The analytic hierarchy process (AHP) as a support in decisionmaking for caprine health programs

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Abstract

In planning of animal health programs, the one who takes decisions must select between different alternatives to assign rightly the limited resources. This kind of decisions is carried out under a series of criteria, such: social, economic, technical and environmental. There are some existent methodologies that can support this process, been one of these, The Analytic Hierarchy Process (AHP). The general objective of this study was to apply a procedure based on the AHP that allows prioritize different sanitary problems as a help to take decisions in planning of health animal programs. This study was carried out taking account the real characteristics of the main goat production region of Chile.

The AHP allows to approach a decisional multicriterion problem, through the analysis of its elements (objectives, judgment and alternatives) organized in a hierarchical structure, as an efficient and graphical form to organize information on complex systems. The group of experts raised the following priority criteria about these sanitary problems: acceptability by breeders to the diseases control measures; impact of the diseases in regional cattle trade; cost and efficacy of control measures; physical decrease of flocks production and impact of diseases in human public health.

Results indicate that the most important criterion impact were on public health and cattle trade. With respect to the diseases, the first three priorities were: tuberculosis, brucellosis and hydatidosis. This result is clearly explained because of the zoonotic characteristics of these diseases. The AHP was useful when there are several criteria to choose in public health issues.

Introduction

Livestock disease control activities require physical, human and operational resources such as medication, specialized personnel, etc. Therefore, the control of diseases can be seen as an economical activity which requires limited resources.

This situation forces to prioritize the different sanitary problems with a view to solve those which are most relevant for the productive results of the exploitation and/or the sector.

These decision making processes have been traditionally analyzed on the basis of a paradigm which considers a single evaluation criterion. This may be outlined as follows. First, a collection of possible or feasible solutions for the decision problem are analyzed. Afterwards, on the basis of a certain criterion e.g., benefit, a number is associated to each solution or alternative which represents the desired degree for the decision making center. Finally, using more or less sophisticated mathematical techniques, a search among the feasible solutions is done to find which possesses the highest desired rank. This alternative is the optimal solution (Ballestero and Romero, 1998).

This structured procedure possesses a highly logical foundation. However, from an empirical point of view this theoretical frame presents a serious weakness which considerably diverts from the actual decision making process. From our point of view, this mix-up is even more certain in the field of public decision making area, especially when to the control of diseases there are economical, public health and social, and why not, environmental aspects that should be explicitly considered. Additionally, it must be highlighted that these conflicts are not only caused among

criteria which represent economical, public health, environmental or other conflicts, but also among one-dimensional criteria. Thus, it is common, for example, that the economical risk is shared in the opposite direction as other criteria of economical nature, i.e., profit.

The objective of this investigation was to exhibit the potentialities of a multi-criteria decision making paradigm as a support of public decisions in the field of animal disease control. The application of the analytical hierarchy protocol (AHP) method for the prioritization of the different livestock sanitary problems in the IV Region, Chile, is proposed.

Material and methods

The methodology used is based upon the application of the analytical hierarchy protocol (AHP). The AHP method was developed by the end of the 70's by Saaty (1977, 1980) and is catalogued among the discrete multi-criteria models.

In its most basic aspect, the AHP proposes to assign weight vectors $W = [w_1, w_2, ..., w_n]$ to the criteria of a certain multi-criterion decision problem. For this, it is necessary to compare each criterion *i* with criterion *j*, assigning to each paired comparison certain values a_{ij} according to the following scale:

A_{ij} value	When criterion *i*, compared to *j*, is...
1	Equally important
3	Slightly important
5	Notoriously more important
7	Provenly more important
9	Absolutely more important

This information can be collected in a squared matrix of order, which is known as the binary comparison matrix $A[a_{ij}]$ (Barba-Romero and Pomerol, 1997). Afterwards, the dominant autovector *w* and its inconsistency ratio are calculated. The software based upon the AHP method, Expert Choice, is used to simplify the calculation procedure.

The application of the AHP method to the hierarchy of caprine livestock sanitary problems of IV Region, Chile, leads to the following the steps on Figure 1.

Respect to the experts selection, it was based upon the following two criteria:
- An expert must possess experience and academic excellence in related areas with decisional problem topics, i.e., epidemiology veterinary economics, animal health program planning, commercialization of cattle products, caprine production, caprine livestock infectious and parasitic diseases.
- An expert must practice a public, private or academic post which shall imply knowledge and management of updated information regarding the production, animal health and/or commercialization situation of caprine livestock.

In order to facilitate group work carried out by experts, no more than 10 people are recommended by Tarulty and Spencer (1993).

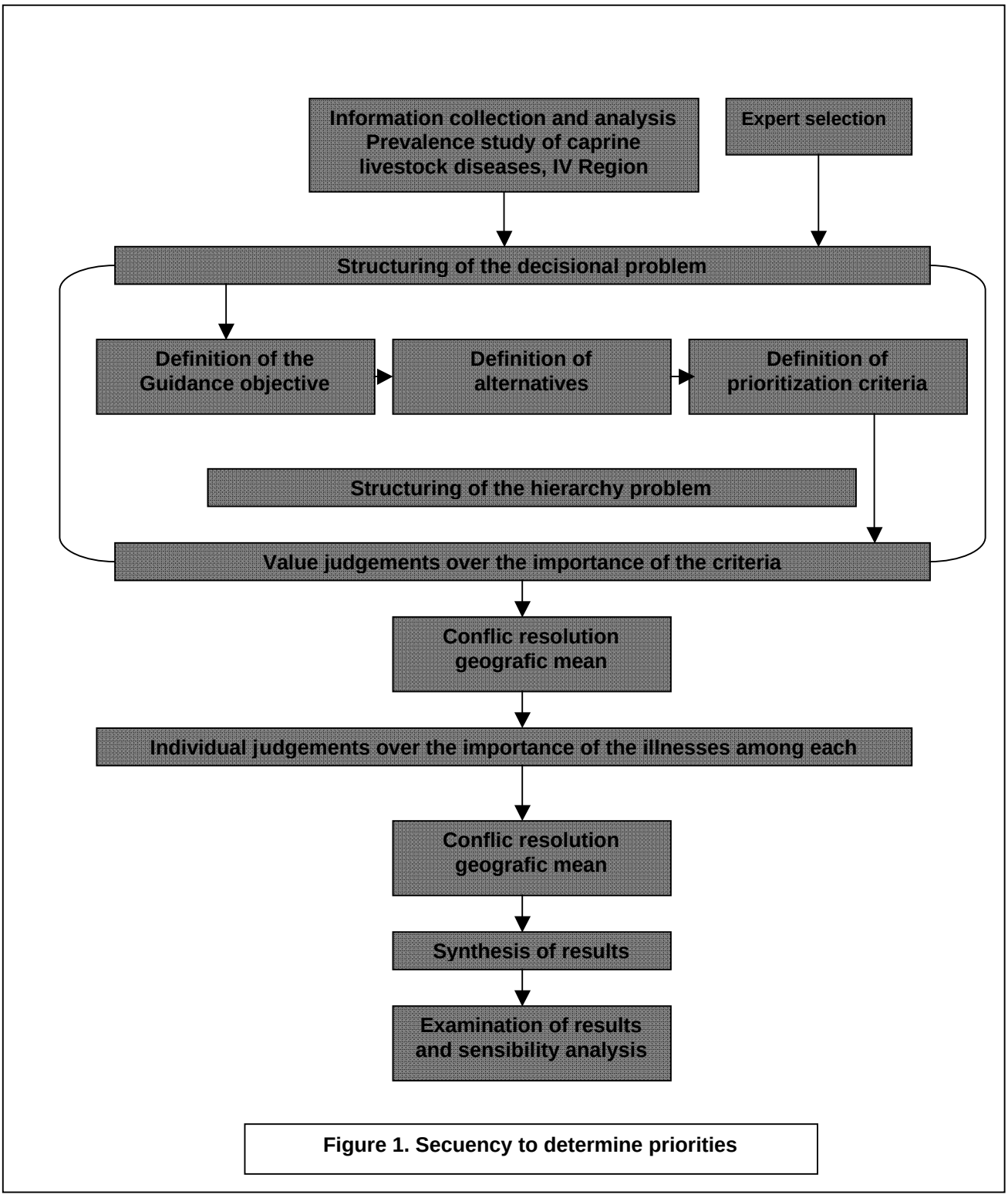


Figure 1. Secuency to determine priorities

Results and discussion

Guidance objective

A high priority for the caprine health in Region IV, Chile was considered as a guidance objective in order to optimize resource assignment in the elaboration of health control programs or projects.

Priorization criteria

The criteria was basically originated from the opinion of experts relying on information provided by veterinarian whose have access to the caprine herds in the some region. The following priorization criteria was considered:

- Acceptability; this correspond to the knowledge and acceptance of producers of the measures involved in prevention of the diseases in their properties. Regarding this criterion, a disease shall have more importance than another if the control measures are better accepted by the caprine live stock producers of the IV Region, Chile.

- Public health; this criterion was defined as the impact, of a caprine disease, on the IV Region population's public health.

- Production; this correspond to the physical diminution of production caused by the disease. It represents an opportunity loss to obtain a higher productive level under the presence of a disease.

- Efficacy; it is defined as the probability of achieving objectives, prevention or control of diseases considering the scenario of IV Region. In other words, this criterion is connected to the effectiveness of the available control measures to confront the sum of considered diseases.

- Cost; the economical cost of carrying out the diseases prevention or control projects. A disease shall be more important than another if the costs of implementation of possible prevention or control measures are lower.

- Trade; it represents the impact of a disease in the formal trade of products, sub products and derivatives of caprine livestock of IV Region.

When analyzing the obtained criteria, they may be classified in two types or groups, ***impact criteria***, which refers to the impact of diseases in different fields such as production, trade and public health, and ***control criteria***, which are related to the feasibility of implementing control measures considering cost, efficacy and acceptability of the possible measures.

Diseases

Seven diseases were considered in the investigation which affect or could affect the caprine livestock of IV Region. The selected alternatives are the following:

- Tuberculosis (*Mycobacterium bovis*)
- Hydatidosis (*Echinococcus granulosus*)
- Caseous lymphadenitis (*Corynebacteriun pseudotuberculosis*)
- Fasciolasis (*Fasciola hepatica*)
- Orf (Poxviridae)
- Brucellosis (*Brucella melitensis*)
- Parasites (gastrointestinal and pulmonary)

The omission of the foot and mouth disease could draws attention despite some risk of this disease entering to Chile and possibly causing a high productive and economical impact. The transhumance of caprine producers to the Los Andes Mountains is as frequent practice, having the risk of contact with Argentinean herds. Nevertheless, its omission would posses certain coherence because during the years before this study there was bans from the animal health authority to bring herds to the high pastures on the mountains, lowering the risk to a minimal. Regarding the Chagas disease, this omission would be associated with a public health decision making center, therefore being less considered in an animal health decision making center. Mastitis, diarrhea and respiratory

complexes, were left aside for being considered responsibilities of the private sector more of the public sector.

Hierarchic structure

The hierarchic structure of the decision making problem is constituted by three levels, as shown in Figure 2, A fist level, constituted by the guidance objective, a second level which includes priorization criteria and a third level, constituted by the diseases.

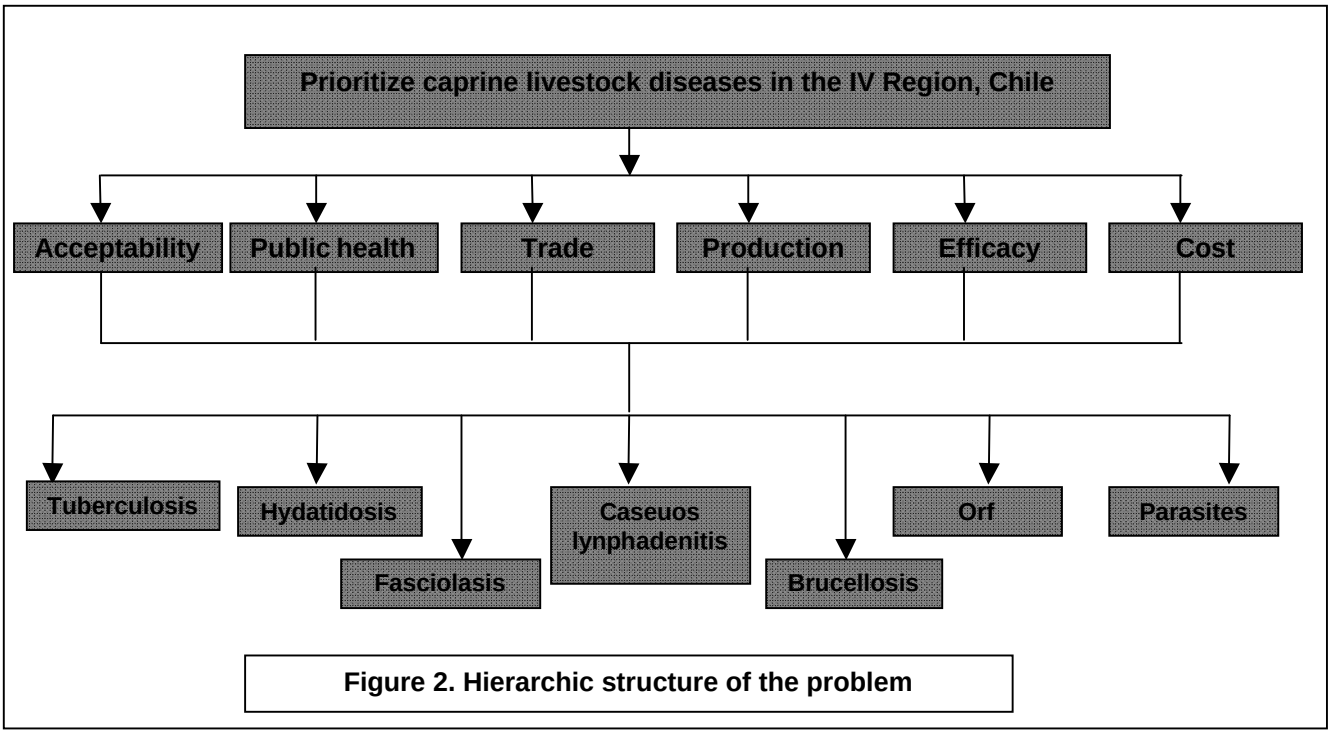


Figure 2. Hierarchic structure of the problem

Relative importance of the criteria

The experts emitted their value judgments over the importance of the priorization criteria regarding the guidance objective. In those comparisons without consensus a geometric mean was applied to the individually assigned value. A distributive synthesis was used for the analysis of the relative weights and priorities in the Expert Choice program.

TABLE 1
Consensus value for the pair criteria comparison regarding the guidance objective

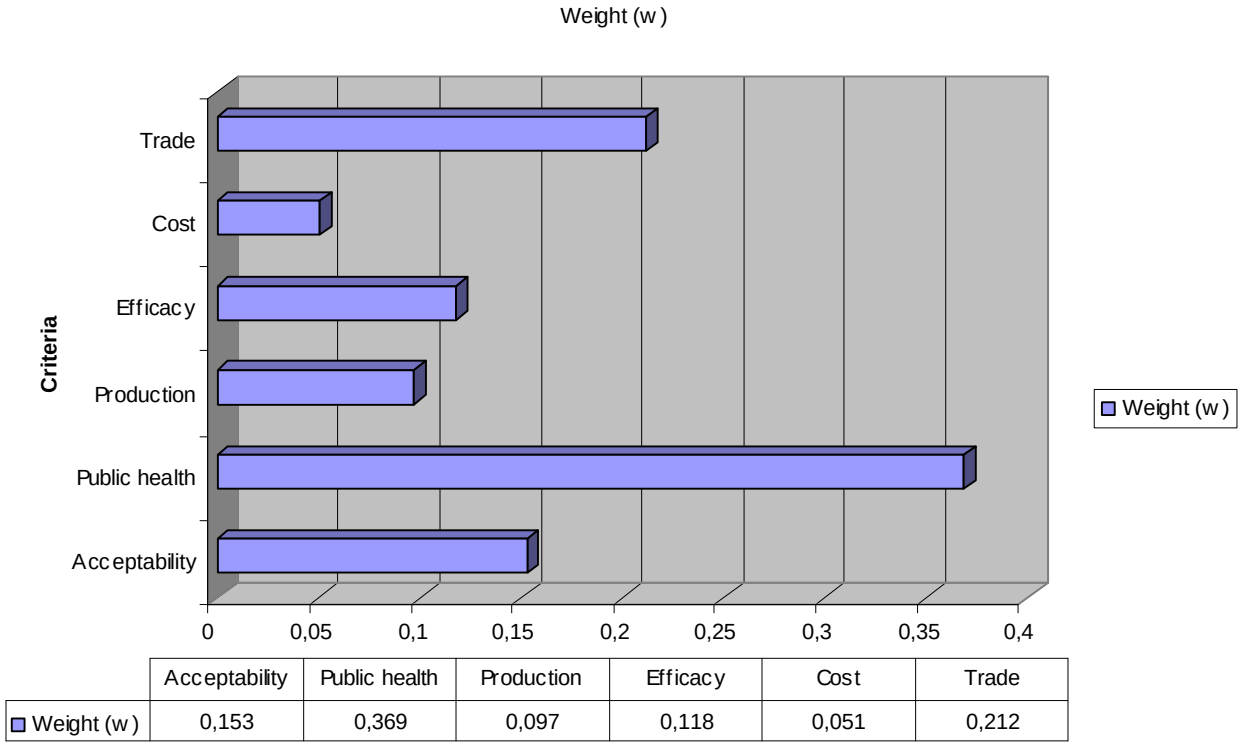
Criterion	Public health	Production	Efficacy	Cost	Trade
Acceptability	**(4)**	**3**	**3**	**2**	**(3)**
Public health		**3**	**2**	**4**	**4**
Production			**(3)**	**3**	**1**
Efficacy				**2**	**(3)**
Cost					**(5)**

Note: the values correspond to the relative importance according to the Saaty Fundamental Scale when comparing the criteria of first column with those of the first row. The brackets indicate inverse importance.

As shown in Table 1, the Public Health criterion is valued as the most important among the rest of the criteria within a range of [2 - 4] of the Saaty Fundamental Scale. Additionally, the Cost criterion was evaluated as least important when compared to the other criteria. The majority of the comparisons among the criteria regarding their importance opposed to the guidance objective did

not reach values greater than 4, except the comparison between Cost and Trade with value equal to (5).

For the matrix represented in the table above, the characteristic vector *w* is given by the values of Graph 1. The Public Health criterion obtained a relative weight of 0.369, followed by the Trade and Acceptability criteria with 0.212 and 0.153 respectively.



	Acceptability	Public health	Production	Efficacy	Cost	Trade
Weight (w)	0,153	0,369	0,097	0,118	0,051	0,212

Graph 1. Priority of criteria respect of the objetive

According to these results the impact that these diseases could have over caprine livestock on the population's public health was the most important criterion considered when prioritizing the diseases. This would lead to a differenced vision over animal health issue, with a notable valuation for zoonoses over other diseases. An ethical-moral factor would exist when granting such importance to this criterion.

In general, the ***impact criteria*** in all possess a relative weight which duplicates the feasibility criteria group. In other words, once consulting the experts, either from the public or academic sector, the impact of the diseases overrides the economical feasibility of carrying out control measures and their efficiency. Perhaps if the investigation had considered the participation of the private sector, then there would exist a greater relative importance of the criteria such as the impact of disease in the production system.

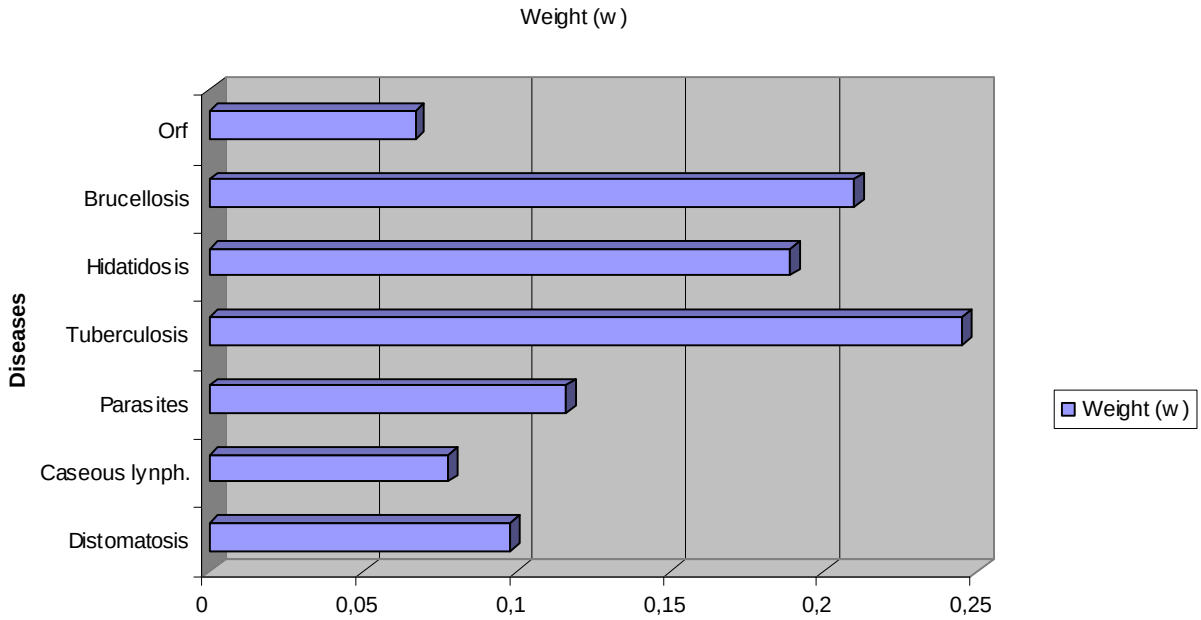
On the other and, Acceptability criterion reaches third priority. This was funded by experts in virtue of field experience where many control or prevention measures fail due to their little acceptance by producers. The caprine production in the IV Region is basically run by farming families. In this part of the country the caprine production constitutes a traditional form of management with low intervention levels of extensive character. This condition is possible maintained by low schooling and formal educational levels of the goat owners. Besides, within a portion of owners, caprine production constitutes only a part of the family's economical activities, therefore neither an adequate amount of time or dedication is offered. Finally, the described diseases are not easily

evidenced as problems. These and other reasons could explain the possible low acceptability to new disease control measures.

The Cost criterion is found in last place of importance within the results. This could be the effect of only proposing this criteris as a comparison point, favoring the priorization of diseases which would present control strategies of lower economical costs, without considering it as actual budget restriction. What draws attention is that both the Cost (in efficiency terms) and Efficacy criteria posses a low valuation despite both standing out as fundamental in the State modernization policy (Interministerial Modernization Committee, 1998).

Final priority

As shown in Graph 2, the final disease characteristic vector indicates that the first three priorities correspond to tuberculosis, brucellosis and hydatidosis, with values of 0.245, 0.210 and 0.186 respectively, followed by internal parasites (0.116) and fasciolasis (0.098), and finally caseous lymphadenitis (0.078) and orf (0.067). The final RC reaches 10%.



	Distomatosis	Caseous lynph.	Parasites	Tuberculosis	Hidatidosis	Brucellosis	Orf
Weight (w)	0,098	0,078	0,116	0,245	0,189	0,21	0,067

Graph 2. Priority of the diseases

On the other hand, when considering the influence of the impact criteria over the final weight of the diseases by priority group, the following was observed:

- In the first group the impact criteria influences in average with a 74.3% of the final disease weight.
- In the second group, the impact and control criteria influences the final weight in very similar way, 49.3% and 50.7% respectively.
- The impact criteria average influence is 65.6% in the third group.

When observing the final results, these indicate the existence pf three priorities or diseases groups. The first group or first priority corresponded, in order of importance, to tuberculosis, brucellosis

and hydatidosis, which in all weighted 64% of the total weighting. The second group was constituted by internal parasites and hydatidosis. And last, come caseous lymphadenitis and orf.

Regarding the first group, which correspond to zoonoses, based on the fact that it affect human being, greater and different value importance than the rest of the diseases would be of assistance. This proposes that while a disease has the possibility to affect human health its relative importance tends to a maximum due to an ethic-moral factor. The priorization of zoonoses was carried out in the investigation under an entity approach that is, based on the single fact of being able to affect animal species and its zoonoses condition; it would present a greater relative importance than the rest of the diseases.

Regarding the previous point, a different treatment could be considered for zoonoses, separating it from the rest of the diseases for its priorization. On the other hand, prevalence and risk of appearance in the analyzed territory should be considered. Zoonoses, which can be classified as very important or dangerous for human health, can have such low prevalence or appearance risk that its relative importance may be less than another disease.

Once analyzing resource optimization during disease control, groups of diseases could be considered and not by separate. For example, if it is found necessary to control tuberculosis and brucellosis zoonoses in the IV Region, this would imply carrying out an epidemiological surveillance program using common resources.

Advantages associated to the use of the AHP method to solve animal diseases priorization problems

In this scope we would at least like to comment two positive topics about the use of the AHP method for solving the subject problem. In first place, with the existence of more than one criterion when having to choose, it is made evident that criteria linked with public health shall always appear when approaching animal health issues, this among other things due to the existence of the so called zoonosis. Nevertheless, this is not all; in fact more environmental criteria associated to these type of decisions appear each time. Thus, incoming diseases which can put an end to certain protected species generate new criteria to be considered when prioritizing which disease to control. Closely linked to this is the qualitative issue which exhibits that advantages and disadvantages associated to a decision can not always be converted into a common metric, e.g., weight, which is demanded by the cost-benefit analysis. A fine example of this is the public health issue. It is true that by means of certain existing methodologies we may approximate the monetary value of a criterion, nevertheless, it is also true that this involves rather important ethical issues as well as other less degree linked to solution cost and precision which makes its use nonviable for these types of problems.

On the contrary, quantitative information of the results reached by each alternative in each considered criteria is nonessential when applying the AHP method but only value judgments of decisions making center in terms of importance of a criterion in relation to another,. In our opinion, all this contributes to impregnate realism to decisions making process in this field.

Sensibility analysis

TABLE 2
Sensibility analysis of critical points

Criterion	Weight (w)	Critical point (p_1)	Variaton (%)
Public health	0.309	0.045	- 85
Acceptability	0.153	0.280	83
Efficacy	0.118	0.338	186
Cost	0.051	0.214	320

The sensibility analysis (Table 2) consists of observing how the final disease priority order behaves when modifying the relative importance of certain criteria. That is, any negotiation or change of scenario which implies a variation of at least 83% of the original weight of the Acceptability criterion would cause a modification in the final range of the three most important diseases.

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