Technological research-extension procedure for the sustainable feeding of sheep, preliminary results

C〇〇DES
COOPERATIVISMO Y DESARROLLO

Procedimiento de investigación-extensión tecnológica para la alimentación sostenible de ovinos, resultados preliminares

Procedimento de pesquisa-extensão tecnológica para a alimentação sustentável dos ovinos, resultados preliminares

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ABSTRACT

Sheep are in high demand in the Cuban population. Most of the sheep production systems in Cuba can be classified as extensive. Ninety-five percent of the mass is in the cooperative or private sector, which implies the development of different work strategies. The objective of the work was to implement a technological research-extension procedure for the sustainable feeding of sheep with local resources. The research was carried out in Las Tunas municipality, Las Tunas province, Cuba. The period analyzed was between 2016 and 2019. The procedure was designed in five stages. Stage

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I: Characterization and typing of sheep production scenarios with a multivariate approach. Stage II: Identification and selection of available local resources with potential for sheep feed. Stage III: Implementation of innovation and local value networks for sheep. Stage IV: Evaluation under experimental conditions of local resources with potential for sheep feed. Stage V: Training and specialization of producers in the use of local resources with potential for sheep feed. Stage VI: Evaluation of the productive, economic, social and environmental impact, under commercial conditions of technologies based on the use of different local resources with potential for sheep feeding. The sequence of operations used could be considered as a technological research-extension procedure for the sustainable feeding of sheep, with local resources that presents a systemic and integrative approach.

Keywords: innovation; process; sheep production; local resources; sustainability

RESUMEN

El ganado ovino posee alta demanda en la población cubana. La mayoría de los sistemas de producción de ovinos en Cuba se pueden clasificar como extensivos. El 95 % de la masa se encuentra en el sector cooperativo o en el privado, lo que implica el desarrollo de estrategias de trabajo diferentes. El objetivo del trabajo fue implementar un procedimiento de investigación-extensión tecnológica para la alimentación sostenible de ovinos con recursos locales. La investigación se realizó en el municipio Las Tunas, provincia Las Tunas, Cuba. El período analizado comprendió entre los años 2016 y 2019. El procedimiento se diseñó en cinco etapas. Etapa I: Caracterización y tipificación de los escenarios de producción de ovinos con un enfoque multivariado. Etapa II: Identificación y selección de recursos locales disponibles con potencialidades para la alimentación de ovinos. Etapa III: Implementación de redes de innovación y valor local para el rubro ovino. Etapa IV: Evaluación en condiciones experimentales de recursos locales con potencialidades para la alimentación de ovinos. Etapa V: Capacitación y especialización de productores en el uso de recursos locales con potencialidades para la alimentación de ovinos. Etapa VI: Evaluación del impacto productivo, económico, social y ambiental, en condiciones comerciales de tecnologías basadas en la utilización de diferentes recursos

locales con potencialidades para la alimentación de ovinos. La secuencia de operaciones empleadas pudiera ser considerada como un procedimiento de investigación-extensión tecnológica para la alimentación sostenible de ovinos, con recursos locales que presenta un enfoque sistémico e integrador.

Palabras clave: innovación; procedimiento; producción ovina; recursos locales; sostenibilidad

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RESUMO

As ovelhas são muito procuradas entre a população cubana. A maioria dos sistemas de produção ovina em Cuba pode ser classificada como extensiva. Os 95% da massa encontram-se no sector cooperativo ou privado, o que implica o desenvolvimento de diferentes estratégias de trabalho. A finalidade do trabalho era implementar um procedimento de investigação-extensão tecnológica para a alimentação sustentável de ovinos com recursos locais. A investigação foi realizada no município de Las Tunas, província de Las Tunas, Cuba. O período analisado foi entre 2016 e 2019. O procedimento foi concebido em cinco fases. Etapa I: Caracterização e tipificação de cenários de produção ovina com uma abordagem multivariada. Etapa II: Identificação e seleção dos recursos locais disponíveis com potencial para a alimentação de ovinos. Etapa III: Implementação de redes de inovação e de valor local para ovinos. Etapa IV: Avaliação em condições experimentais de recursos locais com potencial para a alimentação de ovinos. Fase V: Capacitação e especialização dos produtores na utilização de recursos locais com potencial para a alimentação dos ovinos. Etapa VI: Avaliação do impacto produtivo, económico, social e ambiental, em condições comerciais de tecnologias baseadas na utilização de diferentes recursos locais com potencial para a alimentação dos ovinos. A sequência de operações empregadas poderia ser considerada como um procedimento de investigação e extensão tecnológica para a alimentação sustentável de ovinos, com recursos locais que apresentem uma abordagem sistémica e integradora.

INTRODUCTION

Sheep are in high demand in the Cuban population because they are a source of protein of high biological value, with low financial investment (Cruz Cabrera et al., 2018). Most of these sheep production systems in Cuba can be classified as extensive, which present low productive indicators, with respect to the potential of the Pelibuey breed, mostly used.

On the other hand, 95% of the mass is in the cooperative or private sector, which implies the development of different work strategies, with respect to the panorama that was presented until the 90's of the last century; at that time, the state sector dominated the inventory. In the current context, technological adoption, adaptation and innovation have been slow and insufficient, which is attributed to various objective and subjective causes. Among the factors to be considered is that the technologies generated through conventional agricultural research procedures are not entirely appropriate to the physical-biological conditions and socio-cultural-economic environments of small producers.

Therefore, the implementation of research and technology extension systems, with more effective approaches, such as: multivariate analysis, innovation and value networks, use of local resources, etc., could more quickly change the panorama of small farmers, through technologies aligned with their circumstances, limitations, possibilities and interests.

The objective of the work was to implement a technological research-extension procedure for the sustainable feeding of sheep with local resources.

MATERIALS AND METHODS

Location and period: The research was conducted in Las Tunas municipality, Las Tunas province, Cuba, located at latitude: 20° 57' 25" N Longitude: 76° 57' 13" 0, with an altitude of 90 meters above sea level. The period analyzed was between 2016 and 2019.

Climate conditions: The average behavior of the main climatic variables in the stage showed values of precipitation 700 mm, temperature 28 0C and 76 % relative humidity.

Collection of information: The information was collected at the herd level, with the diagnosis made in the productive area of each farm. Indicators of productive, reproductive, management feeding, structural, social and edaphoclimatic performance were analyzed for 49 % productive scenarios, which represented 58 % of the total.

Variables: 67 variables were examined: 22 quantitative and 45 qualitative.

Statistical and geospatial analysis: Different statistical descriptive analysis were applied, analysis of variance and multi varied analysis. Data were processed through SPSS statistical package, version 16.0 (Visauta Vinacua, 1998). Geospatial information was obtained through a global positioning system (GPS), which was to obtain the exact coordinates of the farms.

Delphi process characteristics: The expert consultation method was applied, according to Espinosa García et al. (2015). A panel of 26 experts was formed, which was integrated with professionals from the locality, the object of the research and researchers from the Institute of Animal Science with experience working in the territory. Two rounds of interviews were conducted. In the first, a selection was made of how many and which resources could be used on the farms, and in the second, the resources were evaluated. The resources were classified into non-herbaceous and herbaceous and the selection of these resources was based on the following criteria:

- Non-herbaceous: Annual availability, Total cost of supply, Nutritional value (protein and/or energy), Time and conservation cost
- Herbaceous: Annual availability, adaptability to local edaphoclimatic conditions, production in low rainfall period, resistance to pests and diseases, production

under rainfed conditions and without fertilization, nutritional value (protein and/or energy)

Methodology for the creation of the innovation network: The snowball criterion was used (Pérez-Luco Arenas et al., 2018); therefore, a questionnaire was applied to ten specialists of the territory for the identification of the actors and these, in turn, incorporated the rest. For this purpose, the questions asked were: What entity or organization do you consider relevant to form an innovation or value network in the sheep industry in the municipality of Las Tunas? With which of the entities or organizations do you establish working relationships? How often during the year?

RESULTS AND DISCUSSION

The procedure was designed based on five interrelated stages (Fig. 1).

Stage I. Characterization and typing of production scenarios. Objective: to determine the particular and average characteristics of the totality of the farms and the surrounding area with respect to sheep production and to achieve an objective classification.

Stage II. Identification and selection of local resources. Objective: select resources with potential for sheep management and feeding, in a sustainable manner.

Stage III. Implementation of innovation and value networks. Objective: to promote the exchange of information, resources and knowledge among the main actors involved in the sheep product-trade chain in order to promote innovation and the increase of added value.

Stage IV. Implementation of technological alternatives and stimulation-training. Objective: to evaluate the impact of different technological alternatives in the management, feeding and marketing of sheep, and to stimulate and train producers and other actors in the sheep food chain in the use of local resources.

Stage V. Impact evaluation. Objective: to determine the productive, economic, social and environmental impact of the innovation process, based on the use of different local resources with potential for sheep feed.
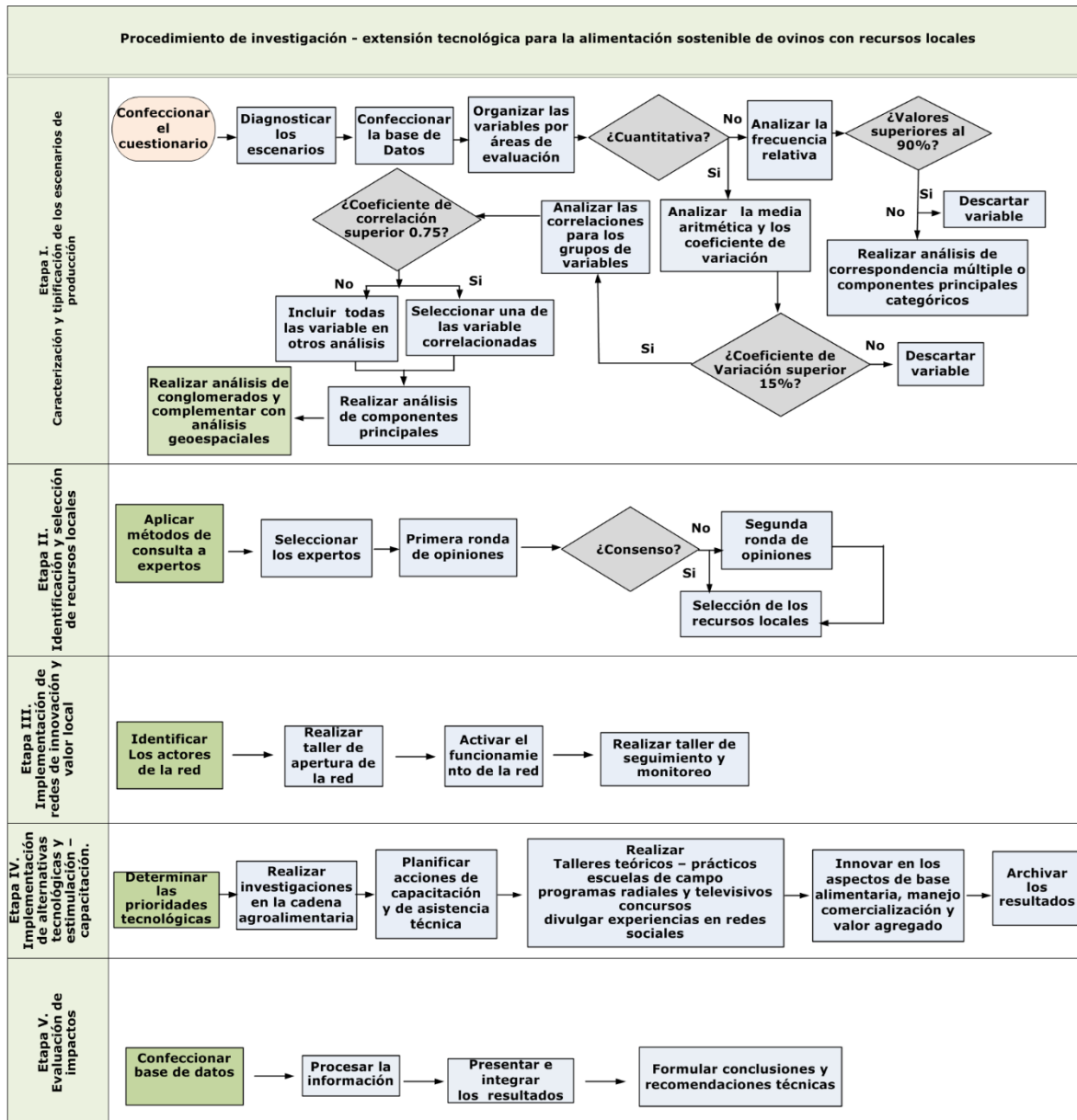

Fig. 1 - Flowchart of the procedure

Source: Own elaboration

Results of the implementation of the procedure

With the characterization and typing stage, it was possible to determine the particular and average characteristics of all the farms and the environment related to sheep production in the municipality of Tunas, which constitutes key information to outline technological and management strategies. On the other hand, the variables with the greatest discriminating power were defined, which constitute important factors to carry out a typification process. In this sense, the conglomeration process yielded the best results with the formation of four types of farms (Fig. 2). Therefore, the most significant average characteristics of each typology, which should be taken into account for the implementation of technological and other actions in the farms investigated, were centered on the following:

Typology I: It consisted of 10 farms and presented the best performance in terms of reproductive efficiency and number of lambs weaned per year. This conglomerate was the one with the greatest experience of its producers in sheep farming; however, it showed substantial deficiencies in the training aspects, with a total absence of direct training activities with the producers. From a qualitative point of view, this group used continuous grazing with high frequency (7). Housing conditions are generally acceptable. The commercialization of production was most frequently carried out through contracting, since 80% of the farms had this characteristic.

Typology II: It was made up of 10 farms, with the least numerous flocks and therefore had the lowest number of births and average weaned lambs. In addition, it grouped producers with less experience in working with animals. However, they were the ones that received the most training in recent years. Regarding the type of grazing, continuous and rotational grazing presented very similar values, with frequencies of 4 and 5, respectively. All of the dwellings were classified as acceptable. Marketing was carried out without any type of legal contract in all cases. The sheep activity was implemented as a by-product of the farms.

Typology III: It was the one with the largest number of farms, with few animals and the smallest number of breeders. They were producers with an acceptable level of experience. The indicators for births and weaned lambs were significantly lower than

those of clusters I and IV, with the worst indicators related to the performance of the breeders. Training was null in the period analyzed, although the experience of the producers was one of the highest among all the groups.

Regarding the grazing system, all the modalities were represented in this cluster, although the highest frequency corresponded to continuous with (16), nomadic with (5) and rotational with (1), entities respectively. The housing aspect presented dwellings between acceptable and in good condition, with the highest percentages of the latter among all the groups. The analysis of the number of producers, who prioritize sheep production, showed 50% for both possibilities.

Typology IV: It was composed of 7 farms, with the most numerous flocks and significantly more reproductive females. However, low reproductive and lamb weaning efficiency was observed. The issue of training was markedly deficient in comparison with the rest of the typologies, with the exception of typology II. The farmers belonging to this conglomerate had an acceptable level of experience in sheep farming. It should be noted that most of the farmers grazed their animals on an itinerant basis (5). In this group, all types of housing were observed in terms of quality, although the highest frequency was found in housing in acceptable condition (3) and the rest of the categories (not good and bad) with (2). The main form of commercialization was through contracts; likewise, in almost all cases, the main activity was sheep production.
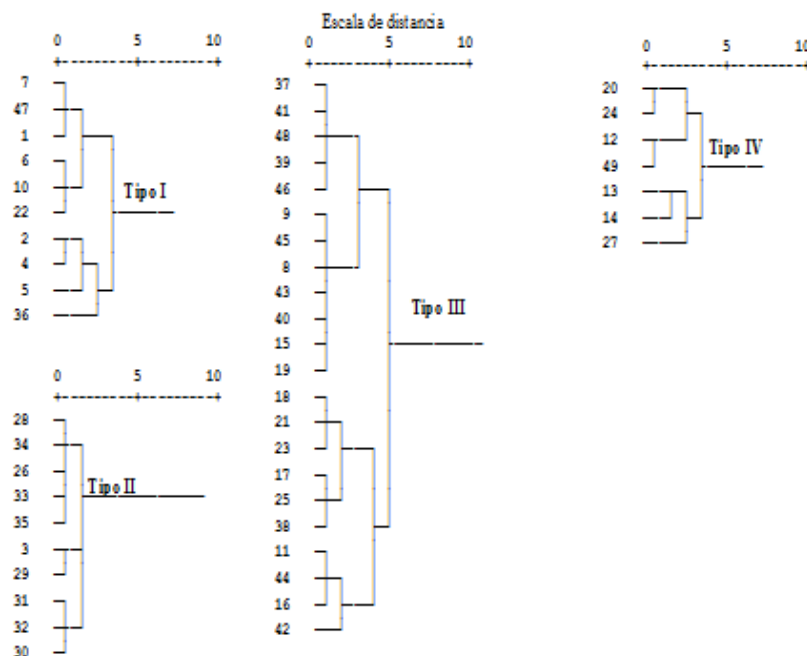
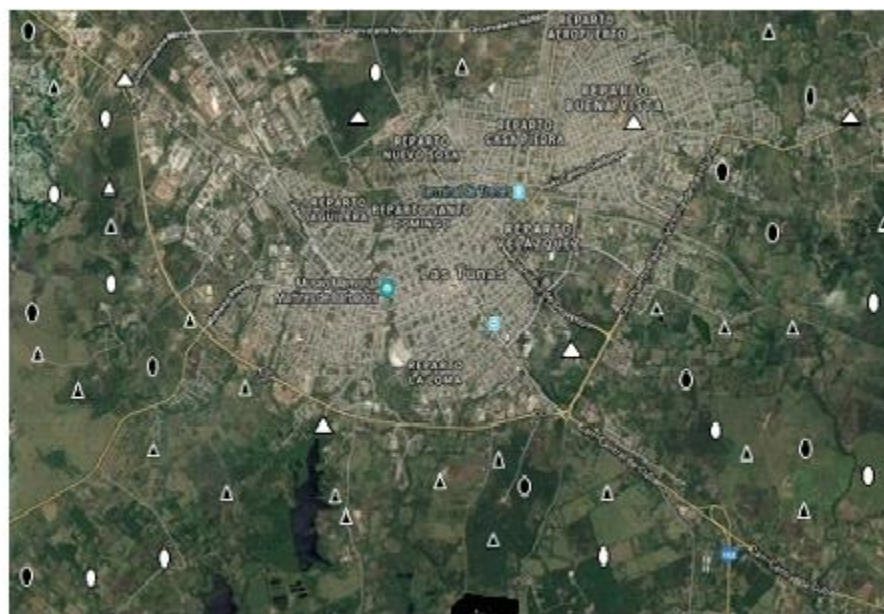**Fig. 2** - Scheme of the conglomeration process

Source: Own elaboration

Geospatial analysis

Figure 3 shows the geospatial location of the farms analyzed and grouped, according to the results of the cluster analysis, within the limits of the municipality of Las Tunas. In this sense, it was observed that most of the farms were located in suburban and rural areas, since only 10.20% were located in the urban area of the city, in which cases itinerant grazing prevailed as a distinctive feature; however, most of them were located near access roads, a positive aspect of great importance in agricultural processes.

Regarding the existence of surface water bodies, the images revealed that only four farms were close to reservoirs, with some importance, which indicated that there was no abundance of water availability with these characteristics, which in turn showed that the water sources, which were used and can be exploited to a greater extent by the producers, are subway, an element that did not coincide with the reports of previous research (Díaz Duque, 2018).

Translated from the original in Spanish

On the other hand, this satellite tool made it possible to reaffirm that the tree density was low and that the predominant relief was flat. Regarding the grouping of the farms, it was found that, as a typology, they were dispersed in most cases, although this element is not significant and does not hinder their management, since the radius of action was approximately 32.71km. The images also showed that the farms are close to each other and that there is sufficient area for agricultural and livestock production.

Legend: Typology I ●; Typology II ◊; Typology III ▲; Typology IV △

Fig. 3 - Satellite image of the geographic location of the conglomeration process.

Source: Own elaboration

With the selection stage of local resources, the general consensus of the surveyed experts was obtained, where: calcium carbonate, distillery stillage and common salt (NaCl) constitute non-herbaceous resources available and accessible to sheep producers in the municipality of Tunas. In the case of herbaceous resources, it was also shown that: Leucaena, sugar cane and some of the varieties of *Pennisetum* can be used with a high probability of success in the productive systems. On the other hand, the following species were discarded because they were considered less productive and vulnerable to climatic conditions: *Tithonia diversifica*, *Moringa oleifera* and *Morus alba*. It is worth mentioning that most of the identified resources were classified as herbaceous, which is
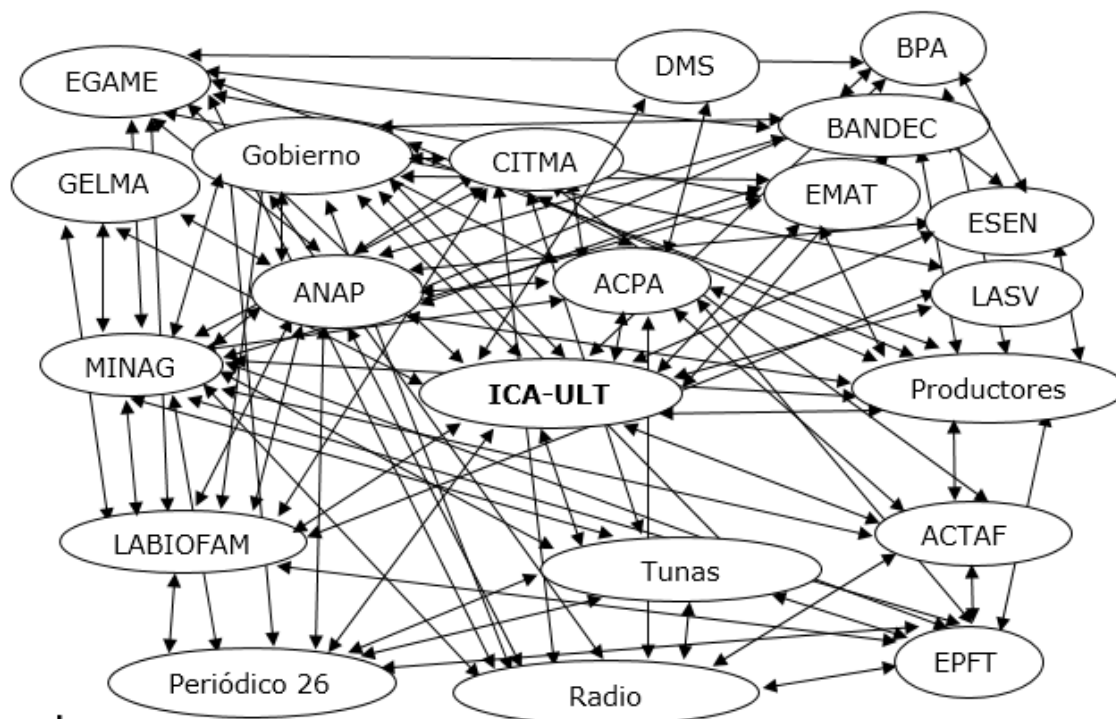
directly related to the principles of ruminant animal production in tropical conditions and production costs (Alonso, 2016).

Innovation network

Figure 4 shows schematically the relationships between the actors in the innovation network. The network was made up of 22 institutional actors or entities of different social profiles, which were also differentiated by type of ownership: state, private, cooperatives and NGOs. A total of 94 interactions were identified. It is worth mentioning that not all the actors in the network established working relationships, which could be considered as an element that hinders innovation processes in the sheep sector in the territory; for this reason, at this stage, the initial priority was to establish connections between key agents.

The main nodes after the establishment of the network in relative terms were formed by the Institute of Animal Science-University of Las Tunas, with 100% of the interactions, the Ministry of Agriculture 17%, the National Association of Small Farmers 15%, the Government 12%, Cuban Association of Animal Production 12%, Radio Victoria 11% and the Experimental Station of Pastures and Forages 10% respectively. These values correspond to the role of each entity, in the innovation system, in which the Institute of Animal Science and the University of Las Tunas acted as coordinators (Arias Gilart et al., 2019).

Regarding the intensity of the relationships or exchange of information between actors, from a qualitative point of view, in the innovation and scientific-technical aspects, the diagnosis revealed the existence of different levels of intensity: none, very weak, weak, strong and very strong. The above, together with the type of relationship, will be a fundamental objective of the subsequent stages of this research. Although this is a preliminary result, it indicated the urgent need to increase the links between producers and the rest of the actors in the network, an element that, according to Zarazúa et al. (2012), is essential for promoting innovation in the agro livestock sector.

Fig. 4 - Diagram of the initial information flow among the network membership

Source: Own elaboration

Analysis of result indicators

The main results achieved in the 2016-2019 period are summarized in Table 1. The visits to gather information on each scenario were carried out in the first two years; this made it possible to learn *in situ* about the characteristics of each farm, a basic element for the implementation of technology transfer programs.

Translated from the original in Spanish

As for the technical visits, which are the actions that allowed the continuity of the process, they increased gradually. In this regard, it is relevant to highlight the importance of systematicity in technology transfer in this aspect, as it allows increasing credibility and trust between producers and the professional team (Amaro Rosales & De Gortari Rabiela, 2016), likewise, such action constitutes, therefore, an experiential training work. The training workshops were held in different urban and rural settings. The objective of these was to increase the level of technical preparation, mainly of primary producers, in addition to the interest in the application of science and technology. It is worth mentioning that the workshops in the rural environment, that is, in the producers' farms or in the offices of the Basic Units of Cooperative Production (UBPC in Spanish) or Credit and Service Cooperatives (CCS in Spanish), were more convenient for the transmission of skills and knowledge, which allowed for the adequate combination of theoretical and practical aspects.

Another approach that was addressed in this process was the preparation of students and professionals, which was achieved through lectures and graduate theses, which, in all cases, were focused on researching and proposing technological actions in the productive scenarios.

In relation to the farms that were technologically managed directly and systematically, a discrete value (6) was obtained up to that moment, but the increase was progressive. In this sense, it was difficult to obtain producers willing to commit themselves to a process of this nature, and the availability of their own means of transportation by the extension team was an important limitation, a factor that significantly limits the technology transfer activity.

In the area of farmer research, the behavior of the main productive and reproductive variables was investigated in two production systems, with notable differences (extensive itinerant and semi-intensive) during 18 months. With this study, the two farms were evaluated comparatively, through the dynamic analysis of the variables. This provided quantitative information to make adjustments in both systems. However, the purpose of the project is to convert each managed farm into a farmer's experimental polygon, that is, a scenario where the farmer learns to innovate, based on the evaluation

of his own results and provides solutions to his own difficulties, a process that becomes a learning tool for the farmer to acquire knowledge of his environment and his production system. This teaching method increases farmers' awareness and pride (Leitgeb et al., 2008).

Two years before the end of the project, only 8.8 ha of cultivated pasture have been planted. In this sense, it was found that the producers were mostly dedicated to planting crops for human consumption, an aspect that corresponds to the national panorama and a key element that undermines the purpose of significantly increasing the productive indicators in the production of food of animal origin. Likewise, in this particular case, a combination of objective and subjective elements were observed that limited the development of pasture and forage planting: availability of seed, machinery, fuel and wire, lack of business and own management, little knowledge and recognition of the importance of the subject, and lack of motivation to innovate.

From the point of view of innovation, 8 technologies were contributed to the implementation: protein bank, biomass bank with King Grass, Biomass bank with sugar cane, application of the FAMACHA method (Mohammed et al., 2016) for the visual examination of the hemoglobin level of animals, implementation of technical control systems; weed control; veterinary kit and methods of negative mass selection. However, most of these innovations were implemented in 6 farms, a value that, although insufficient, is a starting point and reference in terms of technology transfer.

The network innovation perspective, as explained above, constituted one of the fundamental pillars of this research. In this regard, it was necessary to begin intense work on institutional coordination in the municipality of Las Tunas (urban extensionism), which made it possible to involve and commit several key state and non-state actors in the operation of the sheep product system.

Participation in events for producers and students is one of the important activities for knowledge management that contributes to the successful development of technology transfer processes; therefore, it was a priority that showed the same trend as the other indicators. In the third year of the experience, the best result was achieved in terms of both quality and quantity, since 12 sheep breeders participated in international events,

consolidating the exchange of information between national producers and their foreign counterparts. As for the dissemination of results and other aspects, radio programs were systematically carried out in which didactic talks were given on: management, sheep and goat feeding, diseases, local resources available in the province, planting of pasture and forage species. The radio programs used were *Naturalmente*, *El Campesino* and *En casa*, all of them on the provincial radio station Radio Victoria, which were well received and had a good radio audience. In this regard, (Martiñón Martínez et al., 2014) concluded that radio is the most economical means of mass dissemination and allows knowledge to be disseminated very quickly in farming communities.

In the countryside schools, it was not possible to advance beyond planning, however, all the conditions were created for the future implementation of at least two field schools per year. It is important to note that the implementation of this type of training could be one of the most effective forms of technology transfer, since it is based on experiential training, which implies the obligation for each participant to replicate the knowledge acquired during the work sessions on their respective farms (Cadena Iñiguez, 2016). The same happened with the event contests, where the aim is to reward the best producers in order to motivate and encourage innovation in production scenarios. All the results shown in the near future should improve substantially once the work of the innovation and value network for the sheep industry in the province of Las Tunas is consolidated, which in a first stage is projected for the municipalities: Las Tunas, Jesús Menéndez, Puerto Padre and Manatí.

Table 1 - Main performance indicators at the stage

Results	Years				Accumulated
	2016	2017	2018	2019	
Diagnostic visits	49.00	51.00	17.00	3.00	120.00
Technical assistance visits	10.00	16.00	18.00	14.00	40.00
Training workshops	2.00	8.00	5.00	0.00	15.00
Undergraduate theses discussed	----	----	1.00	3.00	4.00

Lectures given to university students and other levels of education	2.00	2.00	3.00	3.00	10.00
Number of farms directly assisted	2.00	4.00	4.00	6.00	16.00
Experiments carried out in production scenario	----	2.00	2.00	2.00	6.00
Areas planted with cultivated pastures (ha)	-----	-----	3.50	2.40	2.90
Innovations introduced		2.00	6.00	8.00	16.00
Institutional coordination visits	14.00	12.00	28.00	18.00	72.00
Participation in events	2.00	6.00	8.00	2.00	18.00
Radio interventions	0.00	2.00	4.00	2.00	8.00
Countryside schools conducted	----	------	0.00	0.00	0.00
Contests organized	-----	------	------	2.00	2.00
Local innovation and value networks	-----	------	------	1.00	1.00

Source: Own elaboration

The sequence of operations employed could be considered as a technological research-extension procedure for the sustainable feeding of sheep, with local resources, which presents a systemic and integrative approach with interrelation between all its stages. At the same time, the implementation of the project had a positive impact on several aspects of the productive and social life of the territory. An increase in most of the variables was observed, which corresponded to the continuous learning process experienced by the project coordinators during its development.

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Conflict of interest:

Authors declare not to have any conflict of interest.

Authors' contribution:

Javier Antonio Herrera Toscano designed the research, in addition to performing the statistical analysis of the data and writing the first version of the article.

Javier Antonio Herrera Toscano and *Oscar Carmenate Figueredo* were involved in making the diagnoses, setting up the databases and interpreting the data.

All authors reviewed the writing of the manuscript and approve the version finally submitted.