PROPOSED METHODOLOGY FOR RESEARCH INTO THE SOCIOECOLOGICAL RESILIENCE OF AGROECOSYSTEMS

[PROPUESTA METODOLÓGICA PARA LA INVESTIGACIÓN DE LA RESILIENCIA SOCIOECOLÓGICA DE LOS AGROECOSISTEMAS]

Diana Nayibe Polanco-Echeverry*, Lizeth Marelly Álvarez-Salas, Leonardo Alberto Ríos-Osorio

School of Microbiology, Universidad de Antioquia, Medellín – Colombia. Email: diana.polanco@udea.edu.co, Tel. (574) 2195492
**Corresponding author*

SUMMARY

Agroecology proposes a new epistemological and methodological paradigm to understand the reality of farming and livestock production systems that are in turn nature-society systems. The research questions around these have traditionally been resolved from two methodological approaches: quantitative and qualitative. Although each complements the other, there have not been sufficient approximations from a perspective that would integrate them. A holistic, transdisciplinary agroecological proposal should transcend the theoretical discourse and become practical trough research aiming to understand the socio-ecological relationships in the agroecosystems, report the complex phenomena arising from such relationships and prepared detailed diagnostics from a systemic point of view. Reflections are presented here on the traditional methodological approaches to agroecology and new proposals that respond to the epistemological approach of the agroecological discourse.

Key words: agroecology; agroecological approach; systemic approach; socioecological relationships; complex systems.

RESUMEN

La agroecología propone un nuevo paradigma epistemológico y metodológico para entender la realidad de los sistemas de producción agropecuarios que son a su vez sistemas naturaleza-sociedad. Las preguntas de investigación en torno a estos, se han resuelto tradicionalmente desde dos enfoques metodológicos: cuantitativo y cualitativo. Si bien cada enfoque reconoce en el otro su complementariedad, no existen suficientes aproximaciones desde una perspectiva que los integre. La propuesta agroecológica holística y transdisciplinaria, debe trascender el discurso teórico y ponerse práctica a través de investigaciones que permitan entender las relaciones socioecológicas de los agroecosistemas, dar cuenta de fenómenos complejos que resultan de dichas interacciones y hacer un diagnóstico detallado de la realidad desde un enfoque sistémico. Aquí se presentan reflexiones sobre los abordajes metodológicos tradicionales de la agroecología y nuevas propuestas que respondan al enfoque epistemológico del discurso agroecológico.

Palabras clave: agroecología; enfoque agroecológico; enfoque sistémico; relaciones socioecológicas; sistemas complejos.

INTRODUCTION

Research in the farming and livestock sector has been oriented towards the search for solutions to isolated problems of production (Francis et al., 2008) or to understanding particular social situations in the field. Consequently, the methodologies used to develop these studies have been defined as a function of the particular discipline of the researcher or as a response to the need to obtain information that provides solutions to these questions. However, farming and livestock systems are in turn natural systems modified by man. This characteristic allows them to be classified as open 'complex' systems. According to Morin (1994), systemic theory establishes the notion of a system, 'this is not seen as a discrete elemental unit, but rather as a complex unit, an 'entirety' that cannot be reduced to the "sum" of its constitutive parts'. It is therefore necessary to place oneself in a transdisciplinary level that simultaneously allows understanding of the material nature of the study object, the types and complexities of the phenomena of association and the organization of the system itself.

In this sense, complex systems should be observed and studied with an epistemological approach that permits an understanding of their complexity and multiple dimensions. As a transdisciplicinary science, agroecology has the socioecological resilience of agroecosystems as its object of study. This is supported by an epistemological base that provides the theoretical and practical basis to achieve a holistic and systemic analysis of the innate phenomena of farming and livestock production systems (Salas et al., 2012; Álvarez et al., 2014).

Because of the above, the methodological strategies should be consistent with the complexity of the system studied; this allows both the quantitative and qualitative dimensions of the phenomena to be tackled (Hernandez-Sampieri et al., 2010). While it is necessary to obtain both qualitative and quantitative information, this does not constitute a solution to the methodological barriers to answering the research questions or prove agroecological hypotheses.

In order to verify the orientation methodology of agroecology, a search was carried out of the literature between July and October of 2013 with a view to defining the methodological approaches used by agroecological researchers. Masters and doctoral theses were analyzed, as well as articles published in high impact scientific journals in scientific databases: EBSCO, DIALNET, SCOPUS, SCIENCEDIRECT and SPRINGERLINK. This document only includes some of the articles in this review, with the objective of illustrating the principal approaches and themes in agroecology. Based on the studies evaluated four methodological tendencies were found that tackled questions related to the area: quantitative, qualitative, mixed methods and to a lesser extent, studies with a systemic approach, oriented towards comprehension of the object of agroecological study, i.e., the socioecological resilience of agroecosystems.

In general, the distinct holistic and integrative approach of a transdiscipline is not reflected in agroecological studies. This may be due to three factors: first, there is no consensus about the object of agroecological study that orients research; second, it has not been explored in more detail in a reflection on the epistemological approach; and third there remains a need to identify adequate research tools to link agroecological discourse and theory coherently with scientific investigations in this area (Gómez et al., 2013).

In this article it is proposed to describe a basic methodolgy to analyze problems in agroecology, with some experiences of its application in two investigative exercises from the systemic agroecological approach: the first of these was suggested to understand whether plant especies endemic to the Darién region could promote food sovereignty strategies and the second to identify the dynamic relationships among components of the cattle ranching system in the alluvial fan of Ibagué, Tolima (Colombia) that influence the behaviour of ticks as an essential attribute of this system.

Theoretical and methodological constructs

Morin (1994) explained how reality is organized into different levels of complexity. Thus, the physical level is less complex than the biological one and both are less complex than the socioecological level which encompasses them. Thus the greater the complexity, the greater the degree of integration of realities of different natures. According to Salas et al. (2012), despite recent developments, research on the natural sciences is still circumscribed to the physical and biological levels of reality; this only makes sense if the processes are studied in isolation. However, the problems of insustainability of the planet are manifested in a level of higher complexity, such as the socioecological one. This author suggests that '*socioecological interactions, which traditionally have been omitted by the classical sciences, have played such an important role in the problems of insustainability that their omission would signify the perpetuation of problems which the science of sustainability [referring to this as a science which examines complexity] aims to resolve*' (Salas et al., 2012).

Next, four different ways to approach research on environmental and agricultural problems from an agroecological perspective are presented: quantitative, qualitative, combined or mixed methods such as the frameworks of evaluation of sustainability and methodologies for complexity (see Table 1).

The first methodological approach is the quantitative one. This emphasizes the biophysical dimension of the system, with biodiversity as a strategy for the regulation of pests and diseases, allowing a better adaptation (Altieri, 2009). Thus, biodiversity is one of the most relevant themes in the area (Moonen and Bàrberi, 2008)

Table 1. Approaches in agroecological research.

Research Approach	Level of reality	Aspects of agricultural systems	Achievements and limitations
Quantitative	Biological Physical	Biodiversity, agro-biodiversity, eco-systemic services, energy efficiency, biological control, fertilization, allelopathy, intercropping, efficient microorganisms, sustainable ranching systems (agroforestry), maintenance and fertility of the soil, soil microbiology, animal integration, maintenance of the microbiota.	Generate sufficient information to design more sustainable agroecosystems. Search for strategies to increase yield and quality of crops through adequate husbandry. Do not transcend understanding towards socioecological interactions.
Altieri et al. 2012; Martínez et al. 2013; Altieri 1983; Ponti et al. 2007; Colvin and Gliessman 2012; Nicholls et al. 2000; Liere et al. 2012; Zapata et al. 2009; Soto et al. 2002; Posada et al. 2013; Patiño and Sánchez 2012; Hilimire et al. 2013.			
Qualitative	Social Biological	Indigenous cosmovision linked to the production of food, knowledge of soil usage, concept of 'weeds', historic agroecosystem transformation processes, attitude of peasants to biodiversity, experimentation and rural innovation, effects of technology transfer, social movements campesinos agroecological, strategies of resilience of systems to climate change, socioeconomic impacts of the introduction of genetically modified seeds, impact of participative strategies of education and research on rural transformation processes.	Participative studies. Generate knowledge necessary to define the actions, which favour transformations on the way to an integrated development. Do not go beyond understanding of socioecological interactions.
Morales and Perfecto 2000; Barrera and Toledo 2005; Chacon and Gliessman 1982; Arístide, 2010; Junge et al. 2009; Leitgeb et al. 2014; Cáceres 2011; Rosset and Martínez 2012; Márquez and Funes 2013; Jacobson 2013; Mackenzie et al. 2012; Lilja and Bellon 2008; Duveskog 2013; Zuluaga 2011.			
Combined or mixed methods as the framework for evaluation of sustainability	Socioecological Biological Physical	Ecological studies on biodiversity, management of systems, ways of life, cooperativism, rural development and ecological managment of resources, management of agroforestal systems, econometric models, genetic diversity, maps and agricultural landscapes, plant variety and adequate management of the soil, management of energy, effects on health of carbon smoke, impacts of biocombustibles, indicators of sustainability, agroecological indicators of environmental and social resistence, MESMIS programme (Marco para la Evaluation de Systems de Management Incorporando Indicators de Sustentabilidad).	Tries to understand the complexity of the system. Analytical tools and epistemological approaches do not permit analysis of socioecological relationships. Analysis of the agroecosystem is partial and descriptive Do not go beyond understanding of socioecological interactions.
Wickings and Grandy 2013; Sales et al. 2013; Mielgo et al. 2001; Wolff 2010; Van Dusen 2000; Astier et al. 2010; Masera et al. 2005; Riojas et al. 2011; Skutsch et al. 2011; Fernández and Woodhouse 2008; Astier et al. 2012.			
Systemic	Socioecological Biological Physical	Development of models for sustainable agriculture, management and design de agroecological systems, production syndromes, adaptation and management of natural resources for ecotourism, effect of subsidies on rural production.	Methodologies have still not been described for its replication. Processes and levels of process and analysis are studied, allowing an understanding of complexity. Approach the socioecological relationships of the system.
Saifi and Drake 2008; Marquardt 2008; Lombardi 2009; Lovell et al. 2010; Vandermeer and Perfecto 2012; García et al. 2008; Ortiz and Cerutti 2008.			

According to the research question raised from the biophysical approach, researchers employ multiple methodologies. These involve comparative experiments, with treatments and repetitions, in which the variance of the experimental error can be estimated. Studies are also developed by comparative observation for which no experiment is designed in strict terms, although groups of individuals or circumstances are generated that are classified as treatments. In both cases the studies are performed within spatial scales such as a laboratory, greenhouse, crop field, farm, countryside, region or country, and within temporal scales as transversal and longitudinal studies. The research questions developed are as heterogenous as the disciplinary bases of the researchers themselves. These seek to resolve technico-productive matters which are circumscribed to the biophysical sphere and may include economic aspects of the system.

On the other hand, social sciences and specifically rural sociology and anthropology have studied certain sociocultural components important for agriculture, from the application of qualitative methodological tools such as ethnography, interviews (structured, semi-structured, in-depth), inquiry through the use of focus groups, social cartography and discourse analysis. One of the most significant theoretical contributions have been made by the ethnoscientific field, preoccupied by the manner in which societies name and order elements of their environment, emphasizing the cognitive aspects in the processes of perception and thought, supporting this through linguistic studies in particular (Turbay, 2004).

Alternatively, methods which combine qualitative and quantitative or mixed strategies, such as frameworks to evaluate sustainability, have been applied in agroecology as a response to its definition as: '*the application of ecological concepts and principles to the design and management of sustainable food systems*' (Gliessman et al., 2007) presenting a new perspective in the field of studies of agriculture and ranching. The understanding of sustainability as an agroecosystem quality is a recent area of research; Caporal et al. (2006) define agroecology as a science whose object is to contribute to the management and design of sustainable agroecosystems and contribute to prospective multidimensional analysis, taking into account economic, social, environmental, cultural, political and ethical factors.

Accordingly to León (2009), descriptive and comparative agroecology tries to classify, describe and analyze the regulations or emergent qualities arising from the increasing complexity of agroecosystems in processes of agroecological conversion. Here, research is addressed in methodological terms with a heterogeneous approach allows the complexity of the system to be understood that to some extent. Nevertheless, the strategies are unable to establish sociological relationships, rather than merely describe the components of the agroecosystem.

In order to overcome the difficulties described previously, methodologies have been developed based on the theory of complex systems. Here, agroecology is seen as a science of complexity, making reference to complex thought which 'seeks, at the same time, to distinguish – but without dividing - and to bind' (Morin, 1994). This perspective allows agroecology to distance itself from the Cartesian paradigm that simplifies, reduces and fragements the object of study. Agroecology defines itself as a science that approaches its object of study from a complex epistemological approach.

Systems of farming and livestock production are included within the systems denominated nature–society, which are open systems in permanent contact with their surroundings (León, 2012; Malpartida and Lavanderos, 1995). Therefore, they are a subsystem of a hierarchically greater system, as is the case of a rural district, municipality, region and even a country. As open systems, they establish energy flows, materials and information with the surroundings to which they belong. Analysis of the productive system should therefore be done in its own context, that is, by analyzing the surrounding conditions (García, 2006).
Complex systems are at the same time adaptive by nature (Maldonado, 2003). This allows them to react to diverse internal or external circumstances and thus the phenomena of the system should be observed and analyzed from their temporal and spatial dimensions or scales. Their components and attributes are the essential characteristics without which the system could not exist, which is why it has the same level of equivalence. For this reason changes in its attributes may affect the entire system positively or negatively.
Based on the theoretical elements described previously we now present two research proposals developed from the approach of complexity, as a form of clarifying the idea of an agroecological science with methodological approximations that are more consistent with the epistemological postulates defined by agroecology.

Methodological proposal

In these two examples of agroecological investigations the complex systems approach is applied to analysis of socioecological resilience in an agroecosystem. To initiate the research process six methodological phases were established, which should be included in all agroecological studies:

- Phase 1. Agroecological description of the desired study phenomenon.
- Phase 2. Focus the view of the phenomenon from a concept or central process on which work will be done, structured from agroecology. This is the process of reference around which the system is structured as an organized totality and without which it loses identity. A theoretical description of this concept is included here, with the methods and indicators for its analysis. It is important to clarify that although this concept may have been described previously an updated vision of this concept should be presented from agroecological principles in the research to be developed.
- Phase 3. Reconsideration of the central process defined from the concept developed in Phase 2. This process has traditionally been performed from agroecology with a Cartesian view of the phenomenon; it is thus necessary to transcend and reconstruct it from a complex perspective of agroecosystem dynamics.
- Phase 4. Modelling of the production system from the central process and description of the dynamics of the system to understand how this process functions. The methodological tools required are introduced in this phase. Aspects that García (2006) suggests for modelling can be considered here, such as:
  (1) Definition of the limits of the system to be investigated: complex systems lack precise limits, however for research purposes 'determinants' are evaluated, these being everything that affects the system. The first determinant is the temporal scale of the analysis, where fieldwork findings contrast with previous investigations in the area and verifiable local histories from secondary sources. The second determinant is spatial and defined from the general objective of the research.
  (2) Determination of the principal elements of the system and structure within the complex system. Fundamental elements to be identified included the history and conformation of the system as well as the dynamics of its transformation.
  (3) Definition of the relationships of first, second and third level processes linked with the principal process: the first level includes those components that directly and locally affect the central process. In the second level are included the metaprocesses that affect the components of the first level; these are of regional or national order. The third level includes international or global aspects that influence both the first and second levels.
  (4) Classification of the subsystems which give rise to the processes and elements according to their ontological nature (economic, institutional, ecological or social).
- Phase 5. Validation of the model with the community in which the research is performed.
- Phase 6. Application of the proposed strategy in association with the community. This phase can be carried out by two methodological routes: the first consists of establishing a conversion system as the final goal of the agroecological research, or in the second instance, establish a system of monitoring and evaluation of the system analyzed which will give an account of the processes of transformation in relation to time. This phase shows of one of the principal characteristics of agroecological science, supported in the paradigm of post-normal science (Funtowicz and Ravetz, 2000), science for decision-making, not only to know the reality but to contribute to its transformation.

Examples of studies developed under this approach

Starting from this basic methodology, we aim to understand two phenomena of the different reality, i.e., the survey of promising food plants as a local strategy to attain food sovereignty in San Francisco de Asís, Acandí, Chocó; and the dynamic relationships between components of the cattle ranching systems that influence the behaviour of ticks as an essential attribute of these systems in the Alluvial fan of Ibagué, Tolima. Although the two methodological proposals were designed with the objective of describing and understanding two phenomena in the two different systems and with the particularities of each researcher, both try to answer research questions in relation to the complexity of these systems.

Approximations to a systemic study of food sovereignty in the settlement of San Francisco de Asís, Acandí, Chocó

This research was carried out in a locality on the Caribbean coast of the Colombian Darién. This region is both a geographical and cultural frontier, characterized as humid tropical forest with high rates of biodiversity, offset by the high anthropic pressure placed on its natural resources. The principal objective of this research was to identify promising food plants as an alternative to consolidate local processes of food sovereignty. The analysis required a transdisciplinary systemic approach (Ríos and Mesa, 2009), taking into consideration factors such as ecological conditions, knowledge of promising food plants, land use, institutions, socioeconomic characteristics of the population and exogenous programmes.

The ethnographic fieldwork was carried out over a period of six months, which allowed the researcher to learn about the subjects' customs, ways of life and how they perceived their reality. The particularities of human groups were analyzed through observation of their daily activities (Guber, 2007), related to the environment; discourses on ethnobotanic knowledge, forms of appropiation and conservation strategies were recorded. The study of food plants was carried out with ethnobotanic methods, revealing the extent of local knowledge, agricultural practices (Alexiades 1996) and processes of culinary transformation. Farms were surveyed using techniques developed for socioeconomic and environmental studies in tropical forests (Turbay, 2004). The promising food plants were identified and collected using standardized taxonomic methods (Martin, 1995). Bromatological analysis provided data from 19 plants and 2 edible fungi on the following nutritional parameters: (a) water content by loss of humidity through drying (Egan 1991); (b) total ash or mineral content; (c) total fats; (d) total protein; (e) total carbohydrates; (f) caloric contribution to the sum of its components (ICONTEC, 1994). Quality of water for human consumption was also analyzed, obeying the premise that quality and access to water are fundamental to developing the concept of food sovereignty. For this, physicochemical analysis was performed with photometric methods and microbiological analysis using the techniques described in Rice et al. (2012), endorsed by the Colombian Ministry of Social Protection.

Data Analysis

The interviews were transcribed, systematized and ordered into six categories for analysis using the ATLAS TI 6.0 program, defined as: (1) Local knowledge associated with the PPUA (subcategories: ethnobotany, ethnoecology, ethnoagriculture). (2) Environmental factors (3) Local economy including cattle ranching, fishing, tourism and the dynamics associated with cocaine exportation. (4) Social aspects (5) Social movements and political organizations. (6) Tenure, use of and access to the land constituted as an emergent category.

In general, definition of the systems is an indispensable element of studies that use system-based approaches. The agroecosystem was specified as the settlement of San Francisco de Asís, the place where the socioecological relationships related to the use, knowledge and practices surrounding promising food plants were analyzed within the municipality of Acandí (Chocó); and consolidated with local food sovereignty strategies.

To delimit the system the central process was identified from the research question: Are promising food plants (plantas promisorias de uso alimenticio - PPUA) and local production strategies e.g. agricultura and fishing sufficient to attain food sovereignty? Here 'food sovereignty' is taken as a starting point based on the definition suggested by the Vía Campesina: 'Food sovereignty is the right of peoples, communities and countries to establish their own agricultural, fishing, food and land use policies, which are ecologically, socially, economically and culturally appropriate to their unique circumstances. This includes the fundamental right to food and the resources necessary to produce it, which means that all peoples have the right to a healthy, nutritious and culturally appropriate diet, and the capacity to maintain themselves and their societies' (Schejtman and Chiriboga, 2009). This organization emphasizes two elements: autonomy for the formulation of policies and the universal right to food (Schejtman and Chiriboga, 2009). The spatial and temporal limits were subsequently established. The principal elements of the system and the structure within the complex system were then identified. A fundamental element for identification of the system is the history of the settlement, which gave rise to the understanding of the current structure of land tenure and the effects of law 70 dealing with specific rights of the Afrocolombian population (Congreso de Colombia, 1993); formation of the settlement; dynamics in the transformation of the ecological knowledge and changes in the local economies. Finally, the first, second and third level relationships linked with the principal process (García, 2006) were established. The system suggested for this research is illustrated in Figure. 1.

Analysis of this complex system starts from the subcategory 'promising plants', which was enriched with the analytical contribution of the ethnobotanical, ethnoecological and ethnoagricultural aspects, as well as tenure and access to land, armed conflict, local economy, local human groups, history of the associated settlement; this in turn allowed the system of agricultural production to be characterised. Bromatological analyses applied to the promising food plants allowed quantification of the nutritional and calorific contributions of these species, with a view to validating notions of satiety and depletion.

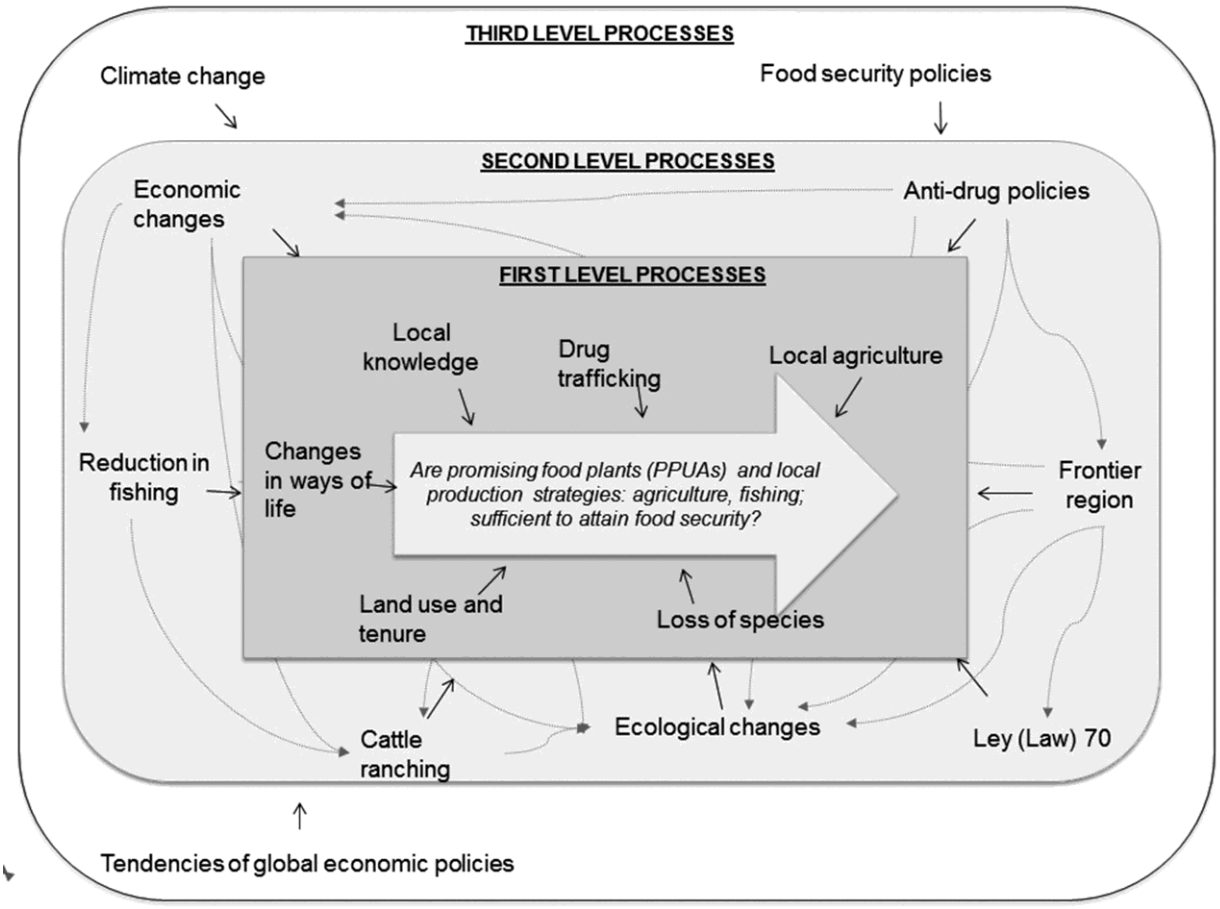

Figure 1. System of promising food plants and food sovereignty in San Francisco de Asís

The effects of the second level processes on sovereignty were subsequently analyzed. These include: ecological changes, cattle ranching, armed conflict, anti-drug policies, local economy, laws on land tenure such as *ley 70*; and other social aspects such as: education, family structure, local human groups, social movements, political organization and health system. These findings were complemented by a bibliographical analysis of agriculture in Colombia during the last 25 years, drug trafficking, *ley 70* on collective land ownership of Afrocolombians and the sociohistory of the Urabá Antioqueño region intimately linked to the study zone. Finally, the third level components which affected the agroecosystem were analyzed by studying local perceptions and review of the literature.

Proposed methodology to analyze the dynamic relationships between the components of the ranching system in the Alluvial fan of Ibagué, Tolima (Colombia) which influence the behaviour of ticks as an essential attribute of these exoparasites

In this section the proposed methodology for the research project 'Agroecological evaluation of silvopastoral systems and conventional production systems with emphasis on populations of *Rhipicephalus microplus* ticks' is presented, developed in the municipalities of Piedras and Alvarado, in the region known as the alluvial fan of Ibagué. Here ranches with silvopastoral intensive systems (SSPi) and conventional systems of ranching were selected, according to the criteria of the Ranching Committee of Tolima and the National Federation of Cattle Ranchers (FEDEGAN). The objective of this project was to characterize from the agroecological approach the dynamic relationships between the components of these ranching systems that influence the behaviour of ticks (*R. microplus*) as an essential attribute of these extoparasites.

Mixed production systems such as SSPi and conventional systems of cattle ranching are complex, multidimensional and related with their surroundings. These agroecosystems are structurally and functionally complex, due to the interactions that are established between the ecological and sociocultural processes. These interactions may cause new qualities to emerge that can only be explained from the relationships that are constituted between their components (Guzmán et al., 2000).

Proposed methodological structure

The analysis and interpretation of agroecosystems is performed by means of the systemic method proposed by García (2006) and developed by Álvarez et al. (2014) as a methodological proposal to tackle problems in agroecology. This method follows a series of phases which are described as follows:

- Phase 1. The phenomenon studied is the process of infestation by ticks (*R. microplus*). This was done by observing three cattle ranching units, with different productive strategies, located in the alluvial fan of Ibagué, in the Colombian *departamento* of Tolima. This phase is documentary and a review of the literature of the agroecological indicators for SSP and conventional cattle ranching systems was used as a methodological tool
- Phase 2. As a result of the description of the phenomenon it was deduced that the research question driving the process would be: ¿What are the relationships between the elements of silvopastoral systems and conventional cattle ranching that condition the presence of and damage caused by ticks *Rhipicephalus microplus*, from the agroecological perspective? This question served for the subsequent elaboration of a concept or initial central process.
- Phase 3. The central process was discussed with academic peers, forcing a reassessment based on a systemic and trasdisciplinary agroecological approach, with the aim of understanding the complexity of the dynamics of cattle ranching agroecosystems. The central process was defined as: *'Infestación by ticks in cattle of the alluvial fan of Ibagué, Tolima'*.
- Phase 4. Starting from the central process the theoretical model of the system was constructed. The spatial limits of three farms located in the municipalities of Piedras and Alvarado were defined as well as the temporal limits that locate the system between the onset of cattle ranching in the alluvial fan of Ibagué (beginning of the 20th century) and the present day. The principal elements of the system are: its history, conformation, type of production and producer, geography and relief, regimen of land tenure and property, climate, size, soil and biodiversity. Starting from these elements the relationships or first, second and third level processes linked to the central process were established. Finally, these processes were classified within the subsystems according to their ontological nature (natural, social, technico-productive or institutional).
- Phase 5. The model was validated using input from different actors of the investigative process. Initially this was discussed with a group of teaching staff and students of the doctoral programmes in Agroecology of the University of Antioquia and National University of Colombia, Medellín campus. Once the observations of this group had been incorporated, the system was presented by the researchers to a group of key partners to discuss and valídate it with the community. The final model of the system represented in Figure 2 allowed the observables and field data collected on these to be established.
- Phase 6. Methodological tools and instruments to obtain biophysical, socio-cultural, socio-economic, socio-political and technico-productive information in the field were defined. In this study the tools used consisted of technical-economic surveys of management and production, semi-structured interviews to know the perceptions of the actors with relation to the phenomenon of interest and the processes that affect it, rapid evaluation of biodiversity and qualitative evaluation of soil health. Furthermore the following field parameters were measured: elevation, precipitation, tick counts on cattle to estimate parasite load, percentage of infections by haemoparasites, tick counts on pasture to estimate the number of them per hectare, green forage and dry material available (both in kg per hectare) and percentage colonization of roots by mycorrhizae.

The system studied forms part of an empirical reality that agrees with the postulates of García (2006), from which elements were extracted for observation to answer questions posed by the researchers on the phenomenon of interest, corresponding to a conceptualization of the observed reality. Causal relationships and processes are also important for the analysis, both agreeing with the author's 'inferences' on the complex system. The elements abstracted from reality show relationships between each other, this set of relationships conforming the 'structure' of the system. The systems constructed have a particular structure in function of the research objetives, determined by the research questions.

Finally, synthesis of information and research findings are the input for future conversion proposals or schemes to monitor the existing system.

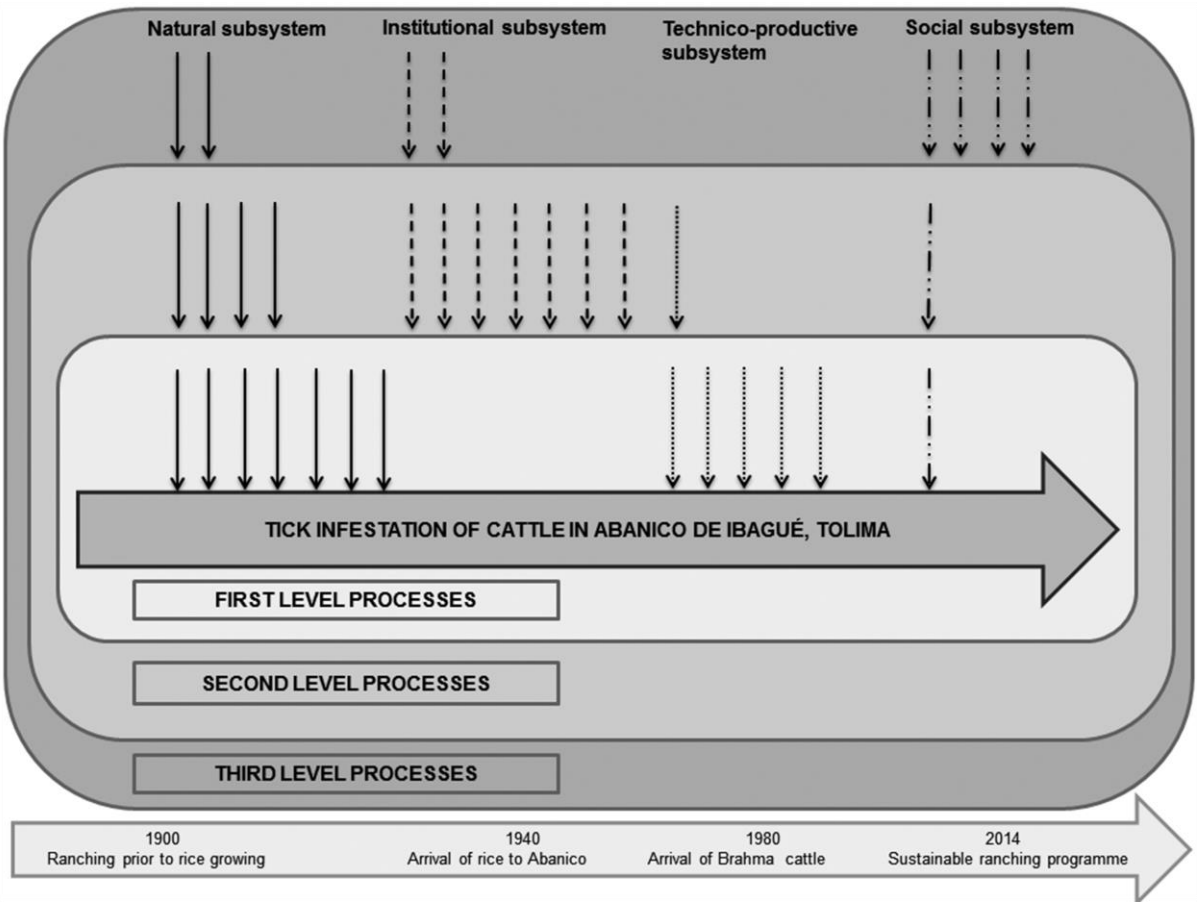

Figure. 2 System of infestation by ticks *R. microplus* on cattle of the alluvial fan of Ibagué, Tolima, Colombia

FINAL CONSIDERATIONS

The arguments expressed allow the complex systems approach suggested by García (2006) to be proposed based on its approximations to Bertalanfy's (1989) General Systems Theory, later modified by Morin (1994), as the theoretical and epistemological bases that underlie the agroecological approach. All the authors consulted concur that agroecosystems are complex adaptive systems which establish energy flows, materials and information with their environment. The phenomena presented within the system can only be analysed by understanding the interactions between their components.

Agroecosystem analysis should start from the premise that each is a socio-cultural system arising from the same history of humanity, all systems being unique cultural constructs. This is why social science methods are as important in their approaches as those of the natural and agrarian sciences. The method used should be capable of integrating social, ecological and productive aspects from an analysis of the context. The difference between research done in Chocó and that done in Tolima lies in this consideration. It is therefore clear that methodologies cannot be standardized, each phenomenon being assumed to have its own methodological particularities.

We call on agroecologists to study the different phenomena from the complexity of the farming and livestock systems in which these occur. The challenge is therefore to understand part of the reality in their complexity and thus obtain sufficient, appropriate information that allows the socio-ecological relationships determining the phenomenon of interest to be analysed and established.

Compliance with Ethical Standards

In this study the academic and administrative norms and techniques for health research established by the Colombian Ministry of Health in resolution 008430 of 4th October 1993 were followed. The informed consent of the ranch proprietors was obtained, this being a mandatory requirement. Finally, this study was considered as being of minimal risk given that it did not involve any procedure that modified the biological, physiological, psychological or social variables of the participants (Ministerio de Salud, 1993).

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