https://doi.org/10.22319/rmcp.v14i3.6134

Article

Interactive laboratories for experiential learning and integrated management of gastrointestinal parasitism of sheep and goats

Manuel Alejandro La O-Arias [a]

Francisco Guevara-Hernández [a]*

José Roberto Aguilar-Jiménez [b]

René Pinto-Ruíz [a]

Luis Reyes-Muro [c]

José Nahed-Toral [d]

[a] Universidad Autónoma de Chiapas. Facultad de Ciencias Agronómicas. Carretera Ocozocoautla-Villaflores, km. 84.5 Apdo. Postal 78. 30470. Villaflores, Chiapas. México.

[b] Universidad Autónoma de Chiapas. Facultad de Medicina Veterinaria y Zootecnia. Tuxtla Gutiérrez, Chiapas. México.

[c] Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP) Aguascalientes. México.

[d] El Colegio de la Frontera Sur. Departamento de Agroecología. San Cristóbal de Las Casas, Chiapas.

* Corresponding author: francisco.guevara@unach.mx

Abstract:

The objective was to evaluate the effectiveness of interactive laboratories in generating meaningful learning, modifier of parasite control practices. Interactive laboratories are a methodology for the building of knowledge that facilitate the interaction of sheep and goat farmers with laboratory techniques, on their own farm, to enrich their perceptions about the parasitic process. The research was conducted in the Cauto River Valley, Cuba, in the municipalities of Jiguaní and Bayamo. Fifty sheep and goat farmers were studied. From an interpretative approach, the effect of the activities implemented with the methodology of interactive laboratories on the learning of farmers regarding gastrointestinal strongylosis of small ruminants was evaluated. The participating farmers showed a limited initial understanding of the processes of parasitic infestation based on the lack of previous perceptions about them. The interactive laboratories allowed the creation of key perceptions of the parasitic process, such as etiological agents, sources of infestation and transmission mechanisms; based on a new semantic network with concepts assimilated from visual and lived experience. This allowed the conceptual differentiation of gastrointestinal strongyles with respect to other etiological agents, as well as different stages of the life cycle of these parasites. As a consequence, there was meaningful learning with effective changes in parasite control practices, consistent with preventive strategies.

Keywords: Goats, Traditional knowledge, Parasitology, Participation, Sheep.

Received: 03/01/2022

Accepted: 04/03/2023

Introduction

The eastern region of Cuba encompasses two mountain massifs, Sierra Maestra and Sierra Cristal, and the Cauto Valley watershed. This region concentrates 55 % of the national population of small ruminants in the country, and of this, more than 80 % is in peasant herds(1). The species of small ruminants present are sheep and goats, both decisive in peasant subsistence strategies. According to La O(2) and La O *et al*(3), in this region the typology of small ruminant farming includes two forms: farming on farms and farming in backyards and plots, which prioritize to a greater or lesser extent the objective of family consumption with respect to the commercialization of products. Nevertheless, social demand requires the need for development in this productive matrix. Since 2016, the peasant sector has been encouraged to sell meat for local consumption and to the Cuban tourism sector, as well as the local production of goat's cheese and milk(1).

Gastrointestinal parasitism is one of the health problems with the greatest economic impact on these systems. Up to 30 % of the losses in these types of farming are associated with these parasites(4), where the group of Strongylates stands out, headed by the genus *Haemonchus* spp(5,6). The most severe impact they produce is death. However, from the economic point of view, what has the greatest impact is the reduction, by up to 25 %, of the productive potential of animals, without being perceived by producers[7].

The late intervention for parasite control favors the progressive rupture of the enzootic balance, with an exponential increase in the parasite population. Under this dynamic, the producer detects parasitosis in the herd late, therefore, these can cause economic damages higher than the costs of treating sick animals and losses due to mortality in the herd. This leads to the need to evaluate the level of perception of producers regarding parasitic processes in their herds. This is a challenge to the ways in which traditional farmers build their knowledge. These are complex cognitive processes based on perceptions[8]. Interactive laboratories are a methodology that aims to reinforce the contribution of the work of laboratories in the building of knowledge about parasitic processes, through epidemiological studies, with a participatory approach. This requires simplifying and adapting, to field conditions, parasitological diagnostic techniques to develop them and interpret their results together with farmers in their own land. Subsequently, spaces for socialization and interaction between groups of farmers and specialists are created for the building and systematization of knowledge.

The proposed hypothesis is that the interaction of farmers with laboratory techniques, adapted to the field, and the participatory carrying out of epizootiological monitoring could enrich their perceptions of the parasitic process and, consequently, strengthen their capacities to implement integrated control strategies. The objective of this research was to evaluate the extent of the perceptions of sheep and goat farmers about parasitic processes and the effectiveness of interactive laboratories in generating meaningful learning, capable of modifying inefficient parasite control practices.

Material and methods

Type of study

The research was based on the interpretive paradigm. The effect of the activities carried out in the methodology of Interactive Laboratories on the learning of farmers regarding gastrointestinal strongyloses of small ruminants was evaluated. With a longitudinal, prospective or follow-up conception, the knowledge system of the farmers at the beginning of the study and its evolution during and after the implementation of the interactive laboratories were analyzed.

Location

The experience was carried out in the Cauto River Valley, in eastern Cuba, in the municipalities of Jiguaní and Bayamo, province of Granma. This region stands out for concentrating more than 55 % of the country's sheep and goats[1].

Producers included in the study

The study included 50 farmers consistent with the farming typology reported by La O *et al*[3] (Table 1): typology of farming in farms, typology of farming in backyards and plots.

General characteristics of production systems

The producers included in the study manage farming systems in direct grazing with natural grasses (*Dichanthium caricosum* and *D. annulatum*). The size of the farms is very variable (Table 1) and marginal and communal areas are additionally used for goat farming. Food compensation areas with *Pennisetum purpureum* are used in 30 % of the systems. The fundamental objective of farming is to simultaneously achieve self-subsistence, accumulation and strategic commercialization.

Table 1: Typology of herds participating in the studies and sampling guidelines

Typology of farming system*	Farming objective	Size of the farm		Herd size		Herds studied	Sampling
		Average	SE	Average	SE		
Farming in backyards and plots	It prioritizes family consumption	4	2.2	14 (12 breeding females maximum)	1.9	20 herds: 18 sheep and 2 mixed sheep goats	The whole herd
Farming on farms: 13 to 60 breeding females	It prioritizes accumulation for strategic employment	11	4.5	26 13 to 60 breeding females	12.7	30 herds: 25 sheep and 5 mixed sheep goats	10 animals per category (breeding males, breeding females, developments and offspring)

* Typology defined by La O[2]; SE= standard error.

Method of obtaining the information

The baseline of knowledge regarding gastrointestinal strongyloses was established through open-ended questions and discourse or content analysis, described by Sampieri[9]. The units of analysis were the following: a) perception of the parasitic process, b) way of identification of parasites, c) direct observation of some adult parasitic form, d) places of observation, e) perceptible signs of the parasitic process, f) sources of infestation, and g) transmission mechanisms. In accordance with the longitudinal nature of the research, these units of analysis were considered in workshops of socialization and follow-up of the experience, with the producers, through in-depth group interviews and participatory building of mind maps.

Descriptive summary of the Methodology of Interactive Laboratories

Interactive laboratories are considered a methodology for systematic, *in situ* and participatory monitoring of gastrointestinal parasitism in small ruminant herds. It is based on promoting the participatory evaluation, with farmers and technicians, of the parasitic process and the factors that influence it. It also promotes socialization and exchange workshops, in which mind maps of the knowledge generated are built and parasite control strategies are proposed. The interactive laboratories use simple microscopy techniques adapted to field conditions for the development of perceptions, in producers, of the parasitic process in general. Finally, a follow-up process is planned to monitor permanent changes in practices, based on observation and interviews (Table 2).

Table 2: Stages and activities in the methodology of interactive laboratories

Stages	Objectives	Activities	Expected results
Baseline definition	Define the baseline in both the level of infestation of the herd and the perception of the farmer about the parasite situation.	1. Identification of the farmer and general anamnesis. 2. Definition of the work plan. 3. Initial parasitological diagnosis.	Baseline of the parasitic process and the level of knowledge associated with it identified.
Participatory epidemiological study	Study the dynamics of the parasitic process at the level of the farming system and the factors that affect it with the participation of farmers	4. Quarterly parasitological studies. 5. Participatory sampling. 6. Participatory and *in situ* analysis of samples.	The fundamental characteristics of the parasitic process and key elements for control at the level of the farming system are defined. The farmer visualizes the parasitic forms and develops

Stages	Objectives	Activities	Expected results
	to develop perceptions in them about this process.	7. Participatory preparation of the study report.	perceptions about them and the epidemiological process in general.
Participatory evaluation of results	Evaluate parasitic processes, their dynamics and factors in participatory spaces to promote the collective building of knowledge about the parasitic process and its control.	8. Annual systematization of epizootiological results at the level of farming system, farmer – experts. 9. Annual workshop of systematization with participating farmers and experts.	Farmers build knowledge about parasitic processes and their dynamics to improve their control practices.

Specifications on participatory parasitological studies conducted under field conditions

Representative animals of all zootechnical categories were studied in 50 herds, breeding males, breeding females, developments and offspring (Table 2). In all cases, data from the sampled animals, such as age, reproductive status, body condition, were controlled, and a clinical examination was performed with emphasis on the search for symptoms of parasitic infestation. The guideline for the sampling was 10 animals per zootechnical category. In the case of small herds, less than 12 breeding females, all animals were examined.

The entire process of parasitological diagnosis was carried out on the producer’s farm and with the participation of the farming family. Feces samples were taken before 0800 h with a monthly frequency for one year. To identify the genera of strongyles present, cultures were carried out, which were protected with activated charcoal for 7 d to avoid contamination by fungi. The egg count was performed using the McMaster technique[10]. In the case of grasses, the sample was taken before 0800 h, through a walk in the grazing areas, in which small portions of grass were collected every 8 m. For the count of infesting larvae per kilogram of grass, the technique described by Cetrá *et al*[11] was used.

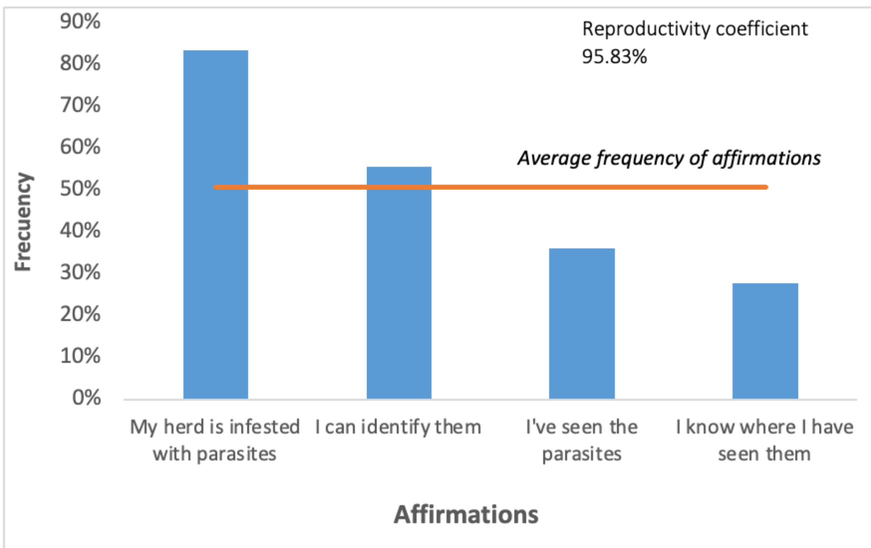
Statistical analysis

Exploratory statistical techniques of simple correspondence factor analyses were applied to associate categorical variables related to learning dimensions and establish cognitive patterns. Contingency tests and frequency analysis were also used. The Software used was Statistica version 10[12].

Results

Regarding the way in which farmers identify parasitic processes, a cognitive gradient of statements was established (Figure 1), according to Guttman's scalegram[13] with the following trend: They claim that their herd is infested with parasites; they manifest some form of identification; they claim to have seen parasites; they identify some place where they have seen them.

Figure 1: Cognitive gradient, according to Guttman's scale, for statements related to the identification of gastrointestinal parasites in small ruminant farmers

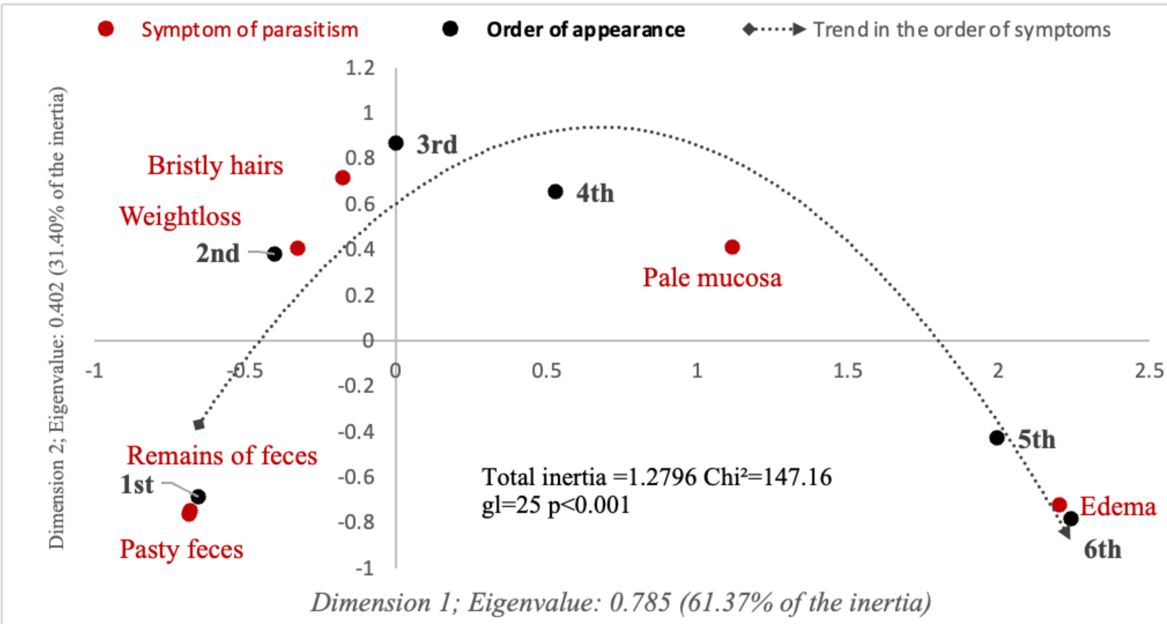


According to Guttman's scale, the first statement is the most generalizing and basic. Each subsequent statement implies a step towards deepening knowledge[9]. That is, "knowing how to locate a parasite" implies "having seen it", and this in turn, "knowing how to identify it" and "having perception of the parasitic process". However, having perception of the process does not necessarily imply having identified the parasites or having seen them. In this study, the gradient was consistent at 95.83 %, which indicates that the ordering of the scale is acceptable.

The ordering and frequency of statements indicate that 83 % of farmers reported having perception of parasitic processes (Figure 1), nevertheless, only two thirds (56 %) support their perception in concrete arguments, particularly the presence of clinical signs in their herds (Figure 2).

Figure 2 shows that the first signs perceived had to do with changes in feces, followed by clinical manifestations in the general condition of the animals and finally, extreme clinical signs of the development of the anemic syndrome.

Figure 2: Clinical signs associated with parasitosis and categories of order of appearance, based on the perception of small ruminant farmers



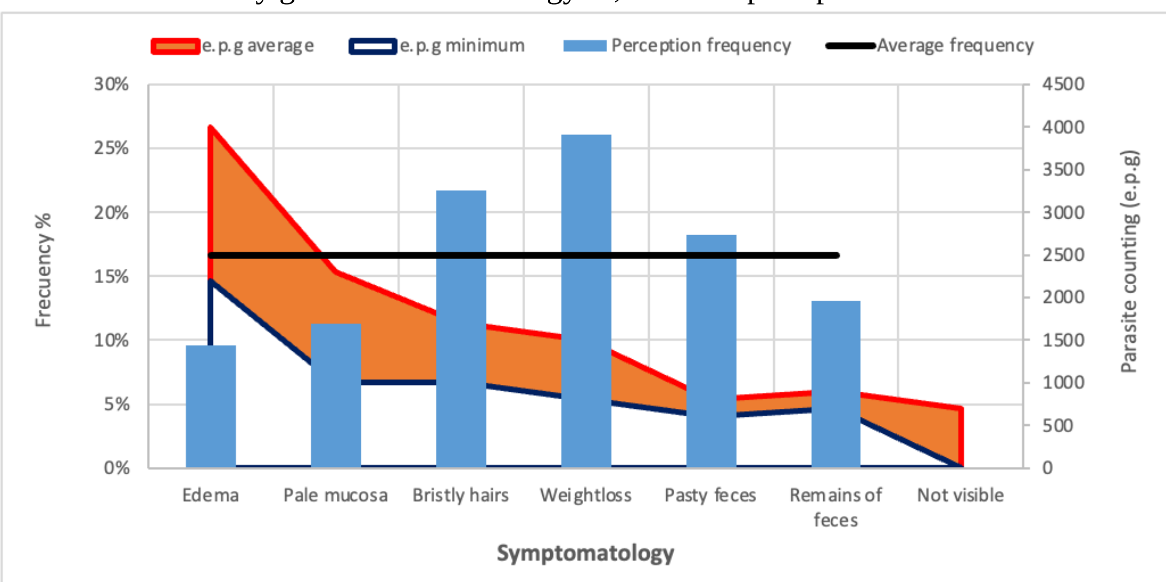
This dynamic is consistent with the pathogenesis of strongyles. The infesting larvae ingested with the grass, in the case of the genus *Haemonchus*, pass to a fourth stage in the tissue of the gastric mucosa, where a kind of encapsulation occurs. Certain stress conditions, in the host, favor the development of these larvae and the continuity of the cycle(14,15). Then, the combination of events related to zootechnical management and the development of the exogenous phase of the biological cycle lead to successive reinfections that cause a gradual increase in the parasite load. In this way, the increase in parasite load first produces irritations of the gastric mucosa and gastroenteric disturbances that are reflected in the aspect of the feces. Gastroenteric dysfunction, in combination with the hematophagous effect of some genera of strongyles, subsequently affects the nutritional status of the sick animal, and in the longer term, leads to the severe anemic syndrome. Precisely, this anemic syndrome is the basis of the Famacha Method(16,17) for the monitoring of the parasitic process and criterion for the application of anthelmintics. However, in the context of traditional farming systems in Cuba, management does not guarantee adequate nutrition of the herd(18). For this reason, anemic syndrome due to undernutrition is also very frequent and its appearance can be confused with the effect of parasites in these herds.

On the other hand, the parasitic process manifested itself by the expulsion of parasite eggs in the feces, long before clinical signs visible to farmers appear[19,20]. In the monitored herds, it was observed that 70 % of the dewormed animals, managed in direct grazing, began to expel parasite eggs 28 d post-treatment (average time) without any other sign of the parasitic process. This period, without discernible clinical signs for farmers, lasted for an average of 55 d, where the egg count reached 1,000 eggs per gram of feces (e.p.g).

The time elapsed between antiparasitic treatment until a new manifestation of the disease at the level of susceptible population is related to the prepatent period of the parasite, the subsequent management of the herd and environmental conditions. In this case, it can be understood that at least two complete cycles of reinfestations were required for the clinical manifestation of the process, including the prepatent period of the genus *Haemonchus*, 21 days according to Pinilla *et al*[21] plus the requirement to develop infesting larvae and spread significantly in the grassland[22].

The signs of impairment of the general condition of the herd, that is, weight loss, growth retardation, as well as bristly and dull hair, are the most recognized by farmers (Figure 3). Nevertheless, they manifest themselves with high levels of infestation which are projected by egg counts greater than 1,000 e.p.g. This shows that farmers perceive the parasitic process when it is in an advanced state with more than two months. In this period, the parasite population increases gradually, after successive cycles of reinfection.

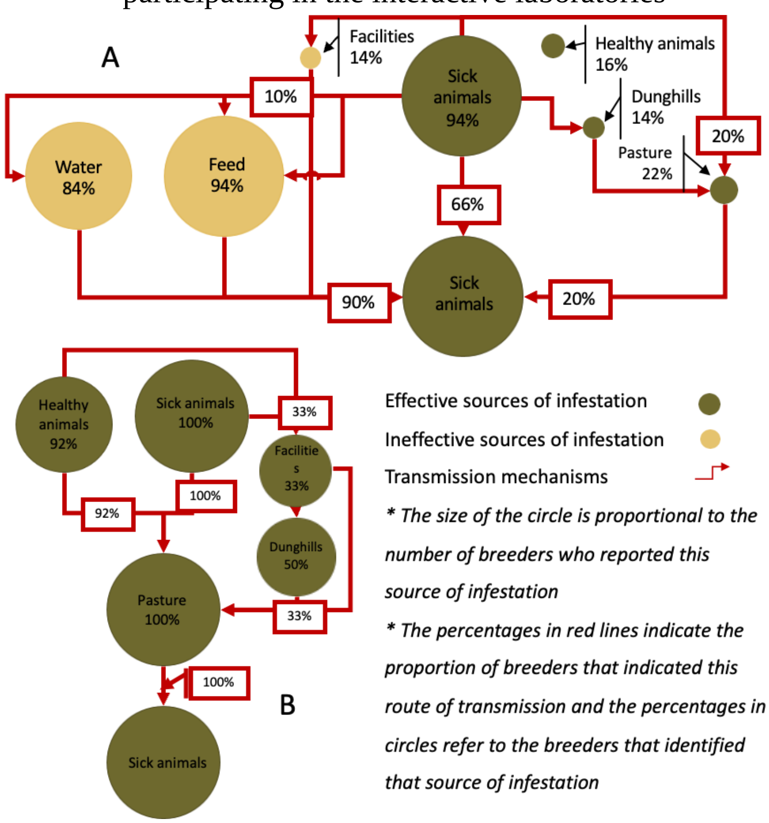
Figure 3: Frequencies of clinical signs of gastrointestinal parasitism in small ruminants, caused by gastrointestinal strongyles, from the perceptions of farmers



Changes in the understanding of parasitic processes through interactive laboratories

Figure 4 shows the causal diagrams of the transmission process of gastrointestinal strongyloses in small ruminants built by the farmers themselves before (Figure 4A) and after (Figure 4B) their participation in interactive laboratories. The initial causal diagram demonstrated a weak understanding of the parasite process by farmers in terms of sources of infestation and transmission mechanisms. Figure 4A illustrates that, prior to their participation in the interactive laboratories, producers identified sick animals, water and food as sources of infestation, and identified ingestion of contaminated water and food, as well as direct contact with sick animals, as transmission mechanisms. On the other hand, a minority group of farmers (16 %) recognized healthy animals as sources of infestation, while 20 % considered the consumption of contaminated grass to be a transmission mechanism. The set of these ideas is inconsistent with the conventionally accepted basis of the parasitic process of gastrointestinal strongyles[23].

Figure 4: Causal diagrams of the transmission process of strongyloses, built by farmers in two moments: (A) Before participating in the interactive laboratories; (B) After participating in the interactive laboratories



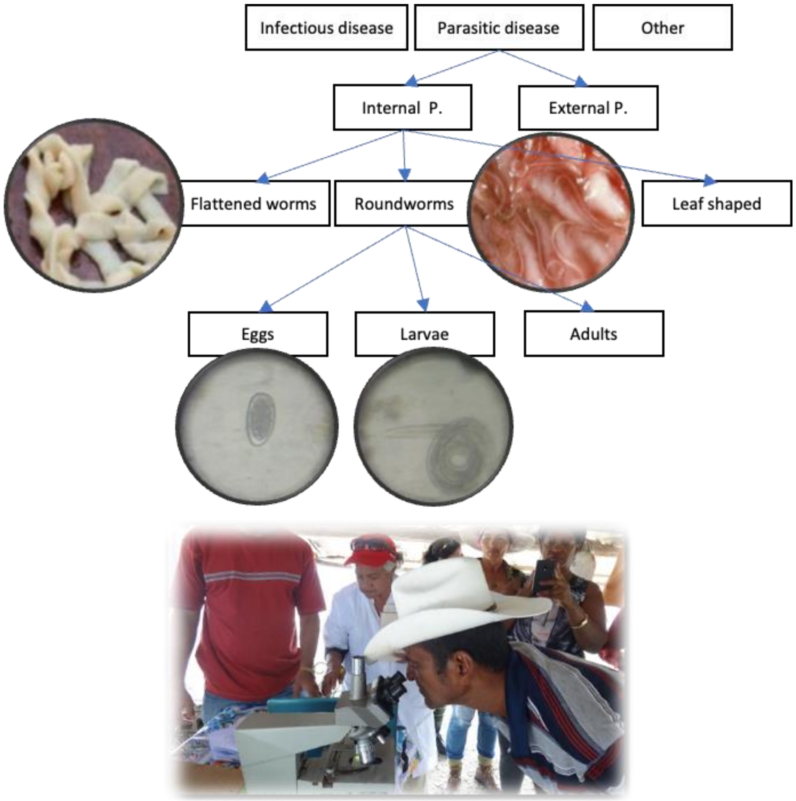
The causal diagram initially built by farmers (Figure 4A) reflects that their perceptions about the parasitic process in general are insufficient to establish an effective and integrated control system. The weakest points in this knowledge system are: a) the late recognition of the parasitic problem, since they observe it when it is advanced and has caused significant damage to the production unit, b) the lack of knowledge about healthy and subclinical animals as primary sources of infestation and c) the lack of knowledge about the consumption of contaminated grasses as an important transmission mechanism.

The basis of the profound inconsistencies in the knowledge of farmers about the parasitic process caused by strongyles is partly due to the fact that most of the events described are imperceptible without the support of instruments and methods specific to veterinary sciences. Basically, participatory training through Interactive Laboratories allows the parasitic process research scenario to be transferred directly from institutional laboratories to production units by adapting techniques to this context. In this way, in the interactive laboratories the participation of the farmer in the parasitic research process and in the systemic analysis of the results is incorporated. This allows the creation of capacities for socioenvironmental innovation, particularly the participatory design of integrated parasite control systems, which are more effective than conventional ones.

The changes of the causal diagram after the experience of the interactive laboratories (Figure 4B) demonstrated an effective ordering of the system of cognitions associated with the understanding of the parasitic process. The most relevant in this rearrangement was the recognition of “healthy” animals as a source of infection, as well as the recognition of the mechanism of infection: “population – feces – grass – susceptible animal”.

The training process through the interactive laboratories created or restructured a semantic network organized around gastrointestinal strongyloses in small ruminants (Figure 5). According to Fraijo *et al*[23], the semantic network is based on the premise that there is an internal organization of information in memory, in the form of a network where words form relationships that together give meaning. So, learning in a domain of knowledge would involve weaving more complex and better organized networks.

Figure 5: Representation of a segment of the semantic network on gastrointestinal strongyloses created by the process of interactive laboratories in sheep and goat farmers



In this study, farmers did not initially manifest a clear differentiation between the concepts of parasitic and infectious diseases; even less, among the types of diseases. This was reflected in the causal diagram built (Figure 4), in which strongyloses are conferred transmission mechanisms typical of other diseases (through water and food in houses). Traditionally, there is virtually no perception of the real mechanism of transmission of gastrointestinal strongyloses in small ruminants: through grasses contaminated with infesting larvae. The most precise knowledge of this transmission mechanism requires the differentiation of the concepts of adult parasite, non-infesting larva and infesting larva.

The participation in the interactive laboratories allowed the farmers meaningful learning from two essential facts: first, the perception of a "new reality" related to the parasitic process and, second, making explicit the new knowledge system. In general, new perceptions are achieved by direct observation of various parasitic groups, such as nemathelminthes, cestodes and trematodes, as well as adult, larval forms and eggs.

The strongyles genera identified in this study were: *Haemonchus, Oesophagostomum, Trichostrogylus* and *Bunostomum*; nevertheless, taxonomy was not relevant to farmers during their participation in the interactive laboratories. However, taxonomy is relevant information for a progressive or gradual conceptual differentiation in the hierarchical scheme shown in Figure 5.

On the other hand, the explanation and appropriation of knowledge is achieved by facilitating the individual analysis of the parasitic process in their own farming system and collective reflection in workshops of socialization of experiences. According to Rodríguez-Lora *et al*[24], conceptual learning is necessarily gradual, is based on explicit processes of construction through culturally sustained reflection. However, the daily practice of the farmer leads mostly to implicit conceptualization with more intuitive than reflective bases. On this type of implicit conceptualization, Pozo[25] stated: "... the extraction or abstraction of regularities in the environment generates a conceptual knowledge, of implicit character, ..." with a high predictive or descriptive value. Nonetheless, the implicit nature of those categories restricts their explicit meaning for the learner, who cannot access that network of relationships or connections woven between those categories". This means that knowledge about the parasitic process, which derives from everyday practice, is limited by the lack of perceptions and its mostly implicit character. Therefore, it is extremely important to make explicit, in an assisted learning program designed with specific objectives that, in this case, has to do with the different parasitic forms, the mechanisms of transmission and development of the epizootic process.

Effective changes in parasite control practices

Meaningful learning is verified in the change of practices. In this case, the new alternatives incorporated by farmers for the control of parasitosis can be classified into three types: a) preventive treatments in hosts -60 % of the farmers involved-, b) reduction of contact of susceptible animals with infesting larvae -90 % of farmers- and c) prevention of grass contamination -90 %-. This means the essential change from a contingency strategy to a preventive strategy.

Preventive treatments are a controversial practice if there is no information about the particularities of the epizootic process. In Cuba, several authors[26,27,28] described different epizootiological specificities consistent with the study regions and production systems. In general, these studies specify several critical points of the parasitic process that can be taken as a reference to plan preventive treatments, such as the beginning of the rainy season, the food stress of the dry period, and the concentration of susceptible categories in the movement of the herd. However, they point out the need to particularize each system to act more precisely, since the indiscriminate use of preventive treatments leads to processes of anthelmintic resistance in the parasitic population[29].

To reduce the contact of susceptible animals with infesting larvae, the most assimilated practice was to change the time to go out to graze beyond 1,000 h. At this time, the "dew" has already dried up and the infesting larvae, due to negative phototropism and positive hydrotropism, have returned to the grass base[30]. For their part, to avoid excessive contamination of the grass, farmers adopted practices such as housing for three days, after anthelmintic treatments, and improved the systems of disposal of feces and dunghills.

Conclusions and implications

The farmers participating in the experience of interactive laboratories initially showed a limited understanding of the processes of parasitic infestation by gastrointestinal strongyles, from the lack of perceptions about it. The interactive training created key perceptions of the parasitic process, such as etiological agents, sources of infestation and transmission mechanisms; supported by a new semantic network. The semantic network built is based on concepts assimilated from the visual and lived experience of producers in interactive laboratories and reinforced the conceptual differentiation of gastrointestinal strongyles with respect to other etiological agents, as well as different stages of the life cycle of these parasites. As a consequence, there was meaningful learning with effective changes in parasite control practices, consistent with preventive and control strategies based on preventive treatments and the reduction of contact between susceptible animals and infesting parasitic forms. It is recommended to extend the training strategies based on the interaction of this type of laboratories with the productive environment to other disciplines as long as the current techniques allow their adaptation to field conditions to carry out more participatory studies that strengthen the learning processes of the producers.

Acknowledgements

The authors expressly thank the Autonomous University of Chiapas for the support given to its professors through the Special Program for the Stimulation of Research (PEEI, for its acronym in Spanish), through which this publication was achieved; and to the postgraduate programs, DOCAS and MCPAT, of that institution for the support granted to its teachers. The Institute of Science, Technology and Innovation of the state of Chiapas (ICTIECH, for its acronym in Spanish) is also thanked for the complementary support granted to carry out the present publication.

Conflict of interest

The authors state that they have no conflict of interest related to the present scientific research.

Literature cited:

1. ONEI, Oficina Nacional de Estadística e Información. Sector agropecuario indicadores seleccionados. Edición octubre de 2018, La Habana Cuba. (No disponible on-line); 2018.

2. La O M. Estudio de conservación de la cabra criolla cubana en la sub-cuenca Cautillo del Valle del Cauto. [Tesis doctorado]. Instituto de Ciencia Animal. Mayabeque, Cuba; 2013.

3. La O-Arias MA, Guevara-Hernández F, Rodríguez-Larramendi LA, Pinto-Ruiz R, Nahed-Toral J, Reyes-Muro L. Evolución de los sistemas de crianza de cabras Criollas Cubanas en el contexto de la conservación del genotipo. Rev Mex Cienc Pecu 2018;9(1):68-85. https://doi.org/10.22319/rmcp.v9i1.4400.

4. Ninamancco ADC, Pinedo R, Chávez A. Frecuencia de nematodos gastrointestinales en ovinos de tres distritos de la Región Ancash, Perú. Rev Invest Vet Perú 2021;32(2). e20021. https://doi.org/10.15381/rivep.v32i2.20021.

5. Rojas N, Arias M, Arece J, Carrión M, Pérez K, Valerino P. Identificación de *Trichostrongylus colubriformis* y *Oesophagostomun columbianum* en caprinos del valle del Cauto en Granma. Rev Salud Anim 2011;33(2):118-120. http://scielo.sld.cu/pdf/rsa/v33n2/rsa08211.pdf.

6. Rojas N, La O M, Arece J, Carrión M, Pérez K, San Martín C, Valerino P, Ramírez W. Identificación y caracterización de especies de *Haemonchus* en caprinos del valle del Cauto en Granma. REDVET. Rev Elect Vet 2012;13(1):1-10. https://www.redalyc.org/pdf/636/63623398003.pdf.

7. Arece-García J, López-Leyva Y, González-Garduño R, Torres-Hernández G, Rojo-Rubio R, Marie-Magdeleine C. Effect of selective anthelmintic treatments on health and production parameters in Pelibuey ewes during lactation. Tropical Anim Health Prod 2016;48(2):283–287. https://doi.org/10.1007/s11250-015-0947-8.

8. Días-Nunes J, Antunes-Zappes C, Marchioro E. Saber tradicional de pequenos agricultores na bacia hidrográfica do rio Duas Bocas, estado do Espírito Santo: uma abordagem da etnoclimatologia. Geografares. 2020;1(30):155–175. https://doi.org/10.7147/GEO30.28022.

9. Sampieri RH. Metodología de la investigación: las rutas cuantitativa, cualitativa y mixta. 6ª ed. Mexico: McGraw Hill; 2018.

10. Tasón M, Montenegro N, Zurdo F. Determinación e identificación de parásitos gastrointestinales de un hato caprino en el Corregimiento de Potrerillo, Provincia de Chiriquí, Panamá. Rev Plus Econ 2021;9(2):23-29. Consultado http://revistas.unachi.ac.pa/index.php/pluseconomia/article/view/499.

11. Cetrá B, Niño-Uribe AI, Pereira M, Gómez S, Romero J, Federico-Adrian I. Estudio de persistencia de la infectividad en los pastos, de larvas de *Haemonchus contortus* susceptibles y resistentes a bencimidazoles, en el sur de la provincia de Corrientes. Instituto Nacional de Tecnología Agropecuaria. 2018;560(6):1-6. http://hdl.handle.net/11336/101269.

12. StatSoft, Inc. STATISTICA (data analysis software system), version 10. 2012. www.statsoft.com.

13. Mesa CV, Pastor FJS, Segura MJM. Evaluación de la investigación formativa: Diseño y validación de escala. Rev Electrónica Educare. 2021;25(1):9. https://doi.org/10.15359/ree.25-1.3.

14. Endo VT, De Oliveira TC, Marchioni-Cabral AP, Massamitsu-Sakamoto CA, Ferraro GC, Pereira V, Zanetti-Lopes WD, Mazzucatto BC. Prevalência dos helmintos *Haemonchus contortus* e *Oesophagostomum columbianum* em pequenos ruminantes atendidos no setor de Anatomia Patológica–UEM. Rev Ciênc Vet Saúde Pública 2014;1(2):112-118. https://doi.org/10.4025/revcivet.v1i2.25397.

15. Medina P, Guevara F, La O M, Ojeda N, Reyes E. Resistencia antihelmíntica en ovinos: una revisión de informes del sureste de México y alternativas disponibles para el control de nemátodos gastrointestinales. Pastos y Forrajes, 2014;37(3), 257-263. Consultado 3 Ago, 2021, http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0864-03942014000300001&lng=es&tlng=es.

16. Rossanigo C, Page W. Evaluación de FAMACHA en el control de nematodes gastrointestinales en cabras de San Luis (Argentina). RIA. Rev Invest Agropecu 2017;43(3):239-246. https://www.redalyc.org/pdf/864/86454121010.pdf.

17. Suárez VH, Fondraz M, Viñabal AE, Salatin AO. Validación del método FAMACHA® para detectar anemia en caprinos lecheros en los valles templados del noroeste argentino. Rev Med Vet 2014;95(2):4-11. https://www.produccion-animal.com.ar/sanidad_intoxicaciones_metabolicos/enfermedades_caprinos/64-anemia.pdf.

18. Ponce-Palma I, La O M, Rojas-Gómez N, Fonseca-Fuentes N, Nahed-Toral J, Parra-Vázquez M, Guevara-Hernández F. Sistemas familiares de producción de pequeños rumiantes. Ann Academia Cienc Cuba. 2016;6(3):1-5. http://revistaccuba.sld.cu/index.php/revacc/article/view/554/561.

19. Hoyos CE, Coronado AC, Ángulo LM, Yánez MB, Garay OV. Prevalencia y grado de infección de nematodos gastrointestinales en ovinos de pelo en pastoreo de cuatro municipios de Córdoba, Colombia. Rev Cient 2014;24(5):414-420. https://www.redalyc.org/pdf/959/95932260005.pdf.

20. Arece J, López Y, Molina M, Alpízar A. Cambios fisiopatológicos en ovinos Pelibuey en estabulación, después de infestación experimental con estrongílidos gastrointestinales. Pastos y Forrajes 2013;36(3):354-359. http://scielo.sld.cu/pdf/pyf/v36n3/pyf07313.pdf.

21. Pinilla JC, Flórez P, Sierra M, Morales E, Sierra R, Vásquez MC, Tobon JC, Sánchez A, Ortiz D. Prevalencia del parasitismo gastrointestinal en bovinos del departamento Cesar, Colombia. Rev Invest Vet Perú 2018;29(1):278-287. http://dx.doi.org/10.15381/rivep.v29i1.14202.

22. Briones-Montero A, Salazar-Rodríguez I, Suárez-Veirano G, Geldhof P, Zárate-Rendón D. Prevalencia y carga parasitaria mensual de nematodos gastrointestinales y Fasciola hepática en bovinos lecheros de dos distritos del Valle del Mantaro, Junín, Perú. Rev Invest Vet Perú 2020;31(2):e17819. https://dx.doi.org/10.15381/rivep.v31i2.17819.

23. Fraijo-Sing BS, Barrera-Hernández LF, Tapia-Fonllem CO, Ortiz-Valdez A. Exploración del concepto de naturaleza desde redes semánticas naturales en estudiantes de educación primaria. Diversitas: Perspectivas en Psicología. 2018;14(2):233-242. https://doi.org/10.15332/s1794-9998.2018.0002.03.

24. Rodríguez-Lora V, Henao-Cálad M, Valencia-Arias A. Taxonomías de técnicas y herramientas para la Ingeniería del Conocimiento: guía para el desarrollo de proyectos de conocimiento. Ingeniare. Rev Chilena Ingeniería 2016;24(2):351-360. https://dx.doi.org/10.4067/S0718-33052016000200016.

25. Pozo JI. Aprendices y maestros. La psicología cognitiva del aprendizaje. Madrid, España: Alianza Editorial; 2008.

26. Noa-Lobaina N, Lafargue-Savón M, Labadie-Pérez L. Infestación parasitaria en pasturas de ovinos en localidades de la provincia Guantánamo, Cuba. Rev Prod Anim 2021;33(2). https://revistas.reduc.edu.cu/index.php/rpa/article/view/e3763.

27. Arece J, López Y, Torres-Hernández G, González-Garduño R, Rodríguez-Diego JG. Epizootiología de la tricostrongilosis gastrointestinal en ovinos sometidos a tratamientos antiparasitarios selectivos en Cuba. Pastos y Forrajes. 2014; 37 (4):442-448. Consultado 03 Ago, 2021, de http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0864-03942014000400009&lng=es&tlng=en.

28. Carballo-Silverio LC, Arece-García J, López-Leyva Y, Luck-Montero R. Variación en la resistencia fenotípica a parásitos gastrointestinales en un rebaño de cabras. Pastos y Forrajes. 2020;43(1):50-55. Consultado 3 Ago, 2021, http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0864-03942020000100050&lng=es&tlng=es.

29. Batista LF, Ramos LF, Brito SNS, de Oliveira AL, Antunes CR, dos Santos LL. Resistência anti-helmíntica em nematoides gastrintestinais de ovinos. PUBVET. 2017; 11:1188-1297. http://dx.doi. org/10.22256/pubvet.v11n12. 1245-1249.

30. Soca M, Roque E, Soca M. Epizootiología de los nemátodos gastrointestinales de los bovinos jóvenes. Pastos y Forrajes 2012;28(3):1-7. https://payfo.ihatuey.cu/index.php?journal=pasto&page=article&op=view&path%5B%5D=732.