The Case for New Domestic Animals

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You do not grow bananas in the north of Scotland or raspberries in the Serengeti. Similarly temperate-zone cattle are not suited to Africa's semi-arid lands but giraffe and eland thrive. So these and other wild species, says the author, should be domesticated for such lands—40 per cent of Africa south of the Sahara is semi-arid—with cattle farming restricted to the highlands. In addition, research on new systems of management should aim to make use of the wild animals' preferences for different grasses, bush and browse—from the tree-top using giraffe to the root-digging warthog.

Drought, and the tragedies that follow, are by no means a new problem in Africa's pastoral areas, and today a grave threat hangs over the remaining pastoralists and their families. Desert encroachment is accelerating, and, despite a clear statement by the 1968 UNESCO Biosphere Conference in Paris, calling for an ecological approach to tropical land use, the current animal production proposals for Africa virtually ignore African ecology. These proposals seek to impose on Africa a grazing land-use policy directly transported from the temperate climate of northern Europe.

To me this approach is wrong. To expect that animals adapted to a temperate climate should suit all the contrasting climatic conditions of the African and Asiatic continents—where the need for improved nutrition is most urgent—and where there is already a range of animal and vegetable species uniquely adapted to the climatic conditions, is, to say the least, unreasonable.

One most difficult problem is that the protagonists are polarised on two extreme views; the first that cattle, sheep and goats are the only species worth considering, the second that in Africa wild species are more productive and should replace the domestic. Both views are unbalanced. The right criterion is to use the animal and vegetation species most suited to the environment. You do not grow bananas in the north of Scotland, or raspberries in the Serengeti; similarly temperate-zone cattle are not much use in Lapland or in country suited to oryx. Only a small proportion of Africa is highland and suitable to cattle. The bulk of the continent either has a high rainfall and is riverine or is semi-arid, the latter being by far the largest in area (40 per cent of all land south of the Sahara), and no conventional agricultural technique is applicable to both; the former is too productive, the latter is dominated by water limitation.

The greatest threat to Africa, the Middle East and Asia is land degeneration and desert encroachment; any wise development policy must include the reversal of desert encroachment. Research in the semi-arid habitat should be designed to release the optimum

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productivity of the drought-resistant animals and the vegetation complex in a manner which ultimately will lead to the reclamation of arid areas.

In a previous issue of *Oryx* (September, 1972) I described briefly the more recent history of the wild fauna and land use. The biological principles behind this challenge are particularly important because the recent proposals by the African Livestock sub-committee of the Consultative Group on International Agricultural Research, ignored the semi-arid and natural ecosystems. (They are now being actively considered.) The reason is probably to be found in a paper by two of the authors, Tribe and Pratt (1973), who, at the recent World Conference on Animal Production, claimed that those animals which can best satisfy man's needs have already been domesticated. Species like the eland were said to be less efficient (Taylor and Lyman, 1967), to have a higher nitrogen loss from the urea, to need a wide range, and biologically to be no different from cattle. Hence, 'there is every reason to believe that man's intensive breeding of cattle for meat production has produced an animal superior to antelopes under these conditions (Taylor, 1970). This paper, however, presents only half the picture.

The historical argument against new domestic species has little substance. Man usually does what is easiest and seldom enquires whether it is biologically sound; a policy which in the past has not been without its adverse consequences. Because man domesticated cattle some 10,000 years ago does not mean either that we are incapable of using or have no need to use other animal systems.

The absence of any domestication programme in Africa could have many simple explanations. Even in Britain the 'intensive' use of cattle and pigs is only about 200 years old, the major developments having occurred within a period of less than a hundred years. In West Africa the guineafowl was domesticated but not in East Africa. In fact, the spread of cattle largely followed the waging of successful military campaigns, and had we been conquered by the Incas we might well be eating llama instead of beef. It is interesting to note that in Australia the bulk of cattle farming has now become climate-orientated and is found in the cooler Victorian climates around Melbourne, whilst in the tropical northern regions buffalo production is proving remarkably successful (Tulloch, 1970).

Priority for Efficiency

On the specific question of comparative conversion efficiencies it is of interest that whilst the Taylor and Lyman (1967) reference quoted by Tribe and Pratt (1973) provides evidence that eland, for example, are less efficient converters than cattle, Rogerson's work (1968) indicates similar efficiencies, and indeed, under controlled laboratory conditions, eland may be more efficient. Recent studies by Amman in East Africa support Rogerson's findings. Hence it might look as though you simply quote the paper which suits your attitude. But if one examines the details the two results are not incompatible.

EROSION: the start of another desert

https://doi.org/10.1017/S0030605300011960 Published online by Cambridge University Press

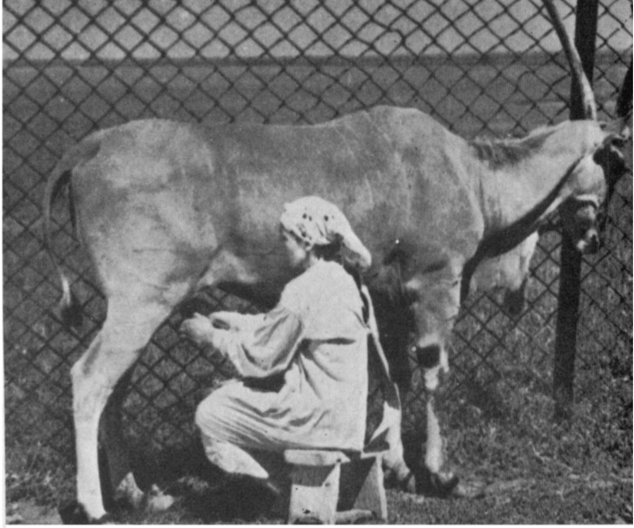
An animal can defend itself against heat stress either by controlling body temperature through evaporation of water, or by abandoning the maintenance of constant body temperature and adapting to change. The semi-arid species permit wide fluctuations in body temperature (32°–45°C) but this involves energy expenditure. A low body temperature is associated with an increased metabolic rate, so the animal must eat more, a seemingly inefficient exercise. But temperatures are low at night and the leaves of the deep-rooted vegetation are filled with water after the evaporative loss in the heat of the day; thus the animal can satisfy its water requirements from food and is independent of surface drinking water. Consequently, an apparently low conversion efficiency for nitrogen is a gain in efficiency for water utilisation which is a considerably more important factor in arid and semi-arid climates.

Advantage to Eland

The marginally greater loss of nitrogen from eland urine compared with cattle could again contribute to the over-riding consideration of water gain from the food especially if nitrogen/water balance in the food is such that nitrogen is in excess of limiting water. As the liveweight gain of eland is 0.73 lbs/day and for cattle on moderately managed East African rangeland 0.3 lbs/day (Talbot, Ledger and Payne, 1962) it is clear that any minor differences of conversion efficiency or increased nitrogen losses from the urine are not restricting the eland's overall performance. Hence one can understand how it is possible for one author (Rogerson, 1968) to examine eland and wildebeest under controlled laboratory temperatures and find conversion efficiencies similar to cattle, whilst Taylor and Lyman (1967), who were interested in the critical matter of water conservation, report on the reduction in conversion efficiency at reduced temperature. Indeed it is the variability in performance which is important. The eland's early morning body temperature can be as low as 32.8°C and rise to 42°C at midday; it can exceed air temperatures and lose heat to the atmosphere. As a

AFRICAN BUFFALO. Their long gestation period (compared with cattle) ensures that calves are born in the next rainy season; the shorter period for cattle may mean that calves are born before the rains.

https://doi.org/10.1017/S0030605300011960 Published online by Cambridge University Press



AFRICAN ELAND being milked at Askanyia Nova, in the Crimea, in the USSR, where there is a domesticated herd. The milk has more fat and protein and less water than that of domestic cattle and is more resistant to some bacteria.

result it does not require to pant or sweat and may never need to evaporate water for heat dissipation (Taylor 1970). Furthermore, such species have a high efficiency for oxygen extraction by the lungs, which again means less water loss for every unit of oxygen gained, and, in comparison with cattle, intestinal water absorption is more efficient, the antelopes producing hard dry faeces in contrast to the bovids.

Given these biological differences between cattle and antelopes it is impossible to sustain the view that there is no meaningful difference between them relevant to utilisation.

The Overall View

Although the use of nitrogen retention can be seen, in the example I have given, where water is a limiting factor, to be an inappropriate measure of efficiency, there are other reasons why the use of nitrogen retention alone is an over-simplication that is no longer justified. For example, domestic cattle bred and fed to produce a standard 30 per cent carcass fat, in fact produce three times as much fat as solid nutrient; strictly speaking this is 'fat' not 'nutrient' production and the real function of animal production is to act as a high quality food resource. Such a balance so heavily in favour of fat (a non-essential energy source) has been criticised, particularly in view of the medical concern over the increasing incidence of heart disease in younger people (Crawford and Crawford 1973). Extensive methods of animal rearing are the converse of the intensive: at a 5 per cent carcass fat and 75 per cent lean, the carcass nutrient value is three times that of the non-essential fat.

What is easily demonstrable is that if one is concerned with a balanced and sensible food structure, either for aid to developing countries or for the overfed West, there is a clear need for nutrients. A 30 per cent carcass fat produces more energy than nutrients. Extensive free-living systems produce more nutrients than energy. This example illustrates the pitfalls of limiting considerations of conversion efficiency to nitrogen without looking at the overall problem.

New Management Systems

The policy for developing and expanding animal production in Africa should have two aspects: to improve cattle husbandry in the appropriate regions—which is largely the application of existing knowledge—and to initiate research into additional new systems of livestock management so that the full range and potential of the African ecosystems can be exploited. The detailed biological reasoning for incorporating wild species into our domestic system has been presented by Fraser Darling 1960, Talbot *et al* 1962, Crawford 1968, Retief 1971, Dasmann 1973, Crawford & Crawford 1973. We disagree with others on one major point: the present practice of 'game cropping'. Fundamentally, disease control, utilisation, effective range regeneration and management cannot be exercised unless animals are sufficiently tame to handle. This means a form of progressive domestication.

That domestication is feasible has been demonstrated by Treus and Krevchenko (1968) and Posselt (1963, also by well-run zoological gardens, and by the current successful programmes of buffalo domestication in Gujarat (India), northern Australia and Trinidad, for milk and fully inspected meat. The reason for incorporating new species is simply that they are biologically adapted to the climate and vegetation with respect to water balance and temperature regulation, and it is the semi-arid systems which urgently need tackling because the principles involved give some hope for reversing the accelerating desert encroachment.

Moreover, the food selection patterns of wild species are complementary. The deep-rooted vegetation is the key to the success of the semi-arid system. Unlike the surface-feeding grass pastures of temperate regions, the deep-rooted system taps the deep water tables and the minerals distributed in the soil below the surface. The complementary feeding patterns of wild animals, with resources ranging from the tree tops for the giraffe to roots for the warthog, open up the potential for an optimum three-dimensional productivity both below and above ground.

Complementary Food Selection

Basically, we have two potential techniques for converting vegetation into animal products:

1. *Monoculture:* the use of a single species. For example, for the semi-arid regions the eland *Taurotragus oryx* would be chosen: it has already been domesticated, can be milked (Posselt, 1963; Treus and Krevchenko 1968), is amenable to management, has highly palatable meat (*Nature*, 1971) and is adapted to eating both grass and browse foods, high temperatures and to little water. In other areas however, wildebeest could be used, and smaller herbivores like Thomson's gazelle and Uganda kob could be particularly valuable.
2. *Polyculture:* the use of a wide spectrum of herbivores utilising different aspects of the vegetation. The complementary food selection pattern could ultimately be developed into a system of crop rotation at a secondary level.

The use of a browsing monoculture and the development of a

https://doi.org/10.1017/S0030605300011960 Published online by Cambridge University Press

THE BROWSER. Despite the formidable thorns on *Balanites*

polyculture system would seem preferable to the alternative method of irrigation with bore hole or fossil water, for the rapid rate of surface-water evaporation makes such a method very expensive and inefficient in terms of water. The consequent sinking of the water table, drying of surrounding areas, increasing salinity of the water, and climatic changes with the high risk of dust-bowl formation are too well established to recommend irrigation where surface water is the limiting factor.

The monoculture would appear to be less reliable than polyculture, being more likely to lead to stagnation of soil and vegetation (Fraser Darling 1960), but it has the advantage of simplicity. In this case, the suggestion is simply to farm eland and bush in semi-arid regions, in the way that cattle and grass are farmed in temperate, well-watered zones.

Polyculture is ecologically more viable because it involves a broad spectrum of vegetation which theoretically could be managed to maintain or even improve soil condition. It is more difficult because the number of variables increases with the number of plant and animal species employed. Nonetheless, the ultimate goal, to arrest erosion and reverse desertification, should be given the highest priority undeterred by difficulties.

Tribe and Platt (1973) criticise the view that erosion is only caused by domestic animals, and cite the erosion of Tsavo National Park as an example of how wildlife, too, can cause degeneration. Is it reasonable, they ask, to believe that man chose to domesticate the only species capable of causing erosion! Of course, in these cases it is not the animals which cause the erosion, but man's use of the animals. The elephants damaged Murchison and Tsavo National Parks because human settlements cut their migration routes and made the parks the only safe place for them (Laws and Parker, 1968). In other words man turned the parks into an overpopulated elephant monoculture. We can also understand how acacia savanna in Kenya's Masailand will support 70,000–100,000 lbs/square mile of standing crop in a mixed population of wild ungulates, and only 11,000–16,000 lbs/square mile of cattle, sheep and goats. Apart from the biological differences in adaptation to heat stress, farming practice for centuries recognised the fact that to sow the same crop in the same field year after year resulted in a rapid soil depletion; crop rotation prevents this. A polyculture of wild ungulates can be likened to a sophisticated system of crop rotation at a secondary level. It is the ecology, not the species, that is critical.

Polyculture in Semi-arid Regions

Basically, a polyculture in East Africa could consist of the following:

Giraffe	Top browser
Eland	Mid-level browser
Kudu	Thick woodland
Oryx	Open grassland
Hartebeest	Low level browse and some grazing
Grant's gazelle	Grazing and some browsing
Oribi	Open grazing

Obviously many variations on this general theme could be used. There are also two separate ways in which the polyculture could be developed: the oryx and oribi tolerate high midday temperatures and exposure to full sun, while eland and giraffe seek shade and woodland; hence, separate areas could be set aside for grazing-orientated and for browsing animals.

It is of paramount importance to improve (or restore) the wood and bushland, because it is largely the deep-rooted vegetation, with its shade, water, and humidity control for smaller plants, that holds the key, not only for productive use but also for land regeneration and the ultimate reversal of desert encroachment.

It is often said that because eland, giraffe and other wild browsing species have a wide range they cannot be maintained in a small area. As browsers they survive with difficulty on a grassland pasture and serious management mistakes have been made in this respect. Their tissue chemistry reflects a high intake of essential vegetable oils

(Crawford *et al.* 1970). However, in areas like southern Karamoja where the vegetation is thick and still relatively unspoilt by overgrazing and fire, they remain within a small locality all the year round. Similarly, the great wildebeest herds of the Serengeti migrate hundreds of miles across the plains, and yet nearby, between Mara and Tarangire, where the vegetation cover is good, there are resident wildebeest that do not migrate.

Perhaps the most interesting polyculture concept is that of crop rotation at a secondary level. If a browsing group is followed by a grazing group the browse has a chance to recover; in this way, the complementary feeding patterns of the animals can be developed into a form of crop rotation with its inherent advantages.

Polyculture in High Rainfall Areas

The riverine and high rainfall areas have a different spectrum of animal species from the semi-arid zones, but they too have complementary food selection patterns. The buffalo with its sharp teeth can eat the tufted grasses like *Sporobulus,* which slip between the lips of the grazing hippopotamus with its lateral swinging head movement; but the hippo lifts the creeping grasses like *Cynodon* with its lower lip and ingests them in quantity.

Vesey-Fitzgerald (1965) has commented on what he calls successional grazing. For example, *Vossia* grows so rapidly in the seasonal swamps during the rains that it is impossible for small species to eat it, but the buffalo can eat these tall grasses, and, in so doing, trample them down, allowing small shoots to sprout from the nodes that have been pressed to the ground. Thus the smaller animals, following after the buffalo, can eat these fresh sprouts.

In the high rainfall areas, the species with potential are:

Elephant	**Forest and woodland management**
White rhinoceros	**High rainfall, high productivity grassland**
Hippopotamus	**Riverine zones, creeping grasses**
Buffalo	**Tufted grass and bush**
Topi	**Plains grazing, slow browse**
Kob	**Grazing, short grass**
Warthog	**Rhizomes, bulbils and grazing**

The basic productivity of the tropical rainfall zones is the highest the world's land mass has to offer; it can be in the region of 60 tons per acre per year. But we have as yet no method to harness the yield of these highly productive areas, and large mammals could be very effective tools.

A Three-tiered Policy

Thus the semi-arid and high rainfall extremes suggest the possibility of a three-tiered system of land management in the tropics:

1. High rainfall—high productivity—large mammals;
2. Moderate rain and climate—cattle;
3. Semi-arid—giraffe, eland, etc.

Conclusion

It is possible that in the near future Africa could double the present world meat production of about 75 million tonnes by using only half of the available semi-arid and high rainfall zones, if their potential can be released.

Basically the thesis is simple. In semi-arid regions the fauna and flora adapted to the environment should be used rather than attempt to make the environment adapt to an exotic animal. At the same time there is room for cattle development in appropriate areas, and this mainly means the application of existing knowledge. Finally, there is room for new livestock management systems based on ecological conditions: no contemporary agricultural tool is suited to either the semi-arid or the high-rainfall regions, and productive research is urgently needed. The rate at which the target is achieved will largely be dependent on the energy invested.

References

CRAWFORD, M. A. 1968. *Br. vet. Rec.*, 82, 305.
CRAWFORD, S. M. & CRAWFORD, M. A. 1973a. What We Eat Today. London.
CRAWFORD, S. M. & CRAWFORD, M. A. 1973b. In: Animal Agriculture, (Eds. H. H. Cole and M. Ronning), San Francisco. In Press.
CRAWFORD, M. A., GALE, M. M., WOODFORD, M. H., and CASPERD, N. M. 1970. *Int. J. Biochem.*, *1*, 295.
DASMANN, R. 1973. Ecological Principles for Economic Development. IUCN and Wiley.
FIELD, C. R. 1968. Symp. zool. Soc. Lond., No. 21, 135–151.
FRASER DARLING, F. 1960. Wildlife in an African Territory. Oxford.
LAWS, R. M. and PARKER, I. G. C. 1968. In: Comparative Nutrition of Wild Animals, Symp. zool. Soc. Lond. No. 21, p. 289. (Ed. M. A. Crawford), New York and London.
Nature 1971 Editorial, *231*, 209.
POSSELT, J. 1963. *Rhod. J. agric. Res.*, *1*, 81.
RETIEF, G. P. 1971. *J. S. Afr. vet. med. Ass.*, 42, 119.
ROGERSON, A. 1968. In: Comparative Nutrition of Wild Animals, Symp. zool. Soc. Lond. No. 21, p. 153 (Ed. M. A. Crawford) New York and London.
SIMON, N. 1962. Between the Sunlight and the Thunder. London.
TALBOT, L. M., LEDGER, H. P. and PAYNE, W. J. A. 1962. Proc. VIII Int. Congr. Anim. Prod., III, 205.
TAYLOR, C. R. 1969. *Scientific Amer.* **220,** 89.
TAYLOR, C. R. 1970. *Am. J. Physol.*, *219*, 1131.
TAYLOR, C. R. and LYMAN, C. P. 1967. *Physiol. Zool.*, *40*, 280.
TREUS, D. B. and KREVCHENKO, D. 1968. In: Comparative Nutrition of Wild Animals, Symp. zool. Soc. Lond. No. 21, p.395, (Ed. M. A. Crawford). New York and London.
TREVELYAN, G. M. 1944. English Social History, Longmans, Green, London.
TRIBE, D. E. and PRATT, D. J. Proceedings of 3rd World Conference on Animal Production, Melbourne 1973.
TULLOCH, D. G. 1970. *Aust. J. Zool.*, *18*, 399.
UNESCO 1968 Final Report of the Inter-Governmental Conference on the Scientific Basis for Rational Use and Conservation of Resources of the Biosphere.
VESEY-FITZGERALD, D. F. 1965 *E. Afr. Wildl. J.*, *3*, 38.

https://doi.org/10.1017/S0030605300011960 Published online by Cambridge University Press