

A New Paradigm for the Control of Gastrointestinal Nematodes in the Tropics

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Introduction

Sustainable production of sheep and goats in the tropics is possible. However, it will depend on respecting the balance between the quantity of foliage harvested, without affecting the field, and animal production. If the balance is right, the number of gastrointestinal nematodes (GIN) in the field and in the animals will be easy to tolerate by the animals. However, most production systems are still trying to obtain the highest production possible per hectare. As a result, the producers still rely heavily on commercial anthelmintic (AH) drugs to sustain such productivity. The problem of anthelmintic resistance (AR) is becoming more common in the humid and sub-humid tropics of Mexico. Thus, we need to reduce our dependence on conventional drugs. In the last 20 years Mexican researchers have investigated different alternative measures to control GIN in small ruminants. In this paper we summarize the work performed in Yucatán with different research groups in México and other countries of the world.

Anthelmintic Resistance in Mexico

Although the first cases of AR resistance were found early in the 1990's, the first trials showing the number of farms with resistant worms were published in the first years of the 21st century (Torres-Acosta et al., 2012a). The current situation is still worsening and recent evidence shows that AH drugs fail to work in many farms of the humid tropics of Mexico. Thus, practical alternative measures to substitute commercial drugs are urgently needed.

What is More Important: Undernourishment or Parasitic Infection?

Practical field experience obtained from sheep and goats in the tropics of Yucatan showed us valuable lessons:

- a) Animals require sufficient hours for browsing, even in the dry season. In the tropical deciduous forests it is not practical to “cut and carry” fodder even for a small herd. Thus, it is better to allow the animals to harvest their own food.
- b) A reduction in feeding time immediately affects sensitive aspects such as milk yield. The recovery to “normal” production levels is unlikely even when feeding was re-established, similarly to what has been observed in other grazing/supplemented lactating cows.
- c) Under the conditions of Yucatan, ruminants cannot satisfy their appetites only by grazing/browsing. Thus, supplementary feeding is needed.
- d) A relatively small proportion of animals are clearly affected by undernourishment or GIN infections. However, it is difficult to define which of the two problems was more important.

With such background information, it was decided to start exploring the nutrition-parasite interactions under the browsing conditions of Yucatan. The first field trials showed that the negative effects of undernourishment and GIN infections (*Haemonchus contortus*, *Trichostrongylus colubriformis* and *Oesophagostomum columbianum*) were both affecting production and survival of kids almost equally. Those studies confirmed the positive economic benefit of supplementary feeding (improved resilience against GIN) during the wet and the dry seasons (Torres-Acosta et al., 2012b). After those first attempts, other studies showed that supplementary feeding was needed at all times during the year. Thus, undernourishment and GIN infections need to be tackled by constant supplementary feeding, and no carry-over effects can be expected (Aguilar-Caballero et al., unpublished).

Energy Supplementation and Resilience against GIN

Early field and pen trials were based on supplements containing protein or energy and protein. However, based on the conditions of the vegetation of Yucatan (abundance of legume trees with a high CP content), it was expected that resilience against GIN could also be improved by using energy feedstuffs (i.e., maize grain, sugar cane molasses). Field trials confirmed that energy supplements improved resilience against GIN in browsing goats and sheep (Retama-Flores et al., 2012). The effect was explained as the result of balancing both N and energy supply in the rumen.

Non-conventional Anthelmintic Materials

Copper oxide wire particles (COWP) were tested as non-conventional AHs against GIN in sheep and goats of Yucatan. The idea was to combine the COWP with the supplementary feeding to improve further the positive effects of energy / protein supplements. Trials in Yucatan showed that the improvement of resilience, above that of supplementary feeding alone, was not evident (Martinez-Ortíz-de-Montellano et al., 2007). Thus, the economic viability was unlikely. In spite of the modest effects on resilience, COWP showed to have a long persistent effect against *H. contortus* (at least 35 days post-treatment) (Galindo-Barbosa et al., 2012).

The direct AH effect of plant secondary metabolites from tropical plants (particularly condensed tannins) against GIN, has been explored in Mexico in collaboration with the research group in Toulouse, France. The first *in vitro* evidence of AH activity of tropical tannin rich (TR) extracts was obtained with French isolates *H. contortus* or *T. colubriformis* (Alonso-Díaz et al., 2008a, 2008b) and Mexican *H. contortus* (Hernández-Orduño et al., 2008). The evaluation of those extracts against Yucatan isolates showed a lower susceptibility in the latter compared to other isolates previously tested (Calderón-Quintal et al., 2010). In spite of the latter, the *in vivo* trials showed that the consumption of tannin containing fodders affected the biology of GIN by reducing the establishment rates of larval stages (Brunet et al., 2008) or reducing either the fecundity or size of adult female worms compared to those parasites exposed to control tannin-free diets. Worms exposed to TR materials under *in vitro* and *in vivo* conditions showed lesions in the cuticle, the muscles and the intestinal cells (Martinez-Ortiz-de-Montellano et al., 2013). Currently, the feeding behavior of ruminants in the heterogenous vegetation of the forests of Yucatan is being investigated. Those studies aim to determine the quantity and quality of the diet consumed by ruminants, including the content of condensed tannins. The effect of ruminant species (sheep or goats) and GIN infection, on the feeding behavior of individual animals, is also being explored.

Reducing the Risk of Infectivity in the Field

The collaboration with CENID-PAVET, Mexico, is directed to explore the use of the Mexican strain of *Duddingtonia flagrans* against GIN. The efficacy of *D. flagrans* against natural GIN infections in goats was the first contribution. Later, the McMaster technique was found suitable to determine the number of spores reaching the feces of sheep (chlamydospores per gram of feces or CPG). This tool and other *in vitro* studies helped to confirm that a large proportion of spores dosed *per os* are destroyed in the digestive tract (nearly 90%) (Ojeda-Robertos et al., 2009). According to recent studies, the best proportion of spores:nematode eggs was 10:1 and a larger quantity failed to improve the trapping efficacy of *D. flagrans* (Ojeda-Robertos et al., 2008). The addition of chlamydospores into feed pellets as a practical spore-dosage mechanism is currently being investigated. The shelf-life studies (under refrigeration, room temperature and outdoors) showed that the spores contained in the pellets maintain the predatory activity against *H. contortus* L₃ for up to 8 weeks. The combined effect of spores and nutrition provided from the pellets is currently being explored.

The Combined Targeted Selective Treatment (cTST) Scheme

Although GIN infections in sheep and goats from Yucatan is present in more than 95% of the individuals, the majority of these animals show mild infections (Fecal egg counts) and only a small proportion of the population show high egg counts. Thus, a TST scheme seemed feasible in theory. In collaboration with Gareth Bath and Jan Van-Wyk, allowed to explore the use of FAMACHA[®] in goats and sheep of Yucatán. We showed that FAMACHA[®] and Body Condition Score helped to detect those animals at risk of suffering severe GIN infection. Those criteria can be used to choose animals for a fecal sample. The studies suggest treating with an efficacious AH drug only those animals above certain quantity of EPG (Torres-Acosta et al., sent for publication). This information can also play a vital role in the construction of breeding schemes

based on the selection of those animals needing least number of AH treatments per year while producing lambs or kids as well as milk.

Conclusions

The search for novel approaches for the control of GIN of small ruminants has produced promising results. The work performed in Mexico has shown that it is feasible to reduce the dependence on conventional AH drugs. However, it is important to realize that the control will need to rely on a variety of tools, and each farm will need to adopt different tools according to the resources available. At present we are moving from the development of different tools to the application of those tools at farm level.

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