Ecological Impact and Cost of Fattening Cattle with Three Different Production Systems Evaluated Using the Eco-footprint method

J D Hummel[1], M A Galina[2], R Macedo[1] and J M Palma[1]
[1]Facultad de Medicina Veterinaria y Zootecnia, Universidad de Colima, Colima, Colima, Mexico.
[2] Departamento de Ciencias Pecuarias, FES-Cuautitlán, Universidad Nacional Autónoma de México, Cuautitlán Izcalli, Edo. de Mexico, Mexico
Email of corresponding author; janethummel@hotmail.com

ABSTRACT With the objective of improving the method of evaluating ecological impact for regions with distinct methods of animal production, the *Eco-footprint* method was applied to evaluate new methods to fatten cattle for ecological efficiency and economical viability. Three methods of fattening were compared: intensive zero-grazing (I), grazing with conventional grain supplement (GS) and grazing with a non-protein nitrogen supplement (NPN). Information from each system was put into a special database using the equations of *Eco-footprint and* reduced land area and cost in US dollars to produce a kg of meat. It was found that system I had a significantly larger impact on land use with 0.07 ha/kg beef as compared to 0.03 for GS and 0.02 for NPN. The cost of production was lower for NPN with $.70 cents per kg of meat produced as compared to $1.35 for I and $1.00 for GS. It was concluded that the system NPN produces a more efficient fattening system with both lower ecological land impact and production cost.

Keywords: [Ecological efficiency, Economical viability, Animal production, Ecofootprint method, Intensive, Grazing]

Introduction

The Ecofootprint method has been continuously upgraded and refined since its development even though the basic algorithms are the same. The simplicity of the method, which is both a merit and a limitation, means that the image created is static and unyielding to dynamic change. Rees (2000), discusses it's simplicity as being due to the static estimation, where nature and the economy are both dynamic systems and footprinting cannot take into account, efficiently, technological change (Rees 2000).

It has been estimated by Pimental et al. (1997), that one-third of the world's land is devoted to supporting the production of domestic animals, primarily large ruminants. Within the Eco-footprint database, grazing is probably the single most important component in consideration of land use. The production of meat from different types of animals is an important factor responsible for landscape changes, both grasslands planted purposely for their consumption or brush land selected for pasture.

With the urban sprawl encroaching on agricultural land (Sierra Club 2000), there is an urgency to make more efficient use of rural space, increasing pressure for more food to feed the hungry masses (Halweil 2000), reducing use of chemical fertilizers, insecticides and illegal hormonal implants, focusing on the production of natural organic and functional foods. All this evolution has created demands on the agricultural community to make changes in methods to grow crops and raise cattle.

Climate has been a key ingredient in deciding the technology employed. In cold northern countries, with the dependence on intensive production, generally coupled with zero grazing, producers use high energy grains and supplements that provide the nutritional demands of ruminants kept in confinement, satisfying the demanding market for animal protein and a rapid turnover of capital for the producers.

In the tropical regions, due to all year forage-animal production, and dry season low vegetable re growth, demands are put on the producer to cope with seasonal changes and force them to be inventive and adaptive. Tropical forage, particularly in the dry season, is often fibrous and has a low digestibility for cattle. Technology is continuously being developed to produce forage of high protein and low fibre which will fatten the cattle quickly adding supplements to produce sufficient meat to an ever increasing population (Galina et al. 2007a).

These new regional unique innovations to the agricultural industry present difficulties for those attempting to produce a uniform database to measure ecological impact. In confronting the difficulties inherent in applying the same method to all areas and due to the simplicity of the Footprint method, the adjustments due to new technology is not incorporated into the calculations due to being less than the error level. Therefore real advancements of environment interaction would not be visible in the total outlook thus defeating the objective of the method itself. A universal uniform method must be versatile and sensitive to take into consideration the pressure to innovate with variables inherent to different regions and climatic zones (Galina et al., 2004).

The objective of this study was to challenge one aspect of the Eco-footprint method to see if there would be a significant difference in production efficiency and cost which would ultimately be reflected in total land impact.

Materials and methods

Three methods of cattle fattening were compared: intensive zero-grazing (ZG), grazing supplemented with a protein grain concentrate to balance cattle nutritional requirements (GS) and grazing with a non-protein nitrogen supplement (NPN).

Intensive zero-grazing

The system of intensive zero-grazing achieves success due to fast conversion to meat production of high energy diets based on grain (Hummel 1996). The feed-lots convert energy in the shortest period of time. It offers the producer a fast turnover of his investment and an efficient source of meat protein to an increasing and demanding market (Hummel 2002).

The diet selected for fattening varies considerably. According to Morales et al. (2000), a representative diet would consist in a grain usually corn or barley with other components to enhance rapid cattle growth. The grains consumed extensively in these diets are grown on the best agricultural land. This system represents the principle system employed in cold climate even though it is under controversy by naturalists and environmentalists as meat produced in this environment has a large quantity of saturated fat and cholesterol which has been proven to be detrimental to human health (Galina et al., 2007b)

Grazing with conventional grain supplementation

Many farmers worldwide depend on pasturing to fatten cattle especially in the tropical zones where a warm climate allows year-round vegetation re-growth. Conventional pasturing has been the choice of production particularly in poor third world communities (Galina et al. 1994). These year round climate conditions permit animals to browse on grass and scrublands that are often lands not suitable for other use. Though animals gain much slower than intensive cattle production systems due to vegetation that is both fibrous and low in protein, it is economically feasibility for marginal producers who are able to take advantage of lands that would not normally be used to raise crops or are unavailable due to geographical adverse conditions.

Grazing with a non-protein nitrogen supplement

The most abundant feed resources available for ruminant production in developing countries are crop residues and native pastures. These feeds are generally low in nitrogen and energy content and this limits the extent of microbial fermentation in the rumen, when these roughages are consumed alone (Galina et al. 2004). The forage feeds are degraded in the rumen by different bacteria, protozoa and anaerobic phycomycetous fungi. This microbial mixture in the rumen is complex and highly dependent on the diet. A deficiency of nutrients needed by micro-organisms reduces microbial growth and biomass, and eventually reduces digestibility, particularly of fibrous feeds. Rumen micro-organisms derive most of their energy from the fermentation of carbohydrates, and utilise ammonia (NH_3), peptides and amino acids from nitrogen sources for microbial protein synthesis. In ruminants, plant carbohydrates are fermented almost exclusively to volatile fatty acids (VFA) realising energy for microbial growth and utilization by the host (Galina et al. 2007). The carbohydrates from low-quality roughages are fermented and release energy relatively slowly when compared with readily fermentable carbohydrates (Galina et al. 2004). It is similarly true that protein nitrogen is fermented to NH_3 more slowly than non-protein nitrogen (NPN), which is converted to NH_3 almost immediately (Galina et al. 2004). The efficiency of nitrogen utilisation by microorganisms depends on the rate of NH_3 release and the rate of carbohydrate degradation in the rumen. Hence, when low-quality forages are fed without a readily available energy source, rumen microorganisms can convert NPN to ammonia faster than they can use it for protein synthesis that allow cattle growth with solar efficiency through NPN supplementation (Galina et al. 2004).

Application of Eco-footprint method

To be able to compare each production system, the variables considered included land yield, yield index (McInnis et al. 1990), stocking rate, principle representative components of diet and supplement plus cost for each system, meat conversion with energy conversion (Hummel 1996). After calculating the stocking rate and land yield needed to grow the main components (corn, soybean and barley) of the Intensive diet (the average cost of the grains was calculated using current prices at the time of the writing of the abstract), and estimate of energy to meat conversion, the land impact and cost per kg. of meat was calculated. The land use for pasturing was more difficult to calculate due to the diversity of vegetation in pasture land, variation from dry to rainy seasons and types of land used including those purposely planted for pasturing, native plants and crop residue, and wildlands and lands inaccessible or of poor quality for urban or agricultural crop land. The stocking rate per ha. and energy conversion is incalculable with any accuracy but was a close enough estimate for the needs of this study.

The results of the calculations were keyed into the original database that was used to calculate Eco-footprint for the state of Colima (Hummel 2002) and the effect on results of eco-impact were registered.

Results

After taking into consideration each variable involved in calculating the land per kg of meat and cost of producing the kg of meat, an estimate was calculated (Table 1).

Table 1. Summary of land use (ha/kg of meat) and cost to produce one kg. of meat for three systems of production.

	Land use ha/kg beef	Cost $ U.S./Kg beef
Intensive Zero Grazing		
Grain production	0.07	1.35
Pasture land	0	0
Total	0.07	1.35
Grazing with conventional grain supplement		
Supplement	0.02	0.75
Pasture land	0.01	
Total	0.03	1.00
Grazing with a non-protein nitrogen supplement		
NPN supplement	0	
Pasture land	0.02	
Total	0.02	0.70

The Intensive system represented a significantly larger impact (0.07 ha/kg of beef) on land use. Both the conventional GS and NPN were similar with 0.03 and 0.02 ha/kg of beef produced.

Intensive production also showed a higher cost to produce a kg. of beef. Both GS and NPN showed similar results with 1.00 and 0.70 US dollar per kg of beef respectively.

When results for each production system were keyed into the Eco-footprint database that had been used to calculate the impact for the state of Colima, Mexico, no change in overall Footprint value was observed

Discussion

The advantages and disadvantages of each system, in the perspective of the producer, has been extensively discussed elsewhere (Galina et al. 2007a; 2007b). It is not our objective to view each system from this angle. Rather, it is the impact of each system in relation to ecological land use and the consideration of forage production and pasture land in the database of the eco-footprint.

There is great variation within grazing areas because of the diversity of plant types growing in the pasture and scrubland. Pasture management needs a balance between stocking rate, pasture size, grazing schedule, animal nutrition and economical return (Tao et al. 1991). The production of a pasture can vary greatly depending on precipitation, fertilizer regime and grazing management.

The pasture size and stocking rate directly affects the production, as intensive use of a pasture field without rotation to other fields lowers the AUM/ha (Tao et al. 1991). The present observation was able to demonstrate that grazing with NPN supplementation did allow cattle to a have a competitive growth in less land and better economical income thus theoretically reducing the eco-footprint.

Pasturing also can take advantage of land that would not be available for use as urban or agricultural crop land. Land on hillsides and brush land which would not be ideal for crop production, could non-the-less provide green fibre that provides nutrients to fatten cattle. Pasture land, especially those using the silvo-pastural system, can also double as wild lands that converts carbon dioxide to oxygen and cleans up the contaminants in air and water.

The need to produce a uniform database which allows all regions and climatic zones to compare ecological impact, suggests that this database must reflect technologies developed to solve local problems caused by local traditions, climatic considerations and land availability. It has been shown clearly in this that there can be a significant difference between production systems and this difference could be of overall importance in the calculation and therefore the comparisons of different regions.

Conclusion

As an indicator to reflect changes in land impact for each region, to motivate regions to develop new technology which lowers the impact on land use, the eco-footprint database must be developed to reflect innovative change.

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