Salmonella Ecology[1,2]

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Abstract

Control of the cyclic phenomena of salmonellosis will be effective only when all sources of *Salmonella* are attacked simultaneously. Salmonella ecology must be studied to clarify the problem. Studies at the Kansas Agricultural Experiment Station related to salmonella ecology have been conducted, in part, in the following areas: (1) Convenience foods studied have shown a decreased incidence of salmonella contamination from 1962–65. (2) The examination of fishes recovered from sewage-polluted streams reveals a high percentage harboring salmonellae in the intestinal tract. Per os inoculation of catfish demonstrated viability of salmonellae in the stomach and intestine for at least 29 days. We believe this indicates a demand for salmonella-free fish food for commercial fish rearing. (3) Human salmonella carriers can develop following contact with cold-blooded animal pets. Food workers in critical areas should be carefully examined as potential carriers of salmonellae. We have shown the potential danger of carrier development in our cold-blooded pet survey.

Haeckel, in 1868, coined the word "okologie," translated ecology, which he defined as "the body of knowledge concerning the economy of nature—the investigation of the total relations of the animal to its inorganic and organic environment." The two Greek roots from which "ecology" was derived meant "a house," "family": "Science." In biology, ecology refers to the science of vegetable and animal economy as shown by their modes of life, e.g., socialism, parasitism, etc. As Haeckel states, the terms biology and ecology are not interchangeable because the latter forms only a part of physiology. Ecology is then, the branch of science that deals with the mutual relationships of living organisms and their environment or the science of the relation of organisms to each other. Ecology is a term that has found increasing prominence in writings and discussions on public health and the concept has become basic to the support of many health related activities.

The ecological concept is essential to the study of all life and particularly of the relationships between man and other animals and the microbial environment in which they live.

The reference to salmonella ecology in this discussion then relates to the study of living organisms with which salmonellae have an important mutual relationship. The living organisms in the salmonellae environment referred to are man and warm- and cold-blooded animals.

The genesis of the salmonellae group is an unimportant factor in this discussion. Suffice it to say that the etiological agent of typhoid fever was proved to be a member of the genus of bacteria that we now recognize as the genus *Salmonella*. At the moment there are approximately 1300 salmonella serotypes recognized. They are all related, but all differ from each other, and all are potentially capable of causing disease or a carrier state in warm-blooded animals and man. Additionally it is believed that certain cold-blooded animals develop a carried state that may persist and result in an environmental seeding which may be reflected by the occurrence of salmonellosis in man and animal.

It is accepted that members of the genus *Salmonella* are found naturally in the environment of man and animal and result in infected and carrier individuals. It is also accepted that the original source of salmonellae in the environment was from infected or carrier man or animal. The central concept of environmental cycling is dissemination from man to man, man to animal, animal to man and animal to animal. That ecological relationship has resulted in episodes of salmonellosis transmitted by water, milk, many foods of animal origin, foods of plant origin contaminated by animals in the environment, distribution of the organisms on inanimate objects and possibly in many cases by yet unknown methods of environmental distribution.

In considering salmonella ecology it appears essential to briefly mention certain factors that may influence the dissemination of salmonella in the environment of man and warm- and cold-blooded animals. Unquestionably the presence of salmonellae in an environment raises the potential possibility that man and animal, in the seeded environment, develop a relationship that can in no way be beneficial. Is it too much to say that man has manipulated certain areas of the environment in such a manner that salmonellae have become ecologically important to animal health?

The distribution of higher forms of plant and animal life in the environment is in many cases restricted by geographical boundaries and by size and weight. The small size of microorganisms tends to facilitate distribution as slight weight plays little part in limiting spread. Microorganisms occur in great numbers, under proper conditions, and as they are asexual, one organism may colonize and extend itself into a new environment. In a matter of a few hours or days the rapid growth of microorganisms has established the species in the environment.

In addition to their small size and light weight, many microorganisms have many structural and physiological adaptations which aid in their dispersal. Aerial dispersal is possible because of structures resistant to drying (spores) and the ability of certain vegetative cells to retain life after being dried.

Water distribution of microorganisms is effective due to their capacity of survival in a low food environment. Dispersal in water by means of flagella may be unimportant when compared to the role of flagella in the dispersal of certain bacteria in the intestine of a host.

Animal dispersal of microorganisms, particularly of pathogenic bacteria and protozoa that have an animal host involving a sexual cycle, is exceedingly important.

Dispersal of microorganisms by inanimate objects is aided by drought resistance and in many cases the adhesiveness of the material in which the organisms developed, i.e., animal waste, blood, food materials.

The ecological relationship of the salmonella group

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to the animal host and the environment is worth mentioning. Salmonellae in certain natural, non-animal environments, grow well. That capability enhances the capacity of the salmonella group to perpetuate the organisms that have been eliminated from the infected or carrier animal. That may, and does, result in certain foods that have become contaminated with salmonellae, associated with improper food management, providing the source of most salmonellosis episodes and occasionally a certain number of fatal infections and carrier developments.

Water-borne epidemics of salmonellosis are only an expression of salmonella ecology on the water consuming animal. Such epidemics would never occur with proper chlorination practices.

Aerial dispersal of salmonellae has added to environmental contamination and resulted in salmonellae infections, by way of the respiratory tract, in certain animals. Additionally, foods have become contaminated by the air-borne route. Salmonellae-contaminated inanimate materials in many cases provide the physical media for the distribution of salmonella from their source to the ultimate destination, which results in infected man or animal or both.

The ecological importance of most salmonellae is complicated by their not seeming to appear fastidious, to any degree, to hosts in which they vegetate. This, then, with a few exceptions, categorizes the salmonella group as one of the infectious groups of microorganisms that is not highly specialized as to host. Lack of a special host adaptation enables these organisms to exert their harmful effects on a wide variety of macroorganisms, which in turn, may be a partial answer to the widespread presence of salmonella in the environment of man and animal—and a partial explanation of salmonella ecology.

Previous mention has been made of man's manipulation of the natural environment and the effect it may have on salmonellae ecology. Man has domesticated animals in an effort to improve his economic well-being by protecting the animals from predators. Domestication results in crowding which exposes the animal to infectious disease agents from which they have no natural immunity. Overcrowding in itself does not cause disease but simply subjects the animal to a greater infection pressure, which more frequently results in an effective dose of some disease agent. The husbandry practices used to combat disease must be increased in excellence in direct proportion to the degree of crowding or overcrowding. The most excellent sanitary practices available will probably not result in freedom from exposure equal to that animals experience in their natural state.

Domestication and overcrowding of animals requires foodstuffs to be assembled, often from widely divergent sources. The advantages of the superior nutrition of balanced formulae feeds may be offset by the unfortunate use of salmonellae-contaminated ingredients. Preventing such occurrences is one of the guidelines of certain control agencies who point toward eventual eradication of salmonellae ecology in man and animal.

Domestication has another aspect worthy of mention in relation to salmonella ecology. Overpopulation and crowding undoubtedly increase the stress factor in animals in such situations. The effect of stress in reducing normal resistance is well recognized. Such stress may lower the effective dose required to produce infection.

Certain studies indicate a decrease in the incidence of salmonellae in human foods at the consumer level, which must reflect increased attention to the purity of ingredients used, sanitation control exercised in fabricating, processing, packaging, refrigerating, where indicated, and complete protection from salmonella contamination from raw to finished product. That is accomplished by cooperation of food processors and various governmental agencies and it requires a tremendous amount of educational effort. Continuation of such efforts with constant re-evaluation of methods to prevent salmonella in all foods will relegate salmonellae ecology to an historical fact.

Another example observed of man's manipulation of the environment results in fresh-water fishes harboring a variety of salmonellae in the intestinal tract. A high percentage of fishes removed from streams receiving improperly treated sewage effluent harbor salmonella. The widespread movements and travel habits of fishes might reasonably be expected to result in contaminating heretofore unpolluted waters. The need for stream pollution abatement, as well as other sewage-source disease agents, thus is a vital public health measure to diminish salmonella.

These observations have lead to experimental studies aimed at determining how long fresh-water fishes could harbor certain salmonellae serotypes in the alimentary canal.

Eighty salmonellae-free catfish were inoculated, one time, per os, and returned to experimental tanks receiving a constant exchange of salmonella-free, chlorine-free water. The fishes received no feed and were in an environment where the fish tank water could not be contaminated with salmonellae from outside sources. Fish were killed at weekly intervals and individually cultured for salmonella. Salmonellae were recovered from the stomach, intestinal tract, or both, of all fishes at necropsy over the 29-day period of the experiment.

We believe such data to be added evidence that even in commercially rearing fish all feeds must be free of salmonellae. The potential of fishes in salmonella ecology, we believe, is important and worthy of increased attention from public health authorities, fish processors and sportsmen.

Other studies on cold-blooded animal pets (turtles, snakes, chameleons, etc.) reveal a source of salmonellae of major ecological importance. In addition to diseased humans, human carriers develop, who, in turn, inadvertantly spread the organisms to other humans or animals, or both, and the cyclic phenomenon continues.

Where in the environment of man and animal are salmonellae of greatest potential ecologic importance? If reference is made to the 1966 Annual Summary, Salmonella Surveillance Report from the Communicable Disease Center, Atlanta, Georgia, certain inferences may be drawn. The number and percentage of nonhuman salmonella isolations are presented. Is it not possible that the environment of man supplies most, if not all, of the salmonellae of ecologic importance to man? The close relationship that exists between the top ranking salmonella serotypes isolated and reported from human and nonhuman sources is not a reflection of salmonella ecology?

The presence of ecologically important salmonellae in the environment has been learned many times only as the result of epidemiological findings following disease occurrence. If all environmental sources of salmonellae were presently known and if adequate control measures were instituted to destroy the organisms and such measures were rigidly adhered to, salmonellae ecology would not exist.

This has been an attempt to call attention to the ecological approach to disease control in man and animal by using the salmonella group, members of which are involved in salmonellosis, a world-wide public health problem.

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