this rejection is, in itself, prima facie evidence that we have somehow exaggerated the benefits of commercial involvement and underestimated the advantages of subsistence production. Judged in terms of the current condition of the African livestock industry, the advantages of commercial production are marginal for many producers, even under favorable conditions. If we are to understand the evolution of African forms of commercial livestock production, we must begin with this reality and work backwards to discover appropriate quantified expressions of the relative advantages of alternative production systems.

It is not sufficient, however, to stop at this level of analysis. This paper has re-examined what might be termed "whole systems" comparisons of subsistence and commercial livestock production--Botswana experimental ranches versus cattle posts, Utah ranching versus Malian pastoralism, Colorado ranching and the Karamoja. But African systems of pastoral production are internally differentiated, and become more so with increasing market involvement (Behnke 1983). Given that the advantages of commercialization are at best marginal, one class of pastoral producers may view commercialization with enthusiasm, while other producers in the same community reject it. What we now require are measurement techniques which are precise enough to highlight the various incentives and disincentives which structure this decision.

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Table 1. Beef Cattle Productivity Under Cattle Post and Ranch Management

Trait	Cattle Post	Ranch
Calving percentage	47.3	74.8
Calf mortalitly %	10.7	8.5
Weaning %	42.5	68.4
Weaning Mass kg.	123.5	180.4
Post weaning gain (7-18 month kg.)	89.7	105.9
Mass of weaner calf/cow/year kg.	52.5	123.4
Mass of 18 month calf/ccw/year kg.	90.6	195.8

Source: APRU, 1980: 9.

Table 2. Comparisons of Ranches and Cattle Posts in Ncojane, Botswana

	Calving %	Calf Mortality as %	Calf wt. Kg at 7 mt.	Calf wt. Kg at 18 mt.	Mortality all age groups %
Ranches	41	0.8	147	263	6
Cattle Posts	46	1.5	121	212	6

Source: APRU, 1979: 80-83

Table 3. Comparison of Herd Performance on Botswana Cattle Posts and Freehold Ranches

Smaller Herds

YEAR	Average Herd Size (Class 1-100)		Ratio of Births to cows		Ratio of Deaths to total cattle	
	C.Posts	Ranches	C.Posts	Ranches	C.Posts	Ranches
1979	28.8	61.0	59.5	66.7	11.2	16.0
1980	26.0	61.8	61.0	55.6	17.0	9.5
1981	26.0	27.6	61.4	66.7	16.5	12.5
1982	25.3	48.0	61.8	63.6	18.1	16.7

Larger Herds

YEAR	Average Herd Size Class 101+	101-500	Ratio of Births to cows		Ratio of Deaths to total cattle	
	C.Posts	Ranches	C.Posts	Ranches	C.Posts	Ranches
1979	165.6	267.5	56.2	64.3	10.2	6.2
1980	197.7	247.1	54.7	62.6	9.8	8.5
1981	213.7	267.9	53.0	66.7	10.0	8.7
1982	225.1	278.0	56.6	67.5	15.6	10.1

Source: Adapted from Hubbard, 1982 and Botswana Agricultural Statistics 1979, 1980, 1981, 1982.

Figure 1

WEIGHT GAIN PER ANIMAL AND PER HA.
AT DIFFERENT STOCKING RATES

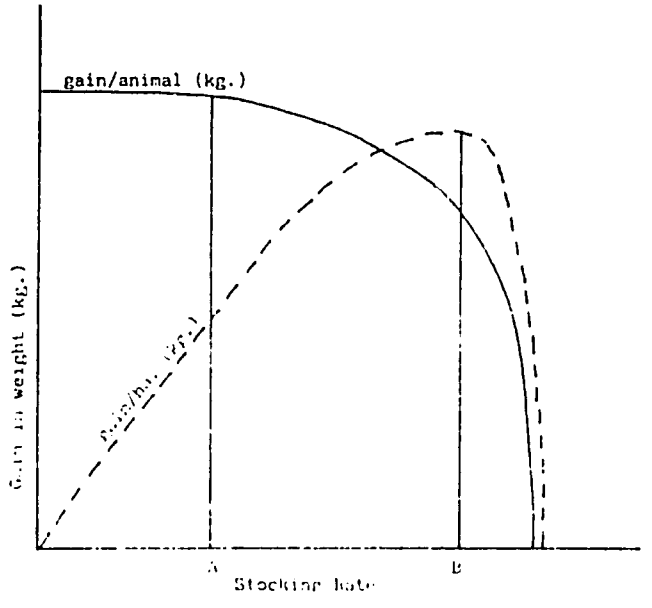

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Table 4. Protein Production in Extensive Grazing Systems

Region	Rainfall mm/yr	Herd Species	Animal Protein kg/ha/yr	Animal Protein kg/man/hr	Ratio of Fossil Fuel Energy to Labor (Million Joule/ Man hour)
USA					
Utah	200	lambs	0.3	0.3	105
New Mexico	200-500	diverse	0.5	1.4	142
Texas	500-900	cattle	4.5	4.3	172
Australia					
Pastoral zone	200-500	sheep	0.4	1.9	628
Wheat/Sheep zone	500-1000	sheep	5.5	1.0	218
Mali					
Transhumance	300-delta	cattle	3.2	.07	0
Sahel	300	diverse	0.4	.01	0
Savanna	300-800	diverse	0.3-0.6	0.01-0.04	0

Source: Penning deVries and Djiteye, 1982: 467 as cited in Stryl 1983.

Table 5. Original and Recalculated Comparisons of the Income to Ugandan Pastoralism and Ranching

Income Measures	Original Results[1] (in US $) PASTORALISTS Nyabushozi	Karamoja	RANCHES Ankole	Revised Results[2] (in kg. grain) PASTORALISTS Nyabushozi	Karamoja	RANCHES Ankole
Income/Hectare	7	7	7(8)[3]	24	24	11(12)
Income/ME (labor force)	163	175	2264	567	567	3735
Income/Head (cattle)	10	11	13(14)	34	34	21(23)

Source: Adapted from Ruthenberg, 1980:

Notes:

1. Income valued in U.S. dollars.

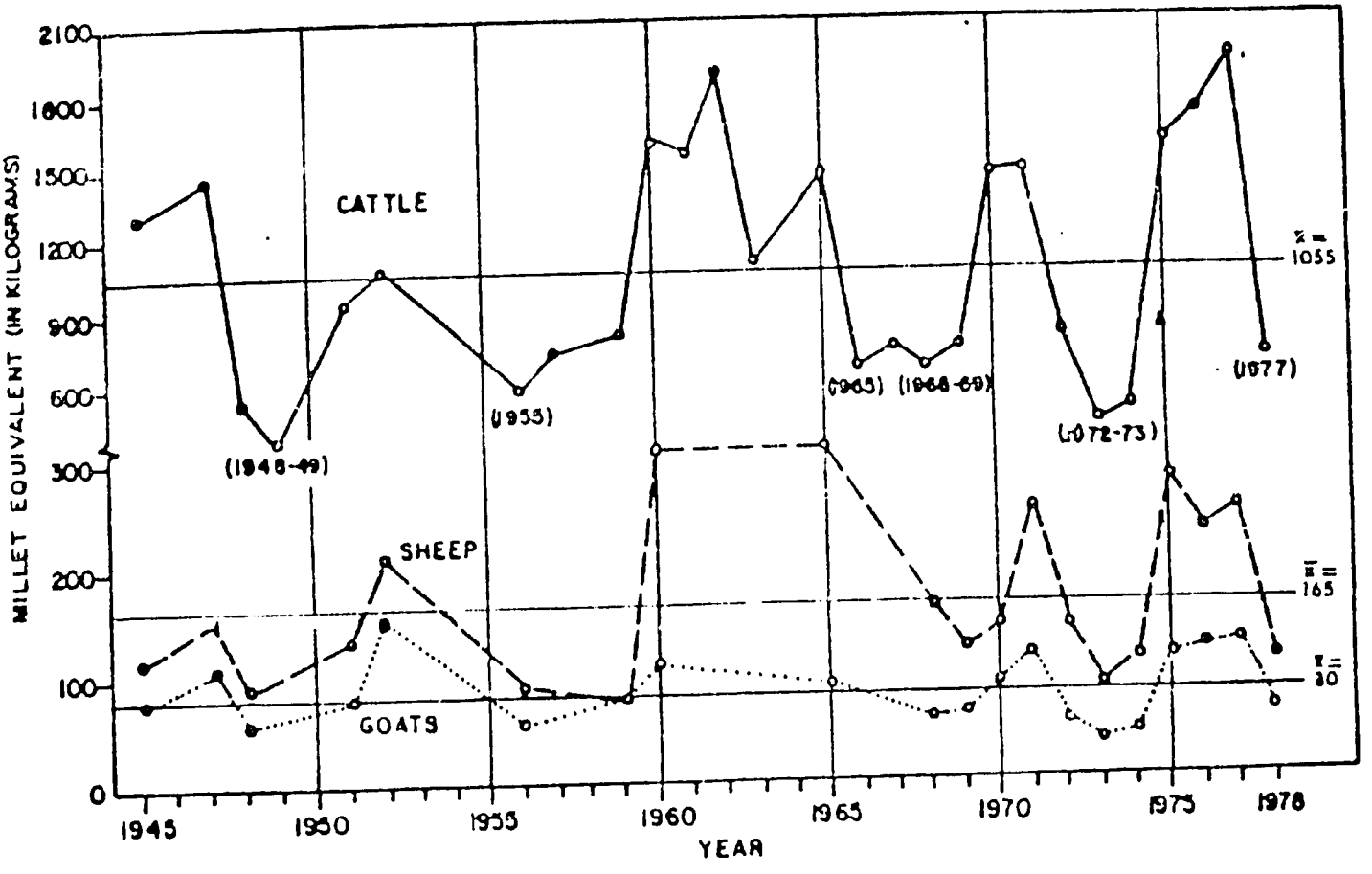
2. All returns expressed in Kg of consumable grain based on the following conversions:
   (i) $91=200 kg meat=150 kg of consumable grain based on Dyson-Hudson and Dyson-Hudson (1969).
   (ii) Assume that sold pastoral animals produce 180 kg of meat and ranch animals produce 200 kg of meat.
   (iii) 200 Kcal/100 grams of meat, 65 Kcal/100 grams of milk, and 360 Kcal/100 grams of corn meal (Teitelbaum, 1977).

3. Derived without deducting the costs of hired labor. Applies to all values in table within parentheses.

Figure 2

TERMS OF TRADE OF ANIMALS FOR MILLET IN NIGER

TANOUT ARRONDISSEMENT



Note: Dates in parentheses indicate the impact of bad harvest years.

Source: Sutter, 1982: 49.

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Table 6. Comparison of the Economic Performance of Different Livestock Systems in Kenya's Maasailand[1]

Criterion of Productivity	Undeveloped Group Ranches	Developed Group Ranches	Individual Ranches
Offtake rate as % of Cattle[2]	11.9	8.4	9.5 (15.8)[3]
Gross Output/Herd-Capital ratio %[4]			
Sales only	14.9	13.2	17.6
Sales & Subsistence	25.1	25.0	23.2
Net Output/Herd-Capital ratio[5]	23.1	21.4	21.8

Source: Sanford, 1983: 125 based on Meadows and White, 1981.

Notes:

1. Land is communally owned on the group ranches and privately owned on the individual ranches. Developed group ranches have access to some modern technical inputs, while the undeveloped group ranches essentially represent the unimproved Maasai pastoral system.
2. Includes offtake for both sales and subsistence purposes.
3. Includes animals purchased for fattening and resale.
4. Includes milk.
5. Includes all livestock (small stock and cattle) and is based on milk sales and subsistence production. Excludes animals purchased for fattening and resale.