Some physical, physiological and biochemical adaptations of ruminant livestock including buffaloes to different feeds and climates.

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ABSTRACT: Some of the adaptations of ruminant livestock to climate and feed resources are discussed.
1. Physical. Various types of coat serve to protect animals from cold and from the sun’s heat.
2. Physiological. Large rumen volumes enables animals to consume large amounts of poor roughages; fat depots in distinct regions of the body allow them to withstand regulation and fluctuating supply of nutrients, seasonality of reproduction matches requirement to seasonal variation in food supply.
3. Biochemical. There are species differences in the ability to recycle N to the rumen (buffaloes) in the requirement for glucose to accommodate several days of fasting (camels), and in adaptation to low atmospheric oxygen tension (yaks).

Such adaptations are important and should be considered when animals exported to areas where climates and feeds are different.

INTRODUCTION - Having had the privilege of seeing livestock in many areas of the world I am always impressed by the way they are adapted to different climates and feeds. I would like to discuss adaptations and consider their importance. Sometimes they tend to be ignored when so-called upgraded animals are imported into climates and conditions very different from those where they were bred. While climates can be created as by use of air-conditioned animal houses in the tropics, this is generally not economical and sustainable. Animals must on the whole be adapted to the environment rather than adapting the environment to the animals.

Physical adaptations
This is particularly important in cold climates where animals have long hair to protect them from cold winters. Yaks in Mongolia and on the Tibetan plateau are a good example with their long dense hair which when cut in the summer is used to produce tents. The Bactrian camels in Outer Mongolia are also well covered in hair to withstand cold winters as are indeed Highland cattle in Scotland. Many species of deer in temperate and cool regions grow a woolly coat in autumn and shed it in the spring. In hot regions many sheep breeds have hair rather than wool such as Maasai sheep in Kenya and other breeds in tropical areas. A woolly coat (camels) or reflective coat (buffaloes) also serves to protect against the heat of the sun.
Physiological adaptations

There are many physiological adaptations. I will mention those I feel are most important.

Rumen volume. There are many breeds of cattle with a large rumen volume relative to body weight. Mould et al (1982) showed that cattle in Bangladesh had rumen volume about one third of the body weight. They can accommodate a great deal of slowly fermenting roughages and survive and grow on straw diets. Chinese Yellow cattle Ma et al (1990) can be fattened on diets of 80% urea treated straw. Buffaloes too have a high rumen volume relative to body weight and survive well on low quality roughages. In many Western countries animals have sometime been selected for high carcass weight relative to body weight and in the process selected against rumen volume and thus against capacity to survive on poor quality roughages. When they are exported to areas where the readily available feed consists of poor quality roughages they will have problems or will have to be given all the high quality feed in the area. I once calculated from work in Iran that the potential milk production from an area would be reduced if Holstein cattle were introduced as they would have to consume all the high quality feed. A milk yield of about 10 l/day would produce the maximum amount of milk from the area. Buffaloes and yaks also adapted to consume large amount of poor quality roughages by having large rumen volumes relative to body weight.

Fat depots. Ruminants are well adapted to areas where feed supply is very seasonal by having large fat stores so they can tolerate a long period with less than maintenance feeding while their fat stores are utilized. In warm areas the fat is generally deposited in distinct parts of the body such as humps in Zebu cattle and camels and in tails and dewlaps in sheep. Awassi sheep in Syria have often tails weighing 5kg or more. Storing fat in distinct regions makes thermo-regulation easier in hot areas whilst in cooler and temperate areas the subcutaneous fat can be evenly distributed and in some way protect against cool conditions though I have no evidence to support that.

Reproduction. Adaptation to reproduce when nutrient supply is expected to be adequate is another interesting aspect and one which has obviously been based on selection for survival. In the temperate zones the hormone melatonin secreted in relation to day length, assists in regulating ovulatory activity so that reproduction occurs in spring when food supply is optimal for lactation and growth of the young. In tropical areas where nutrient supply fluctuates with rainfall reproduction is sometimes timed to occur in the beginning of wet season when nutrient supply is likely to be adequate, although more often there is no seasonality in reproduction. In sheep and goats which often produce twins the number of lambs born may also be affected by the level of nutrition during mating. For instance Blackface sheep in Scotland mated in hill country normally have a lambing percentage of about 80 whilst if they are mated in the lowlands their lambing percentage may well be 150. But if a lambing percentage of 150 took place in the mountains the mortality would be very high. In fact should a sheep have twins in the mountains the shepherd will often remove one for fostering or for sale.

Yaks from the Tibetan plateau and Mongolia would normally have a calf every 2 years though their pregnancy period is 10 months. However, the nutrition in these areas is poor in the winter. Should they be pregnant every year it is likely mortality of calves would be high. However while they virtually cease producing milk for their calf in the winter they
start lactating again the following summer (Weiner et al., 2003) so in effect have two lactation periods for each calf a unique adaptation of reproduction to the seasonality and quality of feed resources.

Heat dissipation. In tropical regions heat dissipation is very important. Here it must be recognized that in ruminants at least 40% (Ørskov 2002) of the energy derived from the food eaten must be dissipated mainly as evaporative heat. As a consequence the ability to loose heat sometimes limits food consumption in hot areas. Buffaloes may have problems, as discussed by Vo (2007), unless they have free access to water or mudpools to help in heat dissipation. Some native cattle are better adapted than buffaloes if there is limited access to water but even so high production of milk requiring high feed intake cannot generally be sustained. Potentially high producing animals may limit their feed intake to reduce heat production. For instance it has been mentioned before milk that production by Holstein cattle cannot be high in the tropics unless the environment is changed to suite the animals as discussed earlier. They attempt to meet their potential by using body reserves both of fat and protein which soon creates problems of immunity to diseases and delayed postpartum ovulation and so a long calving interval. Even at low milk yields there are differences; native cattle have no problem with heat dissipation while Holstein cattle at a similar milk yield are heat stressed.

Biochemical adaptations

There is no doubt there are many biochemical adaptations to climate and feed resources and to fluctuating nutrient supply. I will mention a few that have come to my attention.

Glucose requirement during fluctuation nutrient supply. In ruminants the main source of glucose is propionic acid from rumen fermentation. When a ruminant is fasting due either to lack of available food or to illness the Beta-hydroxybutyrate in the blood increases rapidly due to glucose deficiency (Ørskov 2002). When this occurs ruminants derive some glucose precursors from protein turnover in the animal’s body but this means loss of lean tissue as it would normally be re-synthesized. Fasting nitrogen excretion increases to about double that of basal N excretion. To avoid such protein loss ruminants should if possible be fed at about one third of energy maintenance. Cattle generally require more than sheep. This problem can easily be seen in draught areas in Africa where cattle suffer most. However, if a camel or other camelids are fasting there is little or no increase in ketone bodies. The camelids can generate reducing equivalents from acetate and thus from fat so they can survive and remain healthy for many days of fasting by feeding on their fat stores which true ruminants cannot (Wenswoort et al., 2001).

Adaptation to better recycling of N to the rumen. Many low quality roughages contain insufficient N to satisfy rumen microbial requirement and therefore recycling of plasma urea to the rumen is a great advantage. Urea is recycled to the rumen mainly by transfer from blood via the rumen wall although some is also recycled via the saliva. The time urea remains in the blood depends mainly on the renal glomerular filtration rate (GFR). The GFR generally is higher in animals consuming large amounts of feed so recycling less efficient. The recent use of purine derivatives (PD) in the urine produced by metabolism of nucleic acids, to provide a measure of microbial protein production has been very interesting Makkar & Chen (2004). When this method was applied to buffaloes it was found that PD excretion was only about one third of that of cattle with the same production of microbial

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protein. In the buffaloes the PD was recycled to the rumen to further supplement a very efficient recycling of urea N. This is an advantage as the buffaloes need less N in the poor quality roughages they consume. The biochemistry of the increased capacity of buffaloes is not fully known (Vo & Ørskov 2006) but it has to do with rumen development. The endogenous excretion of PD by young milk fed buffalo calves is similar to that of cattle calves. As soon as rumen is developed in buffaloes PD is recycled to the rumen and their PD excretion is about one third of that from cattle calves. It could be due to differences in GFR or in permeability from blood to rumen.

Adaptation to low oxygen. Yaks are adapted by a high concentration of haemoglobin in the blood to tolerate low oxygen tension in the atmosphere as they are normally found above 2000m in Mongolia, Tibetan plateau, in China, Ganzu etc. In fact if they are moved to lowlands with high oxygen tension they do not do well at all. Another brilliant adaptation to climate and altitude (Weiner et al 2003), which are shared by Camelids in South America in the Andes Mountains.

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