A potential approach to study a beef cow-calf grassland system applying the DEB theory.

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Introduction:

Grazing systems are one of the main types of agroecological system for food production, and as a consequence, there is an increased interest in improving their management and ensuring sustainability (Herrero et.al. 1998b). Different phenomena occurring at the plant-animal interface levels (feed-intake, diet selection) have been identified as the key point components for the management of these systems (Forbes 1988). In Argentina, grasslands occupy an important surface. There is a large range area (6 million ha) in the Buenos Aires province – Argentina, denominated "Depresion del Salado" (Salado River Basin), where highly extensive cow-calf beef operation systems predominate, being the calf crop the main revenue. Soils in this area are characterized by a high salinity and alkalinity, being poorly drained and periodically exposed to waterlogged conditions. Production levels as low as 40 to 80 Kg weaned live-weight per ha/year are frequently reported. There is a need to design realistic alternatives to ensure viable business for smallholder families, but promoting a sustainable and environmentally friendly development. Although local research about grasslands is important, the efforts look highly fragmented. In order to integrate this information and considering the complexity of such systems, a consistent modelling approach could have the potential to provide both, understanding and application. A mechanistic model is *de rigeur* for any programme aiming to grasp the complex response of grassland, to provide the understanding for appropriate management *(Thornley 2001).* As part of the complexity of the system, a quantitative bionergetics to connect the different levels of organization and nutrient flow patterns (sun radiation, grass, cow, milk, calf) also needs to be considered. In this context, some concepts developed as part of the DEB theory will be used to discuss an approach to model a grassland system as previously described.

Characteristics of grassland systems

Grassland systems present heterogeneity to both space and time scale. Pastures have a noticeable seasonal distribution of production, which is highly determined by climatic factors and sward management. As an example, some temperate pastures concentrating 60-70 % of their production within a 4-month period

(Hodgson and Illus 1996). Furthermore, this characteristic requires a need for a flexible approach to grazing management.

The concept of matching nutrients available in forages with nutrient requirements of the cow changing dynamically has been recommended as a means to most efficiently utilise grazed forages (Pang et.al. 1997). Considering the seasonal distribution of grassland yield (by climatic conditionings), animal activities distribution as milk production, pregnancy, and activity are the primary influences on nutrient needs of cattle (Adams et.al. 1996). Hay-making (moving temporally the extra-food) is an additional alternative to buffer the system, although it is not feasible in main part of the target systems of this essay. Furthermore, it is important to appreciate that the manager is an integral part of the grazing system and his/her decision are a strong contributor to the complexity in the system (Naveh and Lieberman 1984, quoted by (Taiton et.al. 1996). This decisor got the chance to select a mating time and so calving, milking and weaning dates as a way to better synchronise the cow's nutrient needs with the seasonal available food (Adams et.al. 1996).

Additionally, a useful methods to synchronise the cow's nutrient needs with grazed forages is use the animal itself as buffer modifying its energy reserves, compelling to use its when food availability is low and increasing this ones when there is food excess (Morris 2001). In summary, the system design makes that plant and herbivores are also strongly connected because these last have a strong effect on plant population, and the sward characteristic control feed intake and so animal performance. The degree of connection has implications within the system for its long-term stability (Taiton et.al. 1996). With so many interacting and feed-back processes involved, an interest in modeling grazing systems is not only justified, but also represents perhaps the only way to accommodate their complexity (Dove 1996).

Plant-Animal interface

As it was previously mentioned, plant-animal interface is the key point components for the management of these systems (Forbes 1988). Short term (instantaneous) intake rate is determined by the rate of biting and the weight of dry matter in each bite; grazing time is an additional factor determining long-term daily intake rate (Gordon and Lascano 1983).

Foraging behavior can be described in terms of a hierarchy of scales, from the food taken in a single bite to patches of selected vegetation and through landscape (Senft et. al. 1987, quoted by (Gordon and Lascano 1983)A grazing animal, may have the ability to respond to space heterogeneity in its food source at a particular scale by selective grazing, but its ability to respond to heterogeneity at other scale may be limited (Taiton et.al. 1996).

Following a highly mechanistic approach, (Woodward 1997) modelled the feed intake including a daily time budget to grazing, idling and ruminating activities, and so to time allocation to bite searching, bite handling and processing. As can be deducted, time budgets will play a central role in feeding behavior as it has been mentioned (DEB, Ch. 10). Similarly, the intake process will not be activated and it will not accept arriving food particles when gut capacity (rumen and reticulum in rumiants) is busy processing previously eaten food particles (DEB, Ch. 10). Inability of an animal to consume enough nutrients in a forage diet is greatest when density of the nutrient is low and/or when animal requirements are high (Adams et.al. 1996). Furthermore, energy density of the food will associate to a longer gut residence time, limiting in this way the animal feed intake.

Animal requirements:

The energy requirements of ruminants have been estimated with reasonable accuracy, however they were not designed to predict intake (Herrero et.al. 1998b) Hence, the quality of the prediction of animal performance are largely dependent of the precision of the intake estimation.

Link nutrition-reproduction

Reproduction success is strongly conditioned by nutrition. Compared to cows in moderate body condition, thin cows or cows in low body condition at calving are more likely to breed late in a breeding season or not breed at all, which reduces the net calf crop (i.e., number of calves weaned per cow exposed to the bull; Dziuk and Bellows 1983 quoted by (Adams et.al. 1996)).

System management:

In circumstances where the system state can be relatively rigorously controlled by management, be advisable to attempt to buffer the spatio-temporal heterogeneity of the system in order to simplify management and maximise production (Taiton et.al. 1996). The key nutrient for the control of the system is energy. They identified complementary forages, calving date, and weaning date as resources for matching forages with the nutrient needs of the cow. In order to maximise calf crop in a sustainable fashion along productive cycles

Potential components and structure of the model

A way to cope with this heterogeneity at different scales, a hierarchical model decomposed into a number of levels of organisations will be built. Potential modules of the model are mentioned as it follows:

Grass:

Stochastic elements will be associated with weather data, such as temperature. The forage production sub-model will be used to predict growth rate and available forage biomass. As a base to develop this component a combined approach of some published models could be used (Tenhunen et.al. 1976; Kim and Verma 1991; Haxeltine and Prentice 1996; Thornley 1998). A spatial arrangement of the herbage will be considered as it has been suggested for a mechanistic approach (Herrero et.al. 1998a).

Plant-animal interface

Feeding behavior and intake will be included as it was previously described. Feeding could be explained resembling enzyme kinetics, on the basis of synthesizing unit (SU) working in a sequential process with a stochastic approach. Sward should be divided into species and plant components with assigned quality and different probability to be eaten upon grazing. With this approach could be predicted the changes of bite dimension as similarly the sward structure are modified as grazing down process occurs (DEB, Ch. 2 and 3).

Animal energy requirements and animal reserves

It will be used to quantify nutrient and feed requirements for calves and cows depending on their physiological status (maintenance, growth, lactation and gestation). Reserves could be modelled along cattle life, since born to the end of productive period, measuring the effect of dilution effect of grow and energy flux, besides assimilation rate according food density applying assimilation model of DEB theory (Ch 3 and 10 of DEB). Depending on reserve status, the start of puberty and rate of reproduction could be inferred. Maximum reproductive rate in DEB theory is an interesting concept on which is possible account differences in animal size due energy spent on reproduction decreases with increasing body volume (Ch 8 of DEB).

Using data to determine the energy flux (maintenance, growth, development and foetal cost), could be predicted the state of reserves when the cow start the next productive cycle. Evolution of gravid heifers, that still are growing, could be known by applying the k rule (Ch. 3 DEB).

Potential Model uses

As it has been mentioned (Thornley 1998), a model like this can provide a framework for discussing available information, identifying information gaps, and predicting time course of the systems upon alternative conditions. Similarly, it will provide both, application and understanding.

. These ecosystems can be highly unstable when changes or techniques are applied without a proper understanding of the potential impact of them to the different components of the system. Hence we need to quantify bionergetics to connect the different levels of organization within the ecosystem. In this sense, the DEB approach will aloud to examine and evaluate the effects of cow size, production traits, and management strategies on the bio-efficiency of these systems.

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