Application of ecopathological methods to the investigation of health problems on farms

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Summary: Application of the techniques of ecopathology to the investigation of health problems on farms has allowed a specific methodology for the study of enzootic diseases of multiple aetiology, dominant under intensive husbandry, to be developed. New knowledge about such diseases has accumulated for various species of animals. Finally, a procedure for regulating and managing the health risks of livestock farming is proposed.

KEYWORDS: Ecopathology - Epidemiology - Intensive husbandry - Multiple aetiology - Preventive veterinary medicine.

INTRODUCTION

During the past decades there has been an intensification of production in the livestock farms of developed countries. This has been manifested by larger production units, accelerated production cycles and the organisation and rationalisation of working methods. Moreover, the setting up of production chains has often been accompanied by geographical concentration of production. Intensification of agriculture has yielded spectacular results in improved economic performance and has led to progress in controlling the major diseases of animals. Paradoxically, the good results achieved in controlling infectious diseases have disclosed various other disorders in intensive units which respond poorly to the traditional procedures of therapy and disease control measures. Such disorders are progressive, but are accompanied by low mortality. If less severe than epizootics, their impact on production costs is considerable; it is therefore necessary to control them in order to maximise the economic efficiency of production (19, 65, 102). The failure of conventional methods to control these enzootic conditions has led to the development of the concept of diseases of multiple aetiology (or multifactorial diseases), owing not to a single causal agent but to the combined effects of diverse factors which, acting in isolation, do not affect the animals much. It is difficult to investigate such diseases in the laboratory because their experimental reproduction is often impossible. Epidemiology can provide the techniques for tackling these farm-specific diseases. Among the investigative routes of epidemiology, ecological pathology (or ecopathology) is particularly applicable to multifactorial diseases and has been applied in various ways to diseases of animals (95, 102).

Ecopathology, from the Greek oikos (meaning enclosed space or house) is concerned with diseases of animals occurring in a given environment in the wide sense (physico-chemical, biological and husbandry conditions) (104). It is based on a

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hypothesis of the existence of interrelationships between the animal, infectious agents and the environment, conferring on a farm the complex properties of an ecosystem. A state of health or illness results from the harmonious or disharmonious functioning of the system, in the same way as the level of production is affected. To investigate and manage health, it is necessary to have suitable techniques for investigating and regulating complex systems (92); the experimental, reductionist approach to analysis of elementary relationships cannot, in fact, take into account the interrelationships within a system. By contrast, a global approach provides a way of describing the behaviour of factors and of proposing methods for intervention. The first developed example of ecopathology applied to herds of pigs with major reproductive problems led to identification of the "thin sow syndrome" and to proposals for rectification before the physiopathological mechanisms responsible for these disorders had been elucidated (50).

Ecopathological methods have been used in different species of animals to investigate and prevent enzootic diseases of multiple aetiology. Examples of those of greatest importance under intensive husbandry are mastitis and lameness in dairy cows, lamb mortality, reproductive disorders of sows, piglet diarrhoea and respiratory diseases of pigs reared for pork (5, 23, 94, 96, 98).

Application of ecopathological methods makes it possible to:

- develop a procedure for investigating relationships between health or illness and the environment;
- generate new knowledge concerning multifactorial diseases;
- propose ways in which this knowledge can be applied to prevention.

**DEVELOPMENT OF METHODS FOR INVESTIGATING THE RELATIONSHIP BETWEEN HEALTH AND THE ENVIRONMENT**

To study health at the level of individual farms, ecopathology must provide tools appropriate for considering the variety and complexity of systems or livestock management. This complexity can be analysed by separating animal breeding into six main subsystems: the animals, animal housing, feeding, infectious or parasitic agents (which may have pathological effects when the equilibrium of the system is upset), the type of husbandry and, finally, the person in charge of managing the entire system (65, 92, 102). Each subsystem is investigated in turn to establish critical points and to analyse both the interactions and the cohesion of the system. This investigation, conducted as a result of ecopathological surveys, is based on observation of how livestock management functions. The conduct of such surveys requires the existence of appropriate methods for measurement, and also a suitable scheme for the application of these methods in order to collect data. Specific data-processing methods are utilised for statistical analysis.

**Development of measuring methods on the farm**

The tools employed for observation and measurements on the farm have to satisfy the same requirements as a piece of laboratory equipment: exactitude, precision, repeatability and reproducibility. Moreover, the specialist in ecopathology pays special
attention to progressive diseases or syndromes and must be able to quantify the severity of disease problems on a farm. The measurements needed are at the level of the animal and also at the level of the farm as a whole. Finally, because of the variety of situations under which they will be used, the procedures must be applicable over this wide range of situations in a standard manner in order to produce reliable results.

Different measuring methods have been developed to cope with the inherent difficulty of farm measurements and the information obtained. For example:

- Indices for quantifying disease (24, 33, 64, 68, 75, 76, 87), which can be specific: the number of coughs produced by 100 pigs in 2 minutes, to quantify the expression of respiratory disease; the percentage of goats having a tarsus/metatarsus or carpus/metacarpus circumference ratio above a threshold value in order to quantify the expression of caprine arthritis. Other synthetic indices may have to be developed, such as a global health index for a pig herd.

- Descriptors for the animals and their behaviour (24, 32, 58, 63, 76, 87), such as an index of cleanliness for dairy cows (individual records); an index of the state of management of a herd of sows (record for the average state of pregnant sows); or an index of the locomotor activity of sows (proportion of sows standing one hour after feeding).

- Descriptors of the management and operation of the animal houses, incorporating a number of additional basic measurements (functioning of the ventilation system, gas content of air, etc.) (99).

- Descriptors for the behaviour of the person in charge (48).

Whenever possible, information collected should be hard data, capable of being analysed objectively; it is often necessary, however, to consider soft data, which are inevitably liable to subjective evaluation by the investigator. This applies particularly to most of the information concerning husbandry practices and the person in charge. Such soft data have to be processed and interpreted with care, but they should not be automatically discarded because this could restrict the range of observations and would not comply with the requirement for a global approach to the farm. It should be noted that the exploitation of this type of data has been developed in numerous epidemiological studies of husbandry practices; for example, of the role of milking practice or of grazing by dairy cows (14, 44). Once the procedure for farm measurements has been defined, the investigator can make arrangements for observation.

**Devising the scheme for use of the methods on the farm**

The scheme for ecopathological observation should provide information on all the components or subsystems on the farm. Only then can the interactions be examined.

The organisation of farm networks supporting the collection of information can take different forms, as indicated by the following:

- the networks may be permanent or confined to a certain time (3, 39, 65, 97, 104, 105);

- a network may be confined to those systems which are homogeneous for certain criteria (size, organisation, performance, geographical location) or, by contrast, it may extend to a wide variety of other systems;
it may be designed for general studies (3, 7, 39, 68, 69) or restricted to a certain pathological condition.

Finally, arrangements should include the management, coding and entry into databases of all the information (4).

Development of methods for processing the adapted information

Epidemiological research relies on the use of satisfactory methods for statistical treatment of data. In ecopathology the information to be processed is characterised by:

— a very large volume of data, because numerous variables are needed to describe the systems investigated;

— data of a highly variable nature, quantitative and qualitative, hard and soft;

— complex structuring because of interrelationships between variables.

The standard statistical tools of epidemiology, owing to their limitations, can be adapted only in part to deal with this data. In order to analyse structurally complex data, a number of regression models have been proposed (46, 90); they, however, cannot take into account all the interrelationships. When such models are used, study of the influence of the model options on the results shows that the choice of techniques for adjusting variables, called “confusion factors”, governs the detection of significant statistical associations. However, the mathematical limitations of these methods do not permit simultaneous treatment of important variability and interrelationships between variables (17, 26, 31).

Methods for structuring epidemiological data (sequential or path analysis) attempt to rank the hypotheses for causality. A system may be broken down into its various elementary components and classified according to a sequence of causal relations; each of the elementary relations is then quantified (18, 28, 71). However, the application of these methods is usually restricted when a system as complex as a farm is examined because it is difficult to construct a complete model, break down the relations observed in order to attribute them to each elementary relation, and introduce the effects of indirect relations (synergy, antagonism or feedback).

A special methodology, suitable for describing the dominant structures of complex information (8, 9, 12, 41, 51, 54), has been adopted for ecopathology. These multidimensional descriptive methods (factorial analyses and classification methods) are applied without a prior hypothesis of the data structure or the form of existing relations. Modelling options are limited before analysis but, by contrast, the interpretation of results must be done at any stage of analysis in order to guide successive stages of processing.

Besides developing specific methods to investigate disease problems on farms, application of the techniques of ecopathology makes it easier to recognise multifactorial diseases, particularly those occurring under intensive husbandry.

KNOWLEDGE CONCERNING MULTIFACTORIAL DISEASES

Ecopathology is used both to describe the complexity and diversity of disease situations encountered on farms and to identify environmental factors related to the appearance or development of diseases.
Multidimensional description of disease enables one to do an inventory of conditions, and thereby to record the prevalence and evidence of pathological associations. It is particularly applied to dairy cows, poultry and pigs and, in the case of pork pigs, has revealed the following associations in a sample of 29 farms: pneumonia and sudden death in some instances and arthritis, atrophic rhinitis and rectal prolapse in others (34, 35, 38, 43, 47, 96, 98, 100). All these conditions are of multiple aetiology in which common factors intervene. On the basis of pathological associations encountered, it is possible to establish a classification of farms by their disease patterns corresponding to the diversity of such farms (33, 68, 69).

The demonstration of relationships between environmental factors and disease is well-developed in epidemiology. The methodology adopted depends on establishing the effect of a limited number of factors, which may be considered a priori as related to the condition under investigation, while correcting statistical associations for confusion factors which upset the analysis. Thus, certain studies have considered the effect of a single factor (1, 42, 49, 84); for example, the level of dietary supplementation in relation to foot diseases of dairy cows. In other cases, two or three factors have been examined (21, 27, 86) or a list of factors has been explored in order to select those associated with disease (14, 15, 16, 29, 45, 89, 93).

Ecopathology proceeds differently. Being based on a more extensive field of observation, it does not establish an a priori hypothesis concerning the role of a given factor, whether a risk factor or a confusion factor. It attempts to identify the circumstances under which a disease appears or develops rather than to demonstrate the causal role. These circumstances are indicators of risk and not the causes of disease. Included among such indicators are the following:

- Risk factors, defined as characteristics of the individual or of the environment under human control; when present and capable of expressing themselves within a population or a system, they increase the probability of the appearance and development of a single disease or of multiple-disease complexes.

- Risk markers, not under human control but possessing the same properties as risk factors (2).

Starting from a more extensive field of investigation, ecopathology seeks to establish a limited number of risk indicators from a large number of variables. Those risk indicators which can be modified are considered in planning intervention programmes for the farm. The various ecopathological studies done to date have been applied to discovering the risk factors of the multifactorial conditions dominant on intensive farms, as follows:

- in dairy farming, mastitis and locomotor disorders (13, 87);
- in sheep farming, mortality of newborn lambs (23, 24);
- in goat farming, arthritis (87);
- in pig farming, the thin sow syndrome (50), behaviour of tethered sows (66), urinary disorders of sows (52, 63), reproductive disorders (59, 62, 67), disorders at farrowing (57), piglet mortality (75), piglet diarrhoea (51, 53, 56, 60) and respiratory diseases of pork pigs (55, 61);
- in poultry farming, conditions affecting broiler production.
After an initial stage concerned with identifying the principal risk factors, ecopathological procedure may then be applied to one of the subproblems within a limited range of investigation (10, 11, 37, 40).

Thus, there is a significant difference between conventional epidemiology and ecopathology. The former, attempting to reconstitute the properties of a system by identifying the properties of its elements, applies a deductive procedure. The latter utilises an inductive procedure in which an examination of the whole system at once precedes and provides orientation for subsequent analytical investigations. Nevertheless, there is some convergence of the themes approached and similar difficulties linked to methodology are sometimes encountered.

The results of ecopathological investigations (farm classification and risk factors) can be used on farms to improve the health situation with respect to multifactorial diseases.

**TOOLS USED IN ECOPATHOLOGY AND RESULTS OBTAINED**

The organisation of agriculture has led to a major difference between the management of an agricultural unit or enterprise and that of an industrial enterprise. Decision-making and implementation are not separated in one agricultural unit, but are done by the same person, the farmer. Therefore, because farming leaves little time for the active seeking of information, technical progress requires that information (particularly about new knowledge) be provided. Information can be provided in various ways, among them provision of the means to aid decision-making.

Ecopathology provides diverse tools to facilitate the spreading of ecopathological results among farms.

- Networks of ecopathological observation enable each farmer to define his relative position, from the aspect of animal health, in relation to a reference group (22, 30, 72, 73, 74, 88, 105).

- Classification of farms makes it possible to identify the group to which a given farm belongs and to select solutions for intervention most suitable for the group (6, 68, 69).

- Forecasts are obtainable by modelling and simulating the interventions in livestock farming (20, 101, 103). Construction of these models takes into account the factors and the principal interactions of these factors within a given group of farms at a given period. Widespread use of these models, or their extension to different situations, has to be preceded by a validation phase under the new conditions. Some other epidemiological models are constructed from the aggregation of elementary data obtained from several partial studies (77, 85). However, in ecopathology, models are built in a different way because the mathematical methods of a general approach used for statistical treatment are extended by multidimensional modelling, dealing simultaneously with many factors and their interactions.

- On the basis of these models, it is possible to propose intervention programmes for a farm, permitting diagnosis, correction of unfavourable situations and the prevention of the appearance of multifactorial diseases. These preventive plans provide
the livestock manager with a rational management tool concerning risk, which he may wish to adopt in view of the disease situation on his premises (8, 9, 23, 52, 53, 55, 56, 57, 59, 60, 61, 62, 63, 75, 76, 83, 87, 103).

Finally, following up the factors identified as elements of predictive value in the health status of a farm provides basic tools for disease surveillance of farm animals. In fact, when these tools are used, relevant data must be selected to ensure that the health of the herd is maintained (25, 70, 78, 79, 80, 81, 82, 91, 106).

Application of ecopathological procedures to health problems on farms is particularly fruitful for dealing with multifactorial diseases occurring under intensive husbandry, for these are complex systems which pose a permanent threat to health. Ecopathology makes available methods for investigating and acquiring knowledge of enzootic conditions in the field, complementary to research laboratory methods. It also provides the tools for assisting in the health management of herds. As a branch of epidemiology, it shares the same principles, but is original in the methodological options available. Nevertheless, future developments in understanding the relationships between environment and health may reduce the differences between epidemiology and ecopathology.

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REFERENCES


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