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► **To cite this version:**

P. Vannier, J.P. Tillon, F. Madec, J.P. Morisse. ENVIRONMENT AND GASTRO-ENTERITIS. Annales de Recherches Vétérinaires, 1983, 14 (4), pp.450-455. <hal-00901452>

HAL Id: hal-00901452

<https://hal.science/hal-00901452v1>

Submitted on 11 May 2020

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ENVIRONMENT AND GASTRO-ENTERITIS

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Abstract

Pathologists are always tempted to account for the occurrence of diseases by the presence or absence of some specific microbiological agent. It is the case when a major infectious agent is in contact with a receptive animal. When the Transmissible Gastro-enteritis virus is introduced into a susceptible herd, the results of the infection are calamitous. Nevertheless, the relationship between the infection and the disease is rarely simple. It is necessary to distinguish two kinds of diseases:

— the monofactorial diseases (T.G.E....)
— the multifactorial diseases (Colibacillosis especially after the weaning...). For these multifactorial diseases the clinical signs and the lesions are induced by an infectious agent which can be considered as a final «effector» whose multiplication depends on factors in the farm which disturb physiological or immunological mechanisms of regulation (humoral immunity, clearance, intestinal motility...). The herd system can be defined by 6 variables which could be considered as limiting factors responsible for the onset of digestive disorders: food, building, management, animal with specific and non-specific resistance, microbism and the farmer who plays a main role in the control of these variables. The disease has to be considered not only as the result of the multiplication of the microbe which is often the last actor of a morbid process but also as the disharmony of the variables defining the structure of the herd.

After the XIXth century, when numerous infectious agents and parasites were discovered, a close association was made between the microbe and the disease. This association microbe-disease is the concept on which is based the fight against the epizoonoses such as Foot and Mouth Disease, Swine Fever, Tuberculosis and Brucellosis. In these major infections, the virus or the bacteria can be considered as responsible for the onset of the disease. In the digestive disorders of the pig, when the Transmissible Gastro-enteritis (TGE) virus is introduced in a herd which has never been infected by this virus, the effects of the infection are widespread.

The experimental reproduction of the disease can be easily carried out with a virulent strain of the TGE virus according to Koch's famous rules: the virus is identified in the sick piglet; it reproduces the disease in experimental conditions; it is reisolated after experimentally-induced disease in a healthy piglet.

Nevertheless, the relationship between the infection and the disease is rarely simple. For example, it has been demonstrated that 2 to 3 month old pigs (Shimizu *et al.*, 1978) maintained at a high temperature (30 ± 2 °C) and exposed to the virulent Transmissible gastro-enteritis virus did not show clinical signs of the disease while main-

tained in those conditions. On the other hand, a sudden decrease in the ambient temperature, either before or after virus inoculation induced severe disease in fattening pigs exposed to the virus.

Concepts of the multifactorial diseases

For some diseases, the discrepancy between the presence of an infectious agent and the clinical disease is far more obvious than in the previous examples.

For instance, the post-weaning colibacillosis of the piglet is expressed by two different clinical forms which are, first, the postweaning gastroenteritis and secondly, the oedema disease. Epidemiological studies (Tillon, 1980-1981) showed that the *Escherichia coli* serotypes usually incriminated in these two clinical forms of the post-weaning colibacillosis can be found in the herds which are affected by this problem as well as in other herds where the problem never occurred. These studies have been carried out in 23 herds in which it could be demonstrated that the onset of digestive disorders was not associated with the presence of a particular colibacillar flora. Taking into account only the infectious variable in the herd it is not possible to explain the fact the disease is observed in certain herds and not in others. So, the causes have to be considered on a much wider scale of the problem. The experimental reproduction of poultry cholera (Pasteurellosis) by Pasteur is one of the most famous illustrations of this thesis: the disease can be reproduced only if the tarsi of the hens are dipped into cold water.

It is necessary to distinguish two kinds of diseases:

- the monofactorial diseases (TGE...)
- the multifactorial diseases (colibacillosis especially after weaning, Salmonellosis...).

In monofactorial diseases, the presence of a germ in a non-immune herd induces the onset of the typical, acute, clinical signs associated with the incriminated agent.

In multifactorial diseases, the clinical signs and the lesions are induced by an infectious agent which can be considered as a final «effector». The multiplication of this microbe depends on factors or unfavourable circumstances in the farm which disturb physiological or immunological mechanisms of regulation such as humoral immunity, clearance, intestinal motility, local immunity and the «barrier effects» of the bacterial flora of the digestive tract.

So, unfavourable circumstances in a herd such as ventilation problems, temperature variations, quantity of feed, quality of water, absence of vaccination scheme,... create conditions for an optimal multiplication of infectious agents which were pre-

sent previously without any expression of pathogenicity.

Unfavourable ▲ Modification ▲ Effector ▲ Disease
circumstances of regulation
Mechanisms

Interactions between environment and gastroenteritis

A farm can be defined as a system including six variables which could be considered as limiting factors responsible for the onset of digestive disorders.

First variable: the animal

This component of the system is important. The disease will appear and run its course if the specific and non-specific resistance of the animal is overcome. Immunity as represented by the specific resistance is largely discussed elsewhere. The non-specific resistance of piglets or calves is less known.

For instance, pigs of all ages are likely to be affected by TGE virus. However the case mortality rate is high in newborn pigs and low in pigs more than 2 weeks old. It seems that the rate of replacement of villous epithelium in the small intestine of pigs contributes to the innate age dependent receptivity to Transmissible gastro-enteritis (Moon *et al.*, 1975). The apparent rate of regeneration of villi in the intestine of the 3-week-old pigs is more rapid (2-4 days) than in the intestine of the newborn pigs (7-10 days). The accelerated replacement of villous epithelial cells in older pigs contributes to the resistance of the animal in a twofold manner. The increased proliferative capacity of crypt epithelium results in a more rapid regeneration of atrophic villi and the comparative young villous absorptive cells resulting from accelerated replacement produce fewer virus particles per cell than the older ones as these juvenile cells are comparatively resistant to virus production after they have migrated onto the villi (Pensaert *et al.*, 1970).

Calves kept in intensive production units, are subjected to numerous stresses induced by their removal from their birth places, by the loading in trucks and the transportation conditions. Research has shown that in stressed calves 11 hematological and biochemical parameters are significantly different from those analysed in unstressed animals. But, within the same group, differences can be observed between animals and these differences result from the variation of the responses of organisms to different levels of stress variable in intensity and length (Morisse, 1982).

So, numerous parameters peculiar to an animal and varying according to its age, its genetical origin... determined its resistance to various stresses and infectious agents.

Second variable: the nutrition

Numerous studies have demonstrated that food has an influence on the clinical expression of bacterial or viral infections but the results are often contradictory and so difficult to interpret.

It was shown that the dietary-management regimen has a profound effect on the capacity of the neonatal gut epithelium to absorb macromolecules. In starved piglets, there continues to be a transfer of internalized macromolecules into the blood just as it is in new born piglets, which does not happen in fed piglets (Lecce, 1973). So it is conceivable that an actively pinocytosing epithelium increases the pathogenicity of an intestinal infection.

The nature and the quantity of the regimen modifies the clinical expression of the post-weaning colibacillosis after a challenge with a haemolytic enteropathogenic *Escherichia coli* strain — Authors were able to produce infection and clinical signs consistently in pigs fed «ad libitum» on a ration composed of 10% fish meal and 90% barley meal, but were unable to infect pigs fed a restricted amount of the same ration. Moreover, they also failed to infect pigs fed «ad libitum» on barley fibre, which is largely indigestible and it was suggested that these different rations could modify the secretory or absorptive functions of the epithelium that are concerned in the bacterial adhesion (Smith and Halls, 1968). By giving a feed extremely low in nutrients and high in fibre to newly weaned pigs inoculated with *Escherichia coli* O139: K82(B), the number of organisms shed with the faeces was markedly lowered and signs of illness were presented (Bertshinger *et al.*, 1978). But, the use of similar diets without inoculating the pigs resulted in unexpectedly high mortality and the authors concluded that *Escherichia coli* enterotoxaemia occurs not only when the piglets are maintained on an extremely high level of nutrition but also at nutritional levels far below those necessary for normal growth. So, authors thought that *Escherichia coli* enterotoxaemia is not primarily a nutritional disorder, but an infectious disease and nutrition is just one of the factors contributing to its outcome. On the other hand, Tzipori thinks that a variation in the energy content of the diet has apparently little effect on the clinical course of the experimental post-weaning colibacillosis (Tzipori *et al.*, 1980). These results are contradictory with the previous ones. Similarly, other studies also demonstrated that the dietary protein level had no effect on the incidence and/or the severity of colibacillary diarrhea in the young pigs (Armstrong and Cline, 1977).

Epidemiological studies showed that the accumulation of one or several factors for the preparation of the meal as bacteriological quality of the

water and quality of the preparation of drenches for young calves can induce sanitary problems and especially digestive disorders. Indeed, the way drenches are prepared (temperature and mixture time) has a great importance on the concentration and the stability of the emulsions at the moment of the meal distribution (Morisse, 1980).

Third variable — The housing conditions

The housing conditions play a main role in the good health of the animal. The exact influence of the housing conditions on the sanitary problems and specially the digestive disorders of the young pig or calf is not really known and, above all, is difficult to appreciate. Most of the studies have been made on the influence of the temperature on the expression of a disease or on the intensity of the clinical signs after an experimental infection. As it was previously noticed, Shimizu showed that a sudden drop in the ambient temperature, either before or after TGE virus inoculation induced severe disease in fattening pigs exposed to the virus. Moreover, the authors demonstrated that pigs raised at temperatures that fluctuated between 20 ± 2 °C and 4 ± 1 °C every 24 h developed profuse diarrhoea. The duration of clinical signs was longer in pigs maintained in the fluctuating temperatures than in those at a constantly low temperature (Shimizu *et al.*, 1978). Armstrong and Cline (1977) think that the cold environment stress imposed on three-week-old weaned piglets can be considered as a predisposing factor that increased the incidence of diarrhoea in these pigs following the *Escherichia coli* challenge. In the same way, other studies demonstrated that the frequency of scours on weaned piglets is higher when the piglets are kept at low temperature than when they are kept at high temperature, although no difference was observed in the weight and feed conversion rate between the two groups (Nielsen, 1980). In the latter experiment, the conditions were more favourable for the piglets than in the previous ones as the lowest temperature of the room in which the animals were was 18 °C.

Fourth variable: the management

By weaning piglets in «sanitary» conditions consisting of an isolated fumigated nursery, and comparing with others weaned in «unsanitary» conditions, the onset of rotaviral diarrhea was delayed until about 12 days post-weaning (Lecce and King, 1980), but the rotavirus diarrhea was not totally prevented, after this delay.

The frequency of rotaviral diarrhea has been compared in two farms with different hygienic conditions. In one farm, there are 4 separated farrowing units with good sanitary measures while, in the other one, there was only one big farrowing house and the sanitary conditions were bad. The rotaviral excretion was studied for 4 months in the

two herds and the excretion rate was similar (92 % of the tested litters). Anyway only 30 % of litters presented diarrhea with Rotavirus in the first farm whereas in the second one, 62 % of the litters had diarrhea with rotavirus (Pensaert, 1982). So, if the viral excretion is the same in the two herds, the clinical expression of infection is different according to the herds.

In the same way, in bovine herds where cows have been affected by and cured of Salmonellosis, 63 % of the 8-day-old calves excrete Salmonella in their faeces and an eventual clinical Salmonellosis will be induced among them by the rearing conditions, the young animal will meet later (Morisse, 1982).

So, the management has a great influence on the diffusion, the excretion and the clinical expression of a viral or a bacterial infection. A change, of the management conditions or unappropriated measures leads to a disruption in the herd between the balance of the infectious pressure on one side and the resistance of the animals in the other side.

Fifth variable: the microbism

The microbism has to be considered as a component of the environment or more widely of the farm system. Many aspects of this variable have been studied elsewhere and only a general view will be discussed here.

Two aspects could be considered in an infectious agent: its nature and a notion difficult to quantify on the field which is the infectious pressure. The selective nature of viral damage has an influence on the intensity of the digestive disorders and on the recovery. Different viruses vary in their selectivity within villous epithelium and this in the severity of absorptive cell loss, malabsorption and diarrhea they cause. For instance, TGE virus is distributed throughout villous epithelium and, in the neonate, destroys all mature absorptive cells resulting in fatal disease accompanied by marked but frequently inadequate crypt hyperplasia. In contrast, the calf rotavirus has a predilection for the more mature absorptive cells on the distal one — half to two — thirds of the villus. The resultant disease is usually not fatal and crypt hyperplasia is less obvious than in TGE (Moon, 1978).

If, in natural conditions, it is difficult to measure what we call the infectious pressure in a herd, it is easier to approach in experimental conditions. It is well known that, generally, the course of a disease or the intensity of the clinical signs or the severity of the challenge varies according to the challenge dose. While a dose of 10^{10} enterotoxigenic *Escherichia coli* produces severe diarrhoea in calves, 10^7 organisms do not induce diarrhoea (Bachmann, 1982).

Sixth variable: the farmer

It could be surprising for some to integrate the farmer to the farm system; but, the man, according to his choices: animal breeds, types of building, to his competence, to his availability will control all the parameters of the farm system and finally the rearing conditions. It should never be forgotten, if it was possible to compare two similar farms, the results and performances would be different with two different farmers.

Discussion

In most of the experimental works, of which some have been discussed previously, herd system variables are generally studied two by two (for instance: post-weaning diarrhea and nutrition influence with *Escherichia coli* infection or TGE infection and the temperature). In a farm, the influences the young animals are subjected to are complex and, above all, act at the same time and together. These conditions are very difficult to reproduce experimentally and to analyse. And even, when only one variable is studied, several parameters could have an influence which could explain the discrepancies between the results. In the study of the food influence on the post-weaning colibacillosis of the piglet, we saw that the energy level or the protein rate had different

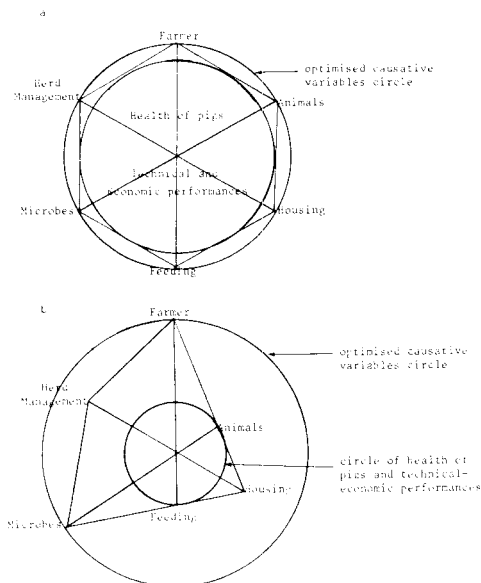


Fig. 1. a. Diagram of the perfect pig or calf unit
b. Diagram of a pig unit with post-weaning digestive disorders

effects according to the experiments; but it is very difficult to individualize the different parameters since not only the absolute value of the components of the food can have an influence but also the nature of the raw material; moreover one cereal mixed with others has a digestibility different from the same cereal used alone.

So, many authors consider that different factors influence the development of enteric diseases (Tzipori, 1980).

For instance, the concept of Lecce is that Rotavirus has evolved in concert with mammalian hosts, into an opportunist that normally persists in its host and rarely produces diarrhoea. The rare event of diarrhoea occurs only when the host is managed in a manner that disrupts the harmonious balance of «live and let live» (Lecce, 1980). In the same way, 10 risk factors have been revealed by a multifactorial analysis for the post-weaning colibacillosis (Madec, 1982).

An illustration of this multifactorial concept is realized on the figure 1 a, b.

The perfect herd can be represented by a regular hexagon enclosed within a circle, the radius of which has its length equal to the unity. This circle is called «optimised causative variables circle» (fig. 1a). Each of the six angles of the hexagon represents a causative variable and all of them are at the same distance from the circle center. The performances (technical, economic, sanitary) of

this pig herd can be represented by a second circle enclosed within the hexagon: this circle is the largest regular geometrical form which can fit into the hexagon: this diagram represents the perfect, or ideal, animal unit.

Frequently, when there is a sanitary problem such as digestive disorders, the herd variables are not optimised. Several may be located somewhere along their axes, between the circumference and the center of the circle. In figure 1b, the irregular hexagon no longer fits into our «optimised causative variables circle». The smaller concentric circle is limited by the angle of the hexagon which is nearest the center and this is the principal limiting factor. Our chosen example concerns a herd with poor technical and economic performances showing post-weaning digestive disorders. It is easy to understand that no long term solution can be found without improving the two main limiting variables [animals: mean weaning weight, heterogeneity] and [feeding: energy level of food for the dam, quantity of dried feed ingested by the suckling piglet]. Having improved these two factors, it will also be necessary to better the variables [herd management] and [housing] if we want to get the best possible results in the production unit (Tillon and Vannier, 1980).

EEC seminar on gastro-intestinal diseases in the young pig and calf 1-3 December 1982, INRA CRZV de Theix 63110 Beaumont, France.

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