Abstract: The adoption of production systems, feeding and nutrition technologies has varied among countries and regions, depending on several factors related to the comprehension by scientists, technicians and livestock farmer. themselves, of the principles behind the technologies and cost-benefit relation of their implementation. Frequently, the first limiting factor is not identified and recognized. So, other interventions don’t generate the expected outcomes. One common situation that limited the expansion of innovative technologies is the distance between researchers and extension agents and farmers. Farmers and technical staff and academics should be together to analyze current challenges and to discuss alternative solutions. This requires a mechanism where everyone feels comfortable, at equal level with the rest of the participants, in order to freely express the concerns and ideas. Once a technology has been identified and accepted by all of ones, then the challenge is to finance its adoption, where risks should be ideally covered by the government. Experience has also shown that certain technologies spread by themselves, without programs and government support. Farmers are readily convinced of its value, usually by observing the technology being used by their neighbor farmers, and accept to make the necessary investments and efforts to adopt it, assuming the risk themselves.

Key words: alimentation, feeding and nutrition technologies, production systems

Sucessos e Fracassos de Práticas de Nutrição Animal e Tecnologias nos Países em Desenvolvimento

Resumo: A adoção dos sistemas de produção, alimentação e tecnologias de nutrição tem variado entre os países e regiões, dependendo de vários fatores relacionados à compreensão por cientistas, técnicos e agricultores. Muitas vezes, o primeiro fator limitante não é identificado e reconhecido e, consequentemente, outras intervenções não geram os resultados esperados. Uma situação comum que limita a expansão de tecnologias inovadoras é o distanciamento entre os pesquisadores, extensionistas e agricultores. Idealmente, os agricultores e técnicos e acadêmicos devem sentar-se juntos para analisar e discutir soluções alternativas adequadas. Isso requer um mecanismo onde todos se sintam confortáveis em igual nível com o resto dos participantes, a fim de expressar livremente as preocupações e ideias. Uma vez que a tecnologia tem sido identificada e aceita por todas as partes, então o desafio é para financiar a sua introdução, em que os riscos devem ser cobertos pelo Estado. Agricultores são facilmente convencidos de seu valor, em geral observando a tecnologia utilizada pelos agricultores vizinhos, e estarão dispostos a fazer os investimentos e esforços necessários para adotá-la, assumindo, inclusive, o risco.

Palavras-chave: alimentação, tecnologias de nutrição, sistemas de produção

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Current Situation

In most tropical countries traditional small ruminant production is practiced in extensive systems, generally in public or communal land. These low-input systems, have certain advantages like low parasite load and acceptable performance levels if animal densities do not cause overgrazing and drastic changes in vegetation composition. However, in most countries, where predators are present, they require shepherds, often assisted by dogs. In these extensive systems, guided by their natural nutritional wisdom, animals balance their diets from the existing vegetation seeking to fulfill their nutritional requirements, eating various forage species and often seeking the most nutritive parts of the plants like young shoots, leaves, seeds and fruits. However, when land becomes limited or animal numbers exceed carrying capacity of land, which is often the case when public land becomes privatized and fenced or when the traditional grazing arrangements are not longer functional, animals begin to suffer from lack of feed and internal parasites start taken a serious toll on production. In fact, the combination of poor nutrition and heavy parasite load, are the main constraint for small ruminant production under grazing conditions in most tropical countries.

Experience has clearly demonstrated that parasites can’t be effectively controlled, in the long run, by medication, due to the capacity of parasite to adapt to the anthelmintics, despite efforts to change the active ingredients. When drenching has to be done at less than monthly intervals, the battle against the internal parasites has been lost, unfortunately. It becomes absolutely necessary to understand the life of parasites, the most important being *Haemoncus contortus*, to break the cycles in order to keep parasite loads at low levels, which do not affect performance. Under confinement systems, where the young larval stages are not consumed by the animals to be able to with their life cycle, internal parasites can be eliminated for practical purposes.

In relation to feeding systems under tropical conditions, the main limitation has been the lack of understanding by technicians and scientists that small ruminants require forages of higher nutritive value than those used for cattle, in order to meet the high nutrient requirements without the need of supplements, which are usually expensive and/or imported. Small ruminants are very often fed as cattle or large ruminants, with the same feed resources, mainly grasses. These forages are inadequate in two ways: in the first place, all grasses, some more than others depending on their vegetative stage, are very fibrous and difficult for small ruminants to consume and to reduce in particle size with rumination to be fully digested by rumen microbes. In the second place, grasses have also a low nutritive value, having both low digestible energy contents and low protein. Usually both factors are related, since they depend on lignin deposits within the cell wall structure. There are many examples of failures in both sheep and goat initiatives when the diet is based on grasses, particularly under grazing systems, where there is also a parasite problem. In some cases, like with *Brachiaria decumbens*, apart from the low nutritive value there is a toxicity problem in both sheep and goats, which can cause severe health problems and death (Assumaidae and Mustapha, 2012). I have personally seen dairy goat projects fail for this reason.

Fortunately, for two decades now, it has become evident that feeding small ruminants with legume leaves (for example *Leucaena leucocephala*, *Gliciridia sepium*, *Clitoria ternatea*, *Neonotonia wrightii* and *Teranmus labialis*) or high quality foliages (for example *Morus alba*, *Moringa oleifera* and *Tithonia diversifolia*), they perform very well under confinement or intensive grazing (browsing) systems.
in tropical conditions without the need of expensive supplements. The net results of these practices are, lower costs, good performance and thus, profitable units. Some of these forages, if properly managed, including adequate fertilization levels, can yield very high production levels. Yields of 46 ton of dry matter per ha per year have been reported for mulberry (*M. alba*) in Costa Rica (Benavides, 2000).

Products from small ruminants, particularly meat, but also milk and dairy products in several countries, particularly in the Caribbean region, enjoy high acceptance levels among the local population and the tourists. However, most of these countries do not produce enough to meet local demand and have to resort to imports of sheep meat (lamb or mutton) from countries in temperate regions. This imported meat is clearly not the same in terms of taste and quality, due to fat carcass content and distribution. In the case of goat dairy products, imported milk (canned or powdered) and cheese, are usually very expensive and as such, with low local demand.

This situation is a very unusual case in the agricultural scene, that a local product in high demand can’t be supplied by local production. Usually the reverse occurs, production is in excess, at least temporarily, and prices go down.

After many years of observing the persistent situation of insufficient production of small ruminants, the conclusion has been that the keys aspects of the nutrition and management of small ruminants in the tropics have not been understood by farmers, researchers and technical staff, in order to develop successful commercial units, until recently.

The main constraint has been that differences in nutrition and feed requirements between large and small ruminants have not been differentiated. Small ruminants generally receive forages meant for cattle and in order to compensate for the inadequate nutrient intake, supplementation becomes necessary, to thus the profit levels are marginal and there is dependency of imported feedstuffs.

There is thus a large potential for increasing small ruminant production in tropical countries, for two main reasons, high local demand for small ruminant products and high biomass growth potential of appropriate forage species.

**Grazing Systems**

Since the understanding of the need of suitable forages for small ruminants has been recent in the American continent, less than three decades, and most producers, technical staff and scientists, are still largely unaware of the special of sheep and goats in the tropics, there have not been many examples of successful intensive pasture (browsing) systems besides the ones naturally occurring in certain areas, like in the semi-arid lands (NE Brasil, El Chaco, Mexican Altiplano) and some Caribbean islands, where suitable species are already there and the challenge is mainly restricted to management to increase carrying capacity and expanding the seasons with acceptable forage quality (Araujo Filho et al, 2010).

In the early 1990s efforts by Cuban researchers from the Ciego de Ávila province to integrate sheep into citrus plantations were under way. The main problem encountered was that of animals damaging trees and decreasing fruit yields due to browsing on leaves, which was been addressed exclusively by physical restriction of certain animal movements. Numerous devices had been designed and tested which mechanically prevented sheep to reach the foliage, including nose and neck attachments (Mazorra et al, 1996). One of the most effective was one made with rubber tubing, fitted like a light jacket around the front legs and neck, which prevented animals to raise their neck and to consume the leaves higher than the mouth level when the animal was standing.
This approach was considered by myself as cruel, violating animal rights. Consequently, an alternative proposal was suggested: to identify and to establish a cover crop in citrus plantations which was compatible with fruit production and more appealing to sheep than the foliage. The cover crop would replace the natural vegetation, mostly composed by grasses, which was present in the space between tree rows. Cuban scientists accepted the challenge and with the support of a small funding from the Feed Resources Group of FAO, immediately began to look suitable forage species, by screening and testing local herbaceous and climbing legumes. After several years of work, and many trials, they found the best species to be used as cover crop in citrus plantations, *Teramnus labialis*, which was also very suitable to plant under coconuts. (Mazorra, 2006; Borroto *et al*, 2007).

This is a very nice example of a problem solving procedure by understanding the main challenges both from the animal and main crop (citrus trees) stand points of view. Although the technical aspects for establishment and management of this species as cover crop have been worked out for several years now, adoption by the plantation managers and owners has been limited due to other reasons beside strictly animal husbandry, including the lack of vision of the benefits of an integrated approach with complementary components, plants and animals. Why complicate things if the plantations were doing fine as such and there were no incentives to produce more? It is also easier for a livestock expert to learn about plant production than to a plantation manager to understand and to accept animals within the premises.

Another example of integration of animals with citrus plantations, is the case of horses (Simón y Esperance, 1997), also in Cuba, where very nice integrated systems have also been developed with two objectives, to reduce cost of weed control in the plantations and to secure a supply of equine blood for hormone extraction from pregnant mares. Horses only eat the grasses and the fallen fruits and they do not damage the trees. This integration is also useful for fruit fly control, since consumed fallen fruits often have within the early larval stages of the fruit fly, which need to emerge and pupate in the soil in order to complete their life cycle.

One browsing system with a lot of potential is based on climbing legumes, either on live support (example *Leucaena*) or on wires, this later called “pedestals” (Batista *et al*, 2006). The principle is that several species of climbing legumes constitute the main forage available for browsing, ideally under a rotational system. The intensive silvopastoral systems using *Leucaena* as the highest strata, with several legumes climbing on it, plus the grass, have been one of the most successful models for reconversion of livestock production in Cuba (Hernández *et al*, 1999, Iglesias y Giraldo, 2011) . This modality of silvopastoral system has not been adopted elsewhere, except in México where the combination of grasses (*Panicum maximum* or *Brachiaria brizantha*), *Leucaena* and *Clitoria* were successfully used in a government program in the state of San Luis Potosí which converted around 10,000 ha of grass-based pastures into silvopastoral systems. In other Mexican states, the current conversion model comprises only *Leucaena* and improved grass (Moreno Torres, V.M. 2011), without climbing species. Although these later systems have been designed for cattle, some producers are starting its use them for sheep.

**Confinement Systems**

Rearing small ruminants in confinement systems using high quality forages started in America with the work at the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) in early 1990s, where many tree and shrub forages were evaluated at laboratories for nutritional value and some of the
most promising were selected for field and animal experiments (Benavides, 1994). One of the best species was mulberry (*Morus alba*), the feed of the silkworm *Bombix mori*, which was used as the base for a family dairy goat model (Benavides, 1995). Mulberry can yield very high quantities of excellent quality feed if properly established and managed. The leaves have a nutritive value for ruminants comparable or superior to grain-based concentrates (Sánchez, 2000). An electronic conference organized by the Feed Resources Group at FAO, exposed and discussed many of the experiences on the use of this forage species in livestock around the world (FAO, 2000).

Based on these studies and experiences, several projects have promoted the use of mulberry and other high quality forages for small ruminants in confinement. The main challenge has been the change of paradigm of not using grasses as the main feed for small ruminants. Another major difficulty, particularly with mulberry, has been its establishment, usually by stem cuttings, and its proper management under intensive cutting, where the replenishment of nutrients is an essential requirement for sustainable production. When mulberry has been associated with legumes (*Gliricidia* and *Erithrina* for example) or where manure recycling is practiced, quality and yields are maintained over time. The recent availability of mulberry varieties which produce seed in Cuba, thanks to their collaboration with China, where mulberry has always been established by seed to assure strong plants with deep roots, will certainly expand mulberry utilization for livestock production.

One of the main constraints for wider utilization of forages for cut-and-carry systems has undoubtedly been the harvesting. At a small scale, harvesting by hand is simple but has a limit on how much forage can be cut and carried, and how many animals can be fed. In Indonesia, a man can harvest and hand carry (or by bicycle) enough forage to feed around 20 small ruminants (with an average weight of around 25 kg). A larger flock can only be kept with further labor or by grazing (in rubber or oil palm plantations).

Most of the equipment used for harvesting and conditioning temperate forages (like alfalfa) is not suitable for shrub forages, for which stronger knives are required. Hay making equipment is been used to produce grass bales, mostly with Pangola grass (*Digitaria eriantha*) which are in high demand especially during the dry season. Despite the low nutritive value of this baled-grass, seasonal feed scarcity and the absence of alternative commercial forages has made it a very popular seasonal supplement in various tropical countries.

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Sugarcane harvesters have been modified to harvest *Leucaena* in Australia, however the majority of the *Leucaena*, very popular in that country, is in pastures, for direct grazing. A *Leucaena* Network has been formed to promote the use of this valuable species for cattle production in combination with grasses (www.leucaena.net). So far, Australia is the country where scientists and farmers have better understood the value of legume shrubs for sustainable cattle production in the tropics.

With shrub forages, offering the entire branches is preferable for the animals in terms of selection of the most nutritive parts of the plants. However, with mechanical harvest, chopping becomes necessary and thus, the opportunity of animals to select is reduced.

Small ruminants do better when forage if kept high and animals need to reach for it, resembling browsing (T.R. Preston, personal communication). With mechanically harvest, chopped, forage, this is neither an option.

**Other Feeding Technologies**

One of the most successful feeding technologies being practiced nowadays is the treatment of cereal
Crop residues with ammonia to be used as the basis for feeding ruminants in China (Tingshuang et al., 2002). Straws mainly from rice and wheat are being treated with ammonia, either from urea, ammonium bicarbonate or ammonia gas, to improve the digestibility by breaking the lignin bonds of the cell wall. When being fed, treated roughages are supplemented with a source of bypass protein in the form of cottonseed mead or other oil cakes, resulting in very acceptable levels of animal performance. Millions of traditional cereal farmers have become livestock producers with this technology, thanks to a very well thought and organized system jointly coordinated by the central, provincial and local governments. Despite the relative abundance of cereal straws in many places, no other country has promoted crop residue treatment and utilization as China.

Another feeding technology that has received a lot of attention by international and national institutions has been the multi-nutrient block, often called “molasses blocks” (FAO, 2007). Although in theory various nutrients can be supplemented via these blocks, in fact, most block have been used to supplement nitrogen. Numerous studies have shown the advantages of supplying nitrogen to low quality diets, the most common nutrient constraint for efficient ruminant fermentation. However, in practice very little blocks are actually being used in countries where they have been introduced and promoted. There are various explanations for this, the most important being the lack of comprehension by farmers of the nutritional principles behind block utilization. Providing blocks to a diet already sufficient in nitrogen gives no benefit. Additional difficulties have been the manufacturing process, procurement of raw materials and equipment to make the block in large quantities, plus the fact that livestock farmer associations, or private companies, often pretend to make unjustified profits when marketing the blocks. Distribution, transportation and placement of blocks are also practical constrains. For all of these reasons the multi-nutrient blocks have only been a good theoretical idea.

Conclusions

The adoption the production systems, feeding and nutrition technologies has varied among countries and regions, depending on several factors related to the comprehension by scientists, technicians and livestock farmer themselves, of the principles behind the technologies and cost-benefit relation of their implementation. Often, the first limiting factor is not identified and recognized, and consequently other interventions don’t give the expected outcomes.

One common situation for the expansion of innovative technologies is the distancing between researchers and extension agents and farmers. Ideally farmers and technical staff and academics should sit together to analyze current constrains and to discuss alternative ideal solutions. This requires a mechanism where everyone feels comfortable, at equal level with the rest of the participants, in order to freely express the concerns and ideas.

Once a technology has been identified and accepted by all parties, then the challenge is to finance its introduction, where risks should be ideally covered by the state.

Experience has also shown that certain technologies spread by themselves, without the need for programs and government support. Farmers are readily convinced of its value, usually by observing the technology being used by colleague farmers and neighbors, and are willing to make the necessary investments and efforts to adopt it, assuming the risk themselves.
Literature Cited


Borroto, Angela; Mazorra, C.A.; Pérez, R.; Fontes, Dayami; Borroto, María; Cubillas, Nieves y Gutiérrez, I. 2007. La potencialidad alimentaria y los sistemas de producción ovina para una finca de citrícola en Cuba. Revista Cubana de Ciencia Agrícola 41(1) 3-12.


