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The Relevance of Animal Physiology to Animal Production in Kenya

THE INAUGURAL LECTURE SERIES was started in the days of the University of East Africa when it was a tradition of the then University College, Nairobi to have its newly appointed Professors deliver their first public Lecture in Nairobi. In the new series of lectures by the University of Nairobi, Professors deliver their Inaugural Lectures after a period of adjustment upon appointment when their topics respond more directly to the changing needs of the society they serve. Professor David Robertshaw typically illustrates this point when discussing how research into a basic science, such as physiology, can be related to the needs of Kenya.

An academic staff member must carry out research in addition to his teaching duties, if he is to effectively transmit his knowledge in an attempt to create solutions to some of the current social and scientific problems, but in the basic medical and veterinary sciences, this is sometimes difficult to achieve. Research in animal physiology by the University of Nairobi, can and should be related to the needs of Kenya, especially when the development of agriculture is of prime importance to the economy of the country. Work undertaken in the Department of Animal Physiology is therefore directed towards understanding the nutrition of ruminant animals, the effects of the different environments in Kenya on productivity, and the nature of infertility resulting from a low plane of nutrition. Professor David Robertshaw is thereby convinced that this field of research should be expanded by joint international support, not only because of the benefit to the country, but also to the local scientific community.

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David Robertshaw

David Robertshaw was appointed as the first Professor of the Department of Animal Physiology (formerly the Department of Veterinary Physiology) in 1969. He is a graduate of the University of Glasgow where, for two years, he was an Assistant Lecturer in the Department of Veterinary Physiology. He first came to East Africa in 1960 as a Research Officer at the East African Veterinary Research Organization, Muguga, and then, in 1963, became a Senior Scientific Officer at the Hannah Dairy Research Institute in Scotland, the Physiology Department of which is concerned with the effects of heat on the productivity of cattle. He returned to Muguga in 1966 for 16 months on secondment, and was an Honorary Lecturer in the Faculty of Veterinary Science. He has also worked and lectured in Sweden, Australia, Israel and the U.S.A. His main research interest is thermoregulation of man and animals.

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THE RELEVANCE OF ANIMAL PHYSIOLOGY TO ANIMAL PRODUCTION IN KENYA

There is always a conflict of interests in the life of a University academic. His main function is to teach but he is also expected and encouraged to carry out research. From the point of view of progress in his career he is usually evaluated on his research publications. There is a strong temptation, therefore, for him to pursue his research at the expense of his teaching duties. Until there is some means of assessment of teaching ability then the standard of teaching in Universities is bound to suffer. This, I would suggest, is one of the major causes of student unrest at present being experienced in many parts of the world and has led, in some instances, to an evaluation from undergraduates of a University member of staff before any promotion is made. This may be a good thing as long as it does not form too large a proportion of the assessment. Some of the cries of undergraduates have not gone unheeded. At a recent International Conference I attended there was a special section on teaching methods. Part of this, I must admit, was stimulated by the increase in availability of new "toys" generally known as audio-visual aids which are thought to improve communication. The results of this symposium made one suspect that possibly the best audio-visual aid in teaching is a good lecturer with a piece of chalk and a blackboard. There are, however, faults on both sides; one sometimes feels disappointed that the results of enthusiasm and hard work by a dedicated teacher are not transferred to those who are taught. This is not a common fault of our Kenyan undergraduates, who show a remarkable capacity for hard work, and a thirst for knowledge.

There is a tradition, originating in mediaeval times, that centres of higher learning should not be asked to justify the type of research they undertake, it being understood that their search for the "truth" is sufficient justification. However, when their research begins to cost money, and in scientific research today it can be very expensive indeed, then it would seem only fair that research in Universities, and here I include other centres of higher learning, should no longer simply be the whim of the individual. The relevance of research is now being sought more than ever. Since the second World War there has been an enormous

investment in research, but the return from that investment is now being questioned. This has resulted in a great deal of disenchantment with the achievements of scientific research and a degree of recession in science has resulted in some parts of the world. There is now in some fields of science an over-production of graduates and post-graduates, and prospective employers are questioning the courses being given in Universities.

It might be argued, therefore, that research in a young developing University is as unnecessary as it is expensive and that all efforts should be directed towards undergraduate training. This thinking is false and such attitudes must die. The training of post-graduates needs to continue as well as that of under-graduates; secondly, the quality of undergraduate teaching in a department in which there is an active research programme tends to be enhanced; the constant stimulus afforded by research is essential for the well-being of the academic mind in the same way that oil is required for the smooth running of a car engine; a lack of oil causes it to seize up!

What kind of research should be carried out, therefore, in institutions of higher learning in developing countries? Should it be the traditional pursuit of learning for the sake of knowledge, or should it be relevant to the needs of the country? The answer should be obvious. In some subjects, the relevance and importance is self-evident. Thus, for example, the results of research into the diseases of both animals and man have great importance to the economy of the country. However, in the basic sciences of human and veterinary medicine, that is physiology, anatomy, and biochemistry, the relevance of the subjects to the needs of the country is not always so apparent.

This lecture, then, is a sort of apologia in a somewhat light-hearted manner for the research programme of the Department of Animal Physiology and a justification for the existence of a Department of Animal Physiology in the University of Nairobi.

Physiology is the science of the processes of life, which can thus be divided into plant physiology and into animal physiology. Animal physiology can be further sub-divided into the classes of animals which it describes. Thus, we have insect physiology, and the University of Nairobi has a prominent insect physiologist amongst its staff,

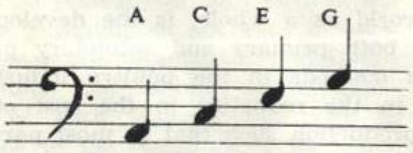
Prof. Odhiambo, who will tell us more about his field in a subsequent lecture. Similarly, there is the physiology of fishes, and, once again, Prof. Hyder is going to enlighten us on the sex life of the Tilapia. Also, there is the study of the life processes of man, and a Department of Medical Physiology exists in the University of Nairobi. Why then do we need a Department of Animal Physiology, which, in the context I am going to speak about, is really the physiology of mammals? The gap between Human and Animal Physiology is a very narrow one; man has elevated himself from other members of the animal kingdom but the difference between man and other animals is the enormous development of his brain, otherwise his bodily functions are very similar. Animal physiologists quite often use man as their experimental animal and likewise the Department of Medical Physiology has just discovered how interesting the sheep can be as an experimental animal.

We are mainly concerned in examining the function of domesticated animals, since we teach physiology to both veterinary and agricultural students. Other potentially productive mammals, such as some of the game animals of East Africa, are also of interest. Another field with a great productive potential, not only in East Africa but in the world as a whole, is the development of birds as both primary and secondary producers. Intensive methods in the poultry industry have resulted in the reduction in the cost of animal protein production such that in most parts of the world this is now the cheapest form of high quality food. We feel, therefore, that we can make little contribution in this field.

Kenya has an economy which is largely agricultural, a large proportion of which is devoted to the production of meat, milk and milk products. The full development of this potential is only just starting. Once the export markets have been obtained, then we might expect to see an enormous expansion in this field. Almost certainly, the use of the large areas of, at present, unproductive land will be determined by the ability to maintain animals on them. Of the meat producing animals of the world, by far the most successful and largest are the ruminant animals, and the physiology of these animals is, therefore, our main interest. One of the most successful of the ruminants from the point of view of its ability

to produce both meat and milk is the cow, although I recently saw in Israel sheep being developed as a milk producing animal. The goat for some years has similarly been used for milk production. The development of sheep and goats as milk producers might, therefore, be seriously considered in the agricultural development of Kenya. Since the cow occupies a key position in the livestock industry of Kenya then its physiological processes should be, and is, our prime concern. Basically, the question we really ask, therefore, is "what is a cow?". A former colleague of mine, who had the ability to stimulate discussion, once suggested that the question we should really ask ourselves is "why is a cow?". However, this is a problem for the student of metaphysics, and also questions the divine origin of nature, although, as scientists, I think we sometimes forget to ask this type of question.

The main characteristic of cattle is that they can convert grass into meat. Students of music probably have never realised their potential as physiologists when they created the mnemonic "All Cows Eat Grass" which stands for the notes of spaces of the bass clef.



Man could probably exist on grass and can certainly live on a diet solely of plant material. I think he is unlikely to make a very good job of digesting grass as I have yet to see a true vegetarian, that is one who eats *only* plant material, who looks fat. Cattle, in common with other ruminant animals, have developed a large stomach (the rumen) in order to be able to digest the thick cellulose walls of the plant cells which constitute their diet. This they do with the aid of bacteria and protozoa, and the digestion of cellulose by bacteria and protozoa takes place in this huge stomach. The bacteria and bacterial products are then digested by the cow. The cow, in fact, feeds the bacteria who then feed the cow. Another

adaptation which they have developed, which may appear to us as rather disgusting, is that of regurgitating their food, rechewing it and then reswallowing, the act known as rumination, hence the zoological classification. By a fairly simple surgical operation, one can make a small hole or fistula in the side of a cow, so that the events taking place in the stomach can be observed. The stomach is seen to be constantly mixing together its contents to facilitate the fermentation processes. The whole procedure is reminiscent of a cement mixer or a fermentation vat. Interest in the movements of the ruminant stomach and the biochemistry of the processes that take place has been very great over the past thirty years, and a very good understanding of the digestive process has now been obtained. It is amazing what this digestive mechanism can cope with. There seems to be no limit to the variety of substances that can provide nutrient material for ruminant animals. A friend of mine working in the Persian Gulf area maintains that a large part of the diet of the goats in that region consists of discarded cement bags. Although this may be exaggerated, there is a certain amount of truth in it; paper after all, is made from wood. Orange peel, which is normally unpalatable, is a by-product of the Jaffa orange industry of Israel. If this is allowed to ferment it then becomes palatable to cattle and a valuable foodstuff. Similarly, the waste products of the brewing industry, known as brewers grains, which are really the unfermented remnants of barley, are extremely palatable, and readily taken by cattle. In the 1930s it was also noted that one could feed cattle on urea, which the bacteria in their stomachs could then convert into protein. In other words, a non-protein substance could be converted to a protein substance. Urea is a fairly simple substance which can be readily manufactured, and the feeding of urea has been developed to maintain cattle through the drought, in Australia and various parts of Africa. This has certainly proved to be one step forward in the search for readily available and cheap sources of animal foodstuffs.

Thus, is can be seen that cows not only eat grass but other materials as well, and are very versatile in their food requirements.

The process of meat or milk production may be simplified into the following equation:

Ruminant + plant food or urea = meat or milk.

The animal nutritionist and breeder have tried to speed up this equation by improving the quality of the food and selecting an animal with a high growth rate. Also by testing the hypothesis that if you feed a cow more food, you will get more meat. This supposition has been tested many times over the years and found to be false. There are limitations to how much food an animal will eat; cows, and for that matter many animals, adjust their food intake to their bodily needs. Man in this respect seems different. He seems to derive so much pleasure from the act of eating that he often indulges this pleasure and tends to over-eat. There seems to be a good correlation between waist measurement and success in business. The cow spends some eight or nine hours a day in eating, and it has been facetiously suggested that such a disproportionate length of time spent in feeding might make the activity somewhat tedious. One disadvantage of the local Zebu cattle is that they are slow maturing when compared with cattle from temperate countries. This could either be a genetically determined factor, or due to the fact that the animals just do not eat enough. An experiment was recently performed to see if supplementing voluntary food intake by placing food directly into the stomach through a fistula would improve growth rate. However, when this was done the animal simply reduced its voluntary intake of food by the amount that had been added directly to the stomach. Had this experiment been successful, i.e. if one could have increased the rate of growth by supplementing voluntary intake by direct introduction into the stomach, then one envisages cattle out in the field with some large device strapped on them containing their additional food supply. Improving the quality of foodstuffs certainly has a beneficial effect on productivity, but it has its limitations; as the quality improves so a whole series of digestive disorders appear; these appear to be due to the fact that on a high quality diet bacterial fermentation in the stomach is so rapid that the animal is unable to absorb all the end products of the fermentation process, and literally poisons itself. The chief end product is acetic acid, more commonly recognised as vinegar; the animal, therefore, literally pickles its stomach lining. With the intensification of methods of animal production in Kenya such problems are bound to arise. Work is at present in

progress in the Department of Animal Physiology into the nature of these digestive disorders.

Although Zebu cattle are slow to mature, they have many advantages over those from temperate countries, in that they can survive and even thrive in areas of low rainfall, on a poor quality high fibre diet. Desert survival is of great interest to physiologists and factors associated with desert survival could be of great use to the understanding of animal management in arid or semi-arid areas. It is here that our studies extend to other domestic animals which live in the desert. It always seems to me remarkable that in the northern areas of Kenya the camels and goats can look fat in what appears to be a barren waste. There are several factors contributing to their ability to thrive. It is known, for example, that Zebu cattle can digest a high fibre diet more efficiently than cattle from temperate countries. Some of the reasons for this have been elucidated by the physiologist and appear to be due to a high rumen fermentation rate. Another important adaptation is the ability to go without water for several days. The camel is notorious in this respect, although one has to be careful here to separate mythology from fact. Claims of the ability of the camel to go without water are usually much exaggerated. Similar claims were made some years ago about the ability of the Bedu arab to survive desert conditions and tales were told of his camel-like qualities. This was tested recently, and the ability to withstand dehydration was tested in both British soldiers and Bedu arabs. The results of the experiments showed no difference between the two groups of people. When the results became known, the Bedu were asked how they managed to go without water for such long periods of time; they treated the question with a certain degree of incredulity, and indicated that it would be stupid to go without water in the desert! What is fact, however, is that several of the East African antelopes, for example, the oryx (*Oryx beisa*) live in areas where there is no available drinking water. As with the reports of snow on the Equator in the early days of East African exploration, so this seemingly incredible feat was dismissed for many years. However, the pioneering work of Dr. C. R. Taylor of Harvard University here in Kenya has shown that animals can survive without water mainly through their ability to concentrate their urine, i.e. to retain water.

Physiologists then can advise the animal breeder that in his selection of cattle for dry areas, one factor he must consider is the animal's ability to tolerate a low water intake. If an animal has a high water requirement, then this limits the distance it can travel to available grazing land around a watering point. If an animal can go without water for several days and yet continue to feed and if the lack of water does not have a deleterious effect on its productive performance then watering points can be well spaced out. Dr. Taylor demonstrated that the oryx is able to increase his water intake by grazing at night. During the night the relative humidity of the air rises as temperature falls and the dried plants on which the animal feeds increase their water content accordingly — they act like blotting paper. In some areas of Kenya there is considerable dew formation at night which rapidly evaporates at dawn. We are currently trying to measure the amount of additional water cattle would obtain if they were allowed to graze before dawn instead of the current system used by pastoral tribes who only release their animals from enclosures after sunrise.

Another aspect of life in the desert is the ability to tolerate the high air temperatures during the day. Except for coastal regions, the Kenya climate is typified by fairly low air temperatures but very high solar radiation. The air temperatures are related to altitude, the higher altitudes having the lower temperatures. If an animal can, therefore, seek shade and find protection from the sun, then in most parts of Kenya heat stress is not a real problem. However, large parts of Kenya have no shade and the animals are subjected to the full effects of the sun. Many of the indigenous wild mammals of Kenya survive the harsh conditions and a study of the mechanisms whereby they withstand the impact of the environment gives us some idea of the factors one must look for in selecting domestic animals to survive similar conditions. This, of course, pre-supposes that domesticated and not feral animals are the ones that one wishes to keep in these unproductive areas. This argument on the relative merits of ranching game animals versus domesticated species seems to be interminable, and I don't wish to enter into it here. Unfortunately, I find that objectivity is difficult to achieve in these sort of discussions, and sentiment tends to cloud the issues. In studies at

present in progress in the Department of Animal Physiology, University of Nairobi, into this question of the ability to withstand high solar radiation, we have chosen to work on the hartebeest or kongoni (*Alcelaphus buselaphus cokii*). This animal is commonly found on plains without access to shade, and appears to have two mechanisms whereby it withstands the heat of the sun. A shiny coat reflects a large proportion of the sun's rays and the tip of the fur gets very hot; this heat is not transferred through to the skin, but is re-radiated to the surroundings. Thus the fur can be an essential barrier to the heat of the sun. We often think of fur as being a means whereby heat loss from the body is prevented. Any woman who owns a fur coat will verify its effectiveness in a cold climate. However, it would appear that it also prevents heat from entering the body. Most animals in Kenya also possess a pigmented skin; this is a protection against the burning effects of the ultra-violet rays of the sun, and is also, of course, a characteristic of people who are indigenous to tropical regions. As one progresses towards the Poles, then the skin pigment of indigenous people and animals gradually disappears. It is interesting that Queensland in Australia has the highest density of Caucasians within the Tropics and also the highest incidence of skin cancer. In animals imported from temperate countries and lacking pigment in the skin, particularly around the eyes which also lack any fur cover, the incidence of eye cancer is high. The two main adverse components of the desert environment, therefore, are lack of water and heat stress. A characteristic feature of mammals is that they maintain a constant body temperature; in fact, a rise in body temperature is usually one of our first indications of disease both in animals and man. The desert is a harsher place for large than small animals since the latter can burrow in the soil and avoid the heat of the sun during the day. Under hot conditions an animal loses heat by the evaporation of water. This may be from the skin as sweat or from the nose or mouth by means of increasing the breathing rate; that is by panting. Until relatively recently, it was considered that only man could sweat but it is now known that many other animals lose heat by this means, including the cow. An animal under desert conditions is trying to conserve water and yet at the same time requires water to maintain a constant

body temperature. A desert-adapted animal like the camel or the oryx foregoes the maintenance of a constant body temperature, or homeothermy as it is called, and allows its temperature to rise. This field of research has been one of our prime interests in recent years and we are now beginning to appreciate some of the adaptations an animal should possess for survival in the desert.

Most of the highly productive areas of Kenya are at an altitude of over 6,000 feet where the climate may be considered temperate, although as we have just noted, solar radiation is high. Night temperatures, however, can fall to freezing point at 9,000 feet and only a few degrees above this at 7,000 feet. A few years ago, we examined the effects of these low night temperature on Zebu cattle. They are well adapted for losing heat, but have few mechanisms for conserving heat. We found that they were, in fact, suffering from cold "stress". We used the rate of secretion of a small gland the adrenal cortex, as an index of "stress". This gland will respond to all types of "stress" non-specifically, whether it be environmental or even psychological. Likewise, it has been shown that cattle of temperate origin are "heat stressed" at lower, hotter altitudes. It would appear, therefore, that, bearing in mind the hazards of ultra-violet radiation, Zebu cattle should be kept at the lower altitude and cattle from temperate countries with their thick coats should be confined to cooler regions. I am not suggesting such a distribution of the human population!

In the dry season, which fortunately in Kenya only lasts for three or four months, the plane of nutrition tends to fall, or put more simply the needs of animals are not met by their food intake, and they therefore have to use their fat reserves. Under these conditions, the females cease to come into oestrous or "heat". Although this obviously protects the animals against the stresses of pregnancy during a period of starvation, this infertility is often prolonged beyond the restoration of body weight. In Zambia, which has a 6-7 month dry season, this is a major cause of low productivity but with a relatively short dry season of many areas of Kenya, it may be possible with a proper understanding of the physiological basis of this infertility, to suggest some solution for initiating oestrous a little earlier. The cause may be due to a deficiency of some of the hormones

that control the sexual cycle. Work is at present in progress in the Department of Animal Physiology into the nature of this disorder.

These illustrations, will, I hope, give some idea of the place of Animal Physiology in animal production in Kenya, and justify the work we presently pursue in the Department of Animal Physiology. The agriculturalist is perpetually presenting us with problems. He is able to say, for example, that a certain type of animal does not produce much milk when taken to coastal areas, although he feeds it well. We try and tell him why the animal is not adapted to that particular environment. We tell him why his cattle become infertile in certain areas; we explain the disturbances associated with intensive methods of management. Likewise, the ecologist is constantly providing us with problems; he wants to know why a certain animal is found in a certain habitat. The examples of the kongoni and oryx have already been given. He also wishes to be able to predict the chances of survival in the event of translocation to another habitat. This might be of importance if it is decided that game ranching is a feasible method of land utilization. An example of the type of question that the ecologist poses is shown by some recent studies on the waterbuck (*Kobus* sp.). These animals are never found more than 1 kilometre from water; is this because of a preference for the vegetation found near water or does the waterbuck require large quantities of water? The studies of Drs. Taylor and Spinage at Muguga demonstrated that they have a poor ability to concentrate their urine, they produce large quantities of dilute urine and, therefore, need to frequently replenish these water losses. Thus, although the subject is a basic science, the results can be very pertinent to problems of the country. This is not necessarily so with all aspects of physiology. We could, for example, spend our time examining the intricacies of muscle contraction, or how certain areas of the brain function, or how a nerve transmits impulses. This, I would like to suggest, is not the type of work that should be done here, either in research institutions or in the University. This work, of a highly academic nature, which might have some application in the long term future, is the type of research that can be done elsewhere; there are many more pressing problems that can only be solved here in Kenya. As a general rule no

research should be done in a developing country which can more easily be done in a developed one. One of the disadvantages of sending graduates abroad for post-graduate training is that their research is often in abstruse fields using highly expensive and sophisticated equipment. On their return they find that their training has not been relevant to the problems of the country and they are incapable of research. J. B. S. Haldane used to be a great advocate of equipment being as simple as possible, maintaining that a lot could be achieved with string and sealing wax. I believe that those days are over, but there is still a degree of truth in his statement; we, for example, find a baked bean tin a very useful piece of physiological equipment! The University of Nairobi and the Faculty of Veterinary Science has now grown to such a stage where it is becoming less necessary to send people overseas for all their post-graduate training; they can, of course, go abroad to learn specialised aspects. It is important that, as far as possible, their research work should be relevant to the problems of, and carried out, in Kenya.

Generally speaking, it can be said that most of the problems associated with agricultural development in the world are now confined to developing countries. In developed countries, and I use the term developed for want of a better word, the difference between a developing and developed country being somewhat arbitrary, many of the problems of agricultural research have been solved, and large research institutes which were established for these purposes have now, to a great extent, fulfilled their function. In fact, it has been estimated that one could wait for ten years for the agricultural industry of developed countries to catch up with scientific achievement. The reverse is the case in developing countries. It might now be the time to divert some of the resources and funds at present being spent on agricultural research in developed countries to solving some of the problems of developing countries. This can best be achieved by a joint effort rather than expecting one particular country to meet all the costs. There already exist International Organizations in virtually every discipline of science which could advise on the type of support that should be provided. Such a venture has recently come to fruition with the establishment of the International Centre for Insect Physiology and Ecology in Nairobi under its Director, Prof. T. Odhiambo. This Centre is supported by many countries, and workers from these countries come to Kenya and work on local problems along with Kenyan scientists. This type of overseas aid supported on a joint international basis has many advantages:

1) It means that the research is carried out in the country which is going to benefit from the results of the research.
2) In most cases it is the only practicable country that the research may be pursued in. Let us say, for example, that we wish to examine the physiology of the camel, and evaluate its adaptation to desert conditions. This is a fascinating animal to the physiologist. They can be readily acquired in Kenya for £10-20 each. A friend of mine in Great Britain enquired into the possibility of purchasing a camel and found the price to be at least £450! This virtually precludes any significant answer being given to the question "what is a camel?".
3) It means that local scientists can, to a certain extent, overcome their academic isolation. It is not easy to carry out research in such isolation. Study leave every five or six years is inadequate. By working with scientists from all parts of the world, they can truly become part of international scientific development, and open up their own particular fields of research, and be ahead of the rest of the world in their sphere.

In conclusion, therefore, I would appeal to overseas aid agencies to support this type of development; it is an investment which will reap many rewards in many directions. A start has been made in Insect Physiology but many other fields are obvious. I hope that you will agree that Animal Physiology is one of them.