COMMENTS ON ZOONOSES TRANSMITTED BY ARTHROPODS

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In public health programs high priority is given to "spectacular" diseases such as cholera, smallpox, plague and typhus. To this group are frequently added malaria, typhoid fever, amoebic and bacillary dysentery, poliomyelitis, encephalitis, dengue. It is only after improvement of sanitary conditions reaches a certain level that the search for unknown diseases, or diseases that usually are of only minor importance, acquires more importance. In this way, several diseases that are naturally transmitted between animals and man have become prominent. Some are of recent discovery, or have only recently been considered zoonoses.

The feature that distinguishes zoonoses from other diseases that affect man and animals is that the etiologic agent must pass directly from animal to man or vice versa, or through a vector. If a pathogen affects independently man or animals, and one is not a source of infection to the other, the disease is not a zoonosis.

The case of myiasis is an example. The female of the mosquito *Psorophora*, according to blood-preferences and availability of the host, may bite man or animals. If the female mosquito is loaded with eggs of the fly *Dermatobia hominis* she may distribute the fly larvae to man or cattle. The larvae of *Dermatobia hominis* do not pass from man to animals or from animals to man. The female *Dermatobia* oviposits on *Psorophora* or other arthropods. Therefore, a myiasis is not a zoonosis.

Here also it may be mentioned that viral hepatitis seems to be a disease of man. Cockroaches, which have been suspected as vectors, might be able to spread the virus in the environment, but they would be only mechanical carriers, not affected by the pathogen.

A critical examination of the list of zoonoses readily separates the group transmitted by arthropods. This distinction seems convenient from the point of view of control as they can be effectively controlled by various chemicals commonly known as insecticides, which are not useful in the other group of zoonoses.

There are a great number of animal-borne viruses the importance of which to human health remains unknown. This great diversity points to a diversity of effects. It is in this group where great advances are expected in epidemiological knowledge, rather than in control.

Some zoonoses seem to affect man very little and consequently they do not receive much attention, as in the case of Newcastle disease of chickens, which produces in man only a benign conjunctivitis. Only through serological analysis can a history of previous infections be detected, infections commonly suffered in childhood. The fact that the disease may be more severe in animals than in man suggests a better adaptation of man to the virus and that the disease is primarily of human origin, with man as the reservoir host.

Actually, some of these diseases do not seem to be exclusively harmful, as man can derive some benefit from them. Such is the case with the African O-Nyong-nyong fever, clinically very close to dengue, not producing mortality, and able to reduce malaria incidence. Here a virus-producing disease affects a disease produced by a protozoon. Of these, at least two more instances are known: the level of viraemia in western equine encephalitis seems to be lower in canaries inoculated with this virus and *Plasmodium relictum* than in canaries inoculated without malaria. In another series of experiments the development of malaria parasites was retarded in ducklings inoculated with *P. lophurse* and a suitable dose of what was described as a "spleen necrosis virus."

In the epidemiology of this group of diseases there is a fundamental interplay of five complex factors. Four of them are biological and a fifth relates to the environment, including temperature, humidity, rain, wind, seasons, soil, vegetation and other factors. The relative importance of all these factors is variable. The biological complex includes (a) man, (b) a single or several vectors, (c) the pathogen and (d) animals, usually a vertebrate.

To detect the presence of these zoonoses a search is necessary because it is in three fields that clues, or the etiologic agent, are found: (a) Man, (b) Animals, (c) Vector, taken one by one or in combinations. In man and in animals, usually a vertebrate, the investigations can be made at any time independently of the season but in the case of the vector there is usually an optimum season. When a particular zoonosis is transmitted by only one arthropod, usually a blood-sucking arthropod, its dispersion marks the distribution of the transmission within a political or geographic region, but clinical cases can spread without danger to the community, to more extensive areas. In certain zoonoses the vectors are transported long distances by the hosts, as in the case of the tick *Hyalomma marginatus rufipes*, which is carried by birds from Africa to Europe. In some of these areas it is possible that transmission cannot occur due to local ecological conditions.

A zoonosis of this group gets a foothold in a new region when the infectious periods in the reservoir host coincide with an adequate population of the vectors, which act as substitutes for the original vector species, transmitting the infection to susceptible vertebrates.

Although the defense mechanism of one vertebrate may be the same as in other species of vertebrates, the immunity variations may be considerable and must be overcome by the pathogen. At least, each vertebrate must have two types of reactions, one against the arthropod and one against the pathogen.

In zoonoses it is desirable to distinguish between the disease that reaches man by overflow from animals and the disease that can affect animals by its high prevalence in human populations. The levels of infections, in either case mark the degree of contact of the vector with man or animals, the abundance of the vector and its feeding habits and its longevity and resting habits in relation to the size of the population of animals. The age composition and other factors have to be known and analyzed to understand the epidemiology, to suggest means of control and to determine the effectiveness of applications.

The etiological agents of zoonosis transmitted by arthropods have more resources for adaptation or survival than pathogens of the other group because of the transfer from one species of vertebrate to another and to an arthropod. An extreme example is the adaptation of the virus of the Russian spring-summer encephalitis and of the relapsing-fever agent, *Borelia duttoni*, harmless to the vector and even congenitally transmitted from the female tick to the egg.

Keeping these facts in mind it is not surprising that when several species of animals are affected by a zoonosis, the specificity of vectors for hosts is less limited. In the laboratory it is possible to take advantage of this characteristic by the use of diverse experimental animals. When this diversity of hosts occurs in nature, the feeding preferences of the vector also must be correspondingly varied, or there may be several vectors with contrasting feeding habits. A long list of hosts suggests that the pathogen comes from remote antiquity and may have a wider distribution than is commonly supposed.

As we are considering in these anthropozoonoses that transmission occurs in both directions via a vector, we are not dealing extensively with pathogens that occasionally may enter a human being as a blind alley, to find no exit or escape. Such is the case of *Hymenolepsis nana*. The eggs of the tapeworm scattered in the environment may be swallowed by the larvae of fleas or the larvae of the grain beetle, *Tenebrio molitor*. Man is infected by eating grains, fruits, flour, contaminated with cysticercoids of the tapeworm. In trypanosomiasis by *T. gambianse* and *T. rhodesiense* man is actually a new host; the *Glossina* flies by cyclical development, or mechanically, transmit the trypanosoms from animals to man, or from man to man but man is not commonly a source of infection even if this is a possibility.

In rabies transmitted by bats the infection in man never passes to animals via the bats. In many parts of the world there is almost a daily occurrence of inoculations into man and animals of a series of living organisms and viruses that do not produce any disease, but also cannot escape from an unwanted host.

Most of the arthropod vectors of zoonoses are insects, mostly Diptera, which are periodic, temporary ectoparasites. The ticks are usually associated with viruses, with *Borelia,* or with rickettsiae and are ectoparasites that remain longer on the host's skin. In most cases we do not know whether transmission of the pathogen is purely mechanical or if there is multiplication or lowering of the number of parasites, either by a defense mechanism or by the effects of the new environment. Also it is not known whether there is added some new character in the cycle of development.

Some zoonoses can seriously affect the vector, as in the case of epidemic typhus, if this disease is really a zoonosis. Here the infected lice have a very high mortality, an impediment to being a reservoir host. There is a similar situation in plague transmitted by the flea *Xenopsylla cheopis.*

Only in malaria can we talk of a "definitive" host, the mosquito *Anopheles* in which the sexual cycle of plasmodia occurs. Of all the arthropod vectors of zoonoses only the eye-gnats, *Hippelates pusio,* suck up ulcerous secretions, sweat and blood from infected animals, including man, to convey the pathogen mechanically. In the numerous group of bloodsuckers there is one constant character, the inability to synthesize necessary chemicals to produce eggs.

It seems necessary to analyze more critically diseases like epidemic typhus, where, as in Addis-Ababa, Ethiopia, with some strains of *Rickettsia prowazaki,* agglutinating antibodies or positive complement fixation reactions have been detected in cattle, sheep, goats, donkeys and horses. It is very important to repeat this search in Addis-Ababa. Similar work should be conducted in other places still reporting typhus epidemics or where these epidemics have recently occurred. Negative data are not helpful, but positive data have great value. The questions that would be immediately posed tend to solve problems relating to reservoir hosts. In the case of man not only the relapses, clinical or subclinical, could be responsible for epidemics, but also the animal reservoir could be the source of *R. prowazeki* infecting man via a vector.

Measures to interrupt transmission, such as chemical drugs or biologicals, can be applied to vertebrates, or insecticides against the vector. One means of control does not exclude the other, but in actual practice this may happen for administrative or economic reasons.

It must be considered that preventive or curative measures applied to a single species of vertebrate, including man, if they are not the reservoir host, could be inadequate to control or to eradicate the zoonoses, since the vector can be infected or convey the infection to other species of vertebrates.

There are zoonoses over which control cannot be obtained in a short time as in the case of sylvan yellow fever or avian infectious jaundice. But others, by their peculiar epidemiology or by their economic importance are at least susceptible to effective control, as is the case of infectious hepatitis transmitted by roaches; urban yellow fever; trypanosomiasis by *Tr. cruzii* and rickettsial pox, which can be prevented or eliminated by the judicious use, in the area of distribution, of measures recommended for the improvement of housing conditions, or by the application of insecticides within the houses.

Analysis of the list of zoonoses show that some of them are necessarily of rural areas without sanitary services, as in the case of the African O'nyong-Nyong Fever, sylvan yellow fever, plague, sylvan leishmaniasis and neo-rickettsiasis; but others like rickettsial pox occur in highly developed urban centers, and are therefore susceptible to prompt and accurate diagnosis, effective treatment and control.

SUMMARY. The group of zoonoses transmitted by arthropods constitutes a convenient group for study, not only epidemiologically but also a group in which it is advisable to test several means of control. Investigations on zoonoses must include man and other vertebrates and arthropod vectors. Measures to interrupt transmission must take into account these factors. The most spectacular advances in the epidemiology of zoonoses are to be expected in those caused by viruses.

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ASSESSMENT OF THE EFFECT OF THE INSECTICIDE BAYER 37344 ON THE BEHAVIOR OF *A. GAMBIAE*

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INTRODUCTION. The assessment of the toxicity of new insecticides, to mosquitoes entering houses, is made in experimental huts by techniques that have been evolved over nearly twenty years since Muirhead-Thomson designed the experimental hut to assess the egress of recently fed *A. gambiae* and *A. melas* from houses in West Africa (Muirhead-Thomson, 1947). The emphasis has shifted progressively from techniques primarily designed to study behavior (Muirhead-Thomson, 1947), through a compromise of techniques (Davidson, 1953) to techniques specifically designed to assess mortality with greater accuracy (Burnett, 1957; Rapley, 1961; Smith and Hocking, 1962; and Smith and Webley, 1963). With the final elimination of the hand-catch (Burnett, 1957), combined with a routine 24-hour retention period for mosquitoes entering the window trap, the basic technique of Muirhead-Thomson, for studying excito-repellent effects of an insecticide, has disappeared in the sacrifice of "behavior" for "toxicity."

In recent years, attempts to eradicate mosquito-borne diseases have been frustrated in several areas by the effects of a residual insecticide on the vectors' behavior (Muirhead-Thomson, 1960; W.H.O., 1960). In other areas the effects of the insecticide on the vectors' habits, while easily detectable, have been of no epidemiological significance because of simultaneously high toxicity that was somewhat delayed (Smith, 1962).

There is thus justification, in a program of testing and developing new insecticidal compounds, for assessing effects on behavior as well as residual toxicity. The problem has been, however, how to assess "behavior" simultaneously with "toxicity," without interfering with the accurate techniques that have been developed over many years. This problem has been recently overcome by (1) substituting a "resting count" for the original "hand-catch," (2) combining counts of fed and gravid mosquitoes into one group —the "feeding section," (3) developing an index of repellency. Further details