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FROM "ECOPATHOLOGY" TO "AGROECOSYSTEM HEALTH"

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La "révolution épidémiologique" des années 60 est née des limites de l'approche réductionniste pour résoudre concrètement les problèmes complexes de production et de santé dans les systèmes d'élevage. Cependant, dans une exploitation, les facteurs individuels intrinsèquement liés à l'animal n'entrent pas seulement en interaction avec les facteurs collectifs ("effet troupeau") tels que l'alimentation, le bâtiment d'élevage et le microbisme, mais aussi avec de nombreux autres facteurs "non-animaux". Pour cette raison, une approche "globale", "holistique" visant à expliciter le sanitaire dans le fonctionnement interne des systèmes d'élevage s'est développée en France sous le terme d'écopathologie.. La discipline épidémiologique est alors intégrée dans une approche systémique incluant un modèle conceptuel préliminaire, un échantillonnage basé sur la prise en compte des systèmes d'élevage, la mise en place de l'étude par une équipe multidisciplinaire, la gestion et l'organisation de l'information sanitaire et zootechnique, l'analyse de données, la diffusion des résultats aux acteurs de l'étude et la proposition d'un plan de prévention sanitaire .Cependant, une exploitation est aussi sous l'effet du milieu social, économique et environnemental dans lequel elle s'insère. Pour prendre en compte ces éléments, un changement d'échelle est nécessaire. Les 3 éléments du système d'élevage considéré en écopathologie (éleveur/troupeau/ressources) deviennent à l'échelle d'un agroecosystème: une communauté humaine (éleveurs, agriculteurs, consommateurs, décideurs politiques), une population animale, et l'ensemble des conditions humaines, sociales et économiques du système. Le concept d'agroecosystem health s'inscrit pour sa part dans le principe du renforcement de la soutenabilité du système et peut être approché par des méthodes issues de l'épidémiologie. L'état de santé d'un agroecosystème peut donc être apprécié par des méthodes familières aux épidémiologistes. Les concepts d'écopathologie et d'agroecosystem health font appel tous les deux aux méthodes d'épidémiologie, mais aussi d'autres disciplines, dans une perspective systémique . L'écopathologie fournit le contexte de la médecine de groupe, et l'agroecosystem health procure le contexte de l'écopathologie.

THE EPIDEMIOLOGICAL REVOLUTION

In an overview paper published in the first issue of *Preventive Veterinary Medicine*, Schwabe (1982) presents a perspective on the developments of epidemiology and economics in veterinary practice in the latter half of this century. In Schwabe's view, four crises became apparent in the 1950's: (i) the persistence of health problems in some herds even after many named infectious diseases had been substantially controlled, (ii) the increasing demands of governments to estimate the economic costs and benefits of animal health, (iii) the absence of appropriate research methods to understand and control etiological complex diseases affecting production, and (iv) the inability of private veterinarians and producers to develop programs to control health and production constraints associated with intensive farming practices. These crises fostered the initiation and progression of an *"epidemiological revolution"* in the 1960's to better identify, quantify and analyze the multiple and interacting causes of many animal health and production problems. Because the "germ-theory " approach failed in these contexts, Schwabe proposed that an *"holistic and epidemiologic approach of the causality of the diseases"* be adopted.

THE SYSTEM THEORY

These changes mirrored a similar revolution among agronomists who were developing the concepts of farming systems theory (Von Bertalanffy, 1970). Faced with numerous failures of agricultural development projects in both industrialized and developing countries, many agronomists questioned the efficacy of their traditional reductionist research methods (Sébillotte, 1978) and searched for more holistic paradigms. Central to farming systems theory was the socio-economic principal that "farmers' practices respond to certain aims and constraints, and the ignorance of those is the principal source of the failure of technical solutions developed from research" (Tourte, 1965). This expansion of the traditional technical domains of animal health and production practice to include consideration of the economic, social, and technical objectives of farmers has been applied in practice by many veterinary epidemiologists (e.g. Bigras-Poulin, 1985), who wisely noted that without this integration, the objectives of the epidemiological revolution would remain unfulfilled.

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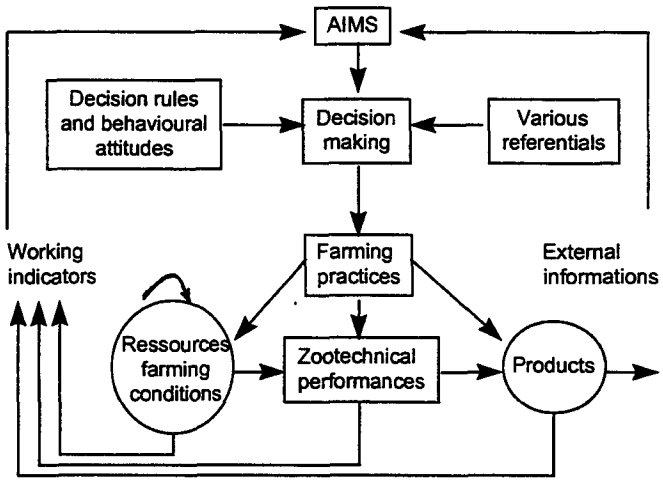
Formally, farming systems research considers the interactions between 3 elements: the farmer, the herd and available resources. The farmer makes decisions in accord with both technical and/or behaviourial criteria. These decisions are made operational through farming practices which by direct or indirect pathways and feed-back loops influence both the performance of the herd and the quantity and quality of animal products. Farmers also influence and are influenced by the resources available in their particular farming system which of course greatly influence herd productivity. The performance of the farming systems have been assessed by various measurable indicators which can be used in whole-farm decision-making..

Landais (1994) described a conceptual model of a livestock production system from his perspective as an animal scientist (see Fig. 1), but its lack of explicit accounting for animal health as a component of the system is not accepted by many epidemiologists. In fact, the basis of the epidemiologic approach to studying animal health and production problems developed in France, called ecopathology, aims precisely to *explain health within the farming system.*

Figure 1
Working diagramme for the farming system (from after Landais, 1994)



ECOPATHOLOGY - EPIDEMIOLOGIC ASSESSMENT OF LIVESTOCK SYSTEMS

Just as farmers make decisions based on technical criteria within the farming systems paradigm, ecopathologists seek to define herd *health "referentials"* as criteria for supporting preventive medicine and herd management decisions to improve *health performance*. Both animal-level (e.g. relative risk of diseases related to seasonal or physiological factors) or herd-level (e.g. the relative incidence of animal diseases in comparison to other farms in the same area) referentials can be used depending on the type of decision to be made. These decisions will also depend, as in the farming systems paradigm, on the farmer's behaviourial attitudes with respect to disease occurrence and risk and they will be implemented through various practices (e.g. management, culling, feeding practices, vaccination) which, separately or in combination, will influence the risk of "disease". In ecopathology, disease or *health performance* is interpreted as just another output of the farming system, like production performance, which can vary depending on environmental conditions (animal housing, climatic factors) and available *resources* (feeding, inputs). For routine decision-making, it can be beneficial to define easily measurable and important *health indicators* to reflect both *health performance* (e.g. somatic cell count as a subclinical mastitis indicator) or risk status (e.g. cleanliness score as a hygiene indicator). However, as in any complex system, the development of useful *indicators* can be both very rewarding and very difficult. In some circumstances, health indicators have been particularly useful in identifying at an early stage imbalances and misfunctions in livestock production systems (Barnouin *et al.*, 1994).

Ecopathologists integrate epidemiologic principles into a systematic method for studying health status within farming systems using an *ecopathological survey*. Such a survey consists of several distinct but complementary stages :

- the sampling of farms by type of farming system;
- the use of rigorous observational study methods by multidisciplinary teams (veterinarians, epidemiologists, zootechnicians, farm technicians, professional organizations, statisticians, computer scientists and others according to the needs of the survey);
- the management and organization of data in a specific data base;

- a staged approach to data analysis which emphasizes exploratory (especially graphical methods), followed by methods to develop "structured" disease models reflecting both previous theory and exploratory results and finally modelling to estimate the relative importance of different risk factors and health indices within the "structure" developed;
- the dissemination of results to all stakeholders and key players in the system

The main objective of ecopathology is very practical, to identify the risk factors and their interactions which most influence health performance in specific priority farming systems. While this approach has been used in tropical countries (Faye *et al*, 1994), the main studies have been conducted in France (Faye et Barnouin, 1996). The ecopathological study conducted in Breton, France is a good example. The study was conducted over four-years (1986-1990) among intensive dairy farms. This particular farming system was chosen since these farms were supposed to represent the trend of French dairy farming to increasing farm size and intensification (Faye et Barnouin, 1987). The study farms specialized in dairy farming, consisted almost exclusively of Holstein-Friesian cattle with mean annual milk yields of 6500 kg, practiced winter feeding based on silage, and had cubicles or free-stalls as the main animal housing. Data were collected by a working group using a protocol, similar in rigour to those of clinical trials, developed by a multidisciplinary team. Data were collected at the cow (e.g. clinical diseases, production and reproductive performance, cleanliness and body score, individual feed supplementation, behaviour, and test results (e.g. milk bacteriology and blood metabolic profile) and farm (e.g. farming practices and conditions, baseline diet, eco-climatic parameters, inputs assessment) levels. After data management and analysis, periparturient diseases were considered to be important and prevention programs based on changes in feeding practices were developed and extended (Barnouin *et al.*, 1994).

In ecopathology, the diversity of disciplines involved both strengthens the contribution of epidemiologists (Sabatier *et al*, 1994) and enlarges the frame of epidemiological survey (Calavas *et al*, 1996). This is done both by including non-medical disciplines (e.g. animal production, economics, sociology) and by mobilizing the practical knowledge of extensionists and farmers in management, reproduction, and feeding. These experiences in expanding the scope of studies and mobilizing stakeholders can provide a useful starting point for evaluating livestock health and production in even broader contexts.

A CHANGE OF SCALE: FROM FARMING SYSTEMS TO AGROECOSYSTEMS

While ecopathology enlarges the scope of veterinary investigations to consider the complexities of farming systems, agroecosystem health enlarges the window of observation even further. An agroecosystem can be defined as *"a socio-ecological system managed primarily for the purpose of producing food, fiber and other agricultural products comprising domesticated plants and animals, biotic and abiotic elements of the underlying soils, drainage networks, and natural vegetation and wildlife"* (Gallopin, 1995, Waltner-Toews, 1996). Agroecosystems are seen as existing in nested hierarchies from farms and their sub-units up to regional and global levels. Agroecosystem health is thus a professional application of systems approaches which have already been demonstrably successful at animal, herd and farm level. If we can talk meaningfully about the health for an animal (clinic), a herd (herd medicine) or a farm (ecopathology), it is possible to talk about the health of an agroecosystem, particularly, its *sustainability*.

Furthermore, just as variables of interest to those studying the health of farming systems incorporate measures of longevity, disease, productivity and capacity to respond in relation to goals, so indicators of agroecosystem health must reflect both socio-economic and biological attributes of the system at various levels. Agroecosystem health is by definition multi-scalar with the farm being the basic unit (Nielsen, 1992). Since considerable work has already been done in studying and assessing farming systems, most recent work on agroecosystem has focused on scales larger than the farm (Waltner-Toews, 1996). For example, at the sub-watershed level, the three constitutive elements of the livestock farming system from an ecopathology view (farmer/herd/resources) become: (i) a human community including different actors of livestock activity (farmers and their organizations, political, economic and environmental managers), (ii) an animal population (domestic herds, wild animals) and (iii) the biophysical environment (water, nutrients, energy).

In ecopathology, the passage from an object "herd" to the object "farm" has required a conceptual change to integrate the multiple purposes of farming and the multiples objectives of the farmer (Bawden, 1995; Faye, 1996). The further generalizations made in agroecosystem health framework better allow the assessment of the interrelationships between farming systems and their environment which were recognized but largely ignored in farming systems studies. First, the complexity of relationships between farms and other components of the agroecosystem (related in part to spatial and temporal feedback loops) is added by enlarging the context of study. Furthermore, whereas a farm family may negotiate goals and implement better management practices for a farm, it is not always clear who should, or who can, do this at larger scales. Neils Roling of Wageningen Agricultural University has identified a meaningful integration of the multiple perspectives of stakeholders as the central problem facing all agroecosystems approaches (Roling, 1996).

EPIDEMIOLOGY AND AGROECOSYSTEM HEALTH

A complex system such as an agroecosystem may be legitimately described in different ways (e.g. economically, by energy flows, by the health of the rural community health, by the happiness of the agricultural workers) which may be rooted in different paradigms and result in different (sometimes contradictory) goal-priorities. While a farmer may balance income losses from disease against preventive program costs, in agroecosystems, we may find ourselves balancing drinkable water against cheap food, or sustainable rural communities against high commodity prices or overproduction.

Researchers at the University of Guelph have made progress in identifying many of the important elements of a multi-level agroecosystem conceptualization, as well as some systemic approaches to applying the concepts (Smit *et al.*,1997). Currently, Guelph is collaborating with the Centre Internacional de Agricultura Tropical in Cali, Columbia on the development and application of an integrated conceptual framework for tropical agroecosystem research based on complex system theories. We are hoping to be able to using the latest ideas about attractors, gradients and state space trajectories and combine them with dynamic spatial modelling and post-normal science to arrive at a coherent understanding of tropical agroecosystems. With colleagues in Nairobi, researchers from Guelph are working to elaborate the practical details of how one combines epidemiological and participatory methods to promote sustainable decision-making in a multi-level agroecosystem.

In brief, a healthy agroecosystem may be defined as one that is able to satisfy societal needs and maintain its ability to cope with natural and socio-economic stresses. Since farmers are inside the agroecosystem, we must work with farmers to understand the kinds of variables which enhance their capacity to adapt to changes in the socio-economic environment, and work to change that broader environment in such a way that fosters those capacities. In other words, we need to recognize that the system responds not only to its past (as a set of constraints) but also to an imagined future, which sets it apart from many other systems which scientists study.
Research on the assessment of health with this multi-level perspective can incorporate *health indicators* which incorporate the development and use of familiar techniques for epidemiologists: diagnostic tests of health status, early warning tests, determination of risk factors. However it will also require assessment methods less familiar to epidemiologists, such as participatory action research and soft systems methodologies (Bawden, 1995; Roling, 1996).

CONCLUSION

Ecopathology, may be considered as an enrichment of epidemiology by the concepts of systemic ecology. In that ecologic context, the herd may be considered as an anthropo-biocenose, i.e. a specific community where micro-organisms (which could be pathogens) and animals live together and in which their reciprocal relationships often exhibit a high level of organization. The farm, or physical space occupied by the herd could then be considered as an anthropo-biotope. Agroecosystem health studies further this process by examining the larger milieu in which these ecologic units exist, not only with broader ecologic discipline studies but also with ecologic studies in a much broader sense including concepts from the agricultural, health, epidemiologic and social sciences. In this context, agroecosystem health studies are to ecopathology what ecopathology is to herd medicine - a broader context in which diagnostic medicine can be understood and evaluated. Ecopathology provides the context for herd medicine and agroecosystem health provides the context for ecopathology.

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