

# ECOLOGY OF PARASITISM IN HUMAN BEINGS<sup>1</sup>

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*Endemic parasitism is a fairly sensitive indicator of environmental conditions. High prevalence of intestinal parasitosis invariably reflects corresponding deficiencies in basic sanitation, general standards of living, and hygiene. Parasites are also directly associated with the process of man's adaptation to his environment—a basic phenomenon on which health and disease largely depend.*

## Introduction

Parasitic infections are influenced by three closely interrelated factors: the parasite, the host, and the environment. Endemicity depends upon the simultaneous occurrence of certain biological and ecological conditions that affect the parasite and the host.

Parasites must first of all be present in specific numbers; they must possess the proper pathogenicity and adaptability to the host and the environment; they must produce enough cysts, oocysts, eggs, and larvae to ensure their dissemination over the environment; they must survive the trials of the environment; and some types must be able to pass from one host or vector to another.

There must likewise be a sufficient number of susceptible hosts to contract and maintain the infection. The resistance or susceptibility of a host species to parasitic infection depends on natural or acquired immunity factors which tend to create favorable or unfavorable biochemical and biophysical conditions. Other contributing factors are the age, nutritional status, and genetic history of the host. In humans other circumstances again, peculiar to man's social condition, are important (1).

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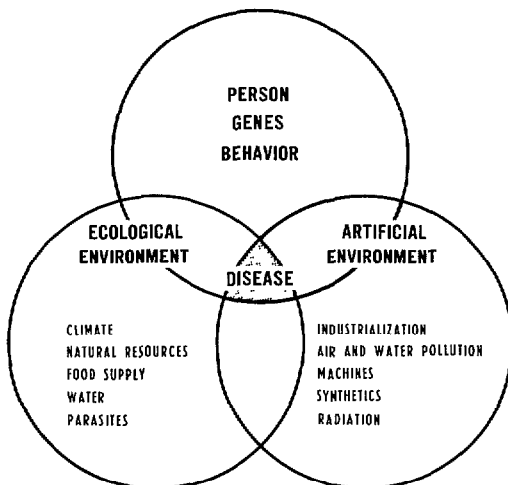
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The pathogenicity of most parasites is weak, and disease only occurs when certain biological, ecological, and above all human factors coincide. As long ago as 1934, Theobald Smith in his classic work *Parasitism and Disease* (2), pointed out that highly virulent parasites sometimes destroy their host, and by doing so jeopardize their own survival. Natural selection tends to weed out the more highly pathogenic species while favoring the survival of the less virulent parasites which can coexist with the host without causing him serious harm. But it is rare to find so perfect a balance between parasite and host as to create the ideal conditions for parasitism. Indeed, it is well known that certain parasites such as *Trypanosoma cruzi* and *Toxoplasma gondii* which can subsist in man for long periods without producing morbid symptoms will suddenly become virulently pathogenic and multiply rapidly, causing serious complications. Such situations are especially noteworthy in the case of immunosuppression to facilitate organ transplants. As René Dubos very pertinently remarks (3) "the concept of successful parasitism is rather a statistical statement," i.e., one that is valid only for a population as a whole; in any individual instance, the outcome of the parasite/host relationship is determined by special circumstances. All parasites, being living organisms, must at one time or another during their life cycle reproduce and their offspring must leave the host, spend some time in the external environment, and then return to another susceptible host, either directly or via suitable vectors. The environment has been defined as

the whole series of external situations, biotic and abiotic, of the ecosystem which influence or affect the life and development of a human being. It is generally divided into a number of categories: physical, biological, and socio-economic. The division is of course artificial, since there is a marked interdependence between them. At the same time, health and sickness are the result of reaction and adaptation by the individual to particular environments which are subject to changes often produced by man himself. Thus disease is an ecological phenomenon, which can be interpreted as the interaction of the etiological agent, the host, the vector, and the environment (natural or artificial); and it represents the breakdown of the ecological balance between these elements (Figure 1).

The environmental factors are an essential link between parasite and host; they can help or hinder the survival and growth of the parasite and the transmission of infections, either directly or through vectors. The factors in question are climatic changes such as temperature or humidity; the influence of the structure and composition of the soil; sunlight; and the presence or otherwise of plants or animals. In the case of parasites in man, sociological, economic, and cultural factors also play their part.

FIGURE 1—Epidemiological diagram of disease.



The physical environment, for example, affects various parasitic infections in humans. The tendency of certain types of malaria to flare up in the spring and summer-autumn seasons is well known. The dependence of the biotic environment (flora and fauna) on the abiotic and physical affects the distribution and frequency of particular types of parasitosis in the various parts of a territory. With this in mind, in 1958 Neghme and Silva (4) made a study of the epidemiology of ascariasis and trichocephaliasis in the various geographic zones of Chile, from the northern desert area to the irrigated agricultural zones of central Chile and the rainy zones of the extreme south. Many parasitic infections are confined strictly to certain geographic areas, according to climatic conditions which favor or limit their spread in the external environment. Some infections occur at particular seasons of the year when the climate is most favorable to the survival and multiplication of hosts and vectors; this is especially true of invertebrates that can flourish in the external environment without any close connection with human ecology (5). The *Anopheles* and *Planorbidae* are good examples. The air temperature is the major climatic factor, since it affects the progress of the evolutionary cycle the parasite must go through in the organism of the vector (6). We know, for example, that malaria is not found in regions where the mean temperature does not exceed 15°C.

To sum up, the distribution and prevalence of the different species of parasites in man can be related to the following ecological factors: (a) those deriving from the natural environment of a given geographic region; (b) those deriving from the ecological characteristics of individual populations; and (c) the changes made by man in the natural environment, i.e., housing, industry (including agriculture and stock-raising), irrigation, dams, highways, waste disposal, etc.

Endemic parasitism is a fairly reliable indicator of these ecological factors. For example, a high incidence of intestinal parasites reflects not only natural ecological factors that favor

infection but shortcomings in basic sanitation, general levels of living, and hygiene.

Parasitic diseases in Latin America affect different population groups in different geographic areas. Since any parasite species needs suitable biotypes to evolve and develop, the predominant types of infection in some regions are parasitic protozoa, in others helminths transmitted via the soil. Certain regions of the Hemisphere, such as the extreme north and extreme south, are susceptible to parasitic zoonoses, and in many areas the diseases produced or carried by arthropods are at the present time problems difficult to solve.

On the basis of our experiments in Chile (4, 7, 8, 9), and those of R. Silva (10, 11), let us make a few general comments and look at some examples which illustrate the points we have to make.

#### Intestinal Parasitic Protozoa and Commensal Protozoa

As examples let us take *Entamoeba histolytica* and *Giardia lamblia*, cosmopolitan parasites which can subsist in a variety of climates and geographic regions once the minimum facilities for finding new hosts are forthcoming. Both these protozoa are found most frequently in densely populated areas or in small groups of people living in overcrowded conditions; in other words, according to their biological characteristics, the prevalence of these parasites will depend on the relative extent of human contact. The situation is made worse by economic and cultural factors. In communities that enjoy none of the benefits of sanitation, the inhabitants' deficient hygienic habits and practices encourage transmission of the infectious forms of these parasites to other members of family groups and the community. It is quite common to find in individuals in both urban and rural sectors certain species of commensal protozoa such as *Entamoeba coli* and *Endolimax nana*, whose life cycle is similar to that of *E. histolytica* and *G. lamblia*. Their presence in the human intestine is evidence that there is contamination of food by fecal matter

in the particular community. In Chile these parasites have been found to be most common and in greatest numbers in rural, suburban or "shanty town" sectors where sanitary, economic, social, and cultural conditions are poor. They are also found to a lesser extent in hot, dry regions such as northern Chile (18° to 29° latitude south), where the climate destroys most cyst forms. In spite of this, the species in question are able to grow and spread quite successfully in this type of zone among population groups living in highly overcrowded conditions (4).

#### Helminths Transmitted via the Soil

Infections by *Ascaris lumbricoides* and *Trichuris trichiura* develop special characteristics according to the local temperature and humidity and the physical and chemical composition of the soil (12). A glance at the infection figures for the whole of Chile (from 18° to 48° latitude) shows that the proportion of persons infected rises steadily at a rate closely parallel with the increase in humidity and vegetation (Table 1 and Figure 2). The ideal temperature for the eggs of *A. lumbricoides* ranges between 20° and 25°C, and for those of *T. trichiura* it is around 30°C. However, strong sunshine and dry climate destroy the eggs or prevent them from thriving in the earth, so that in addition to a suitable temperature there must be a certain amount of environmental humidity for the life cycle to proceed. Hence in the desert area of northern Chile, infection by *Ascaris* is exceptional and by *Trichuris* quite rare. On the other hand, both are fairly common in the agricultural provinces of the south, where rainfall is heavy and the mean temperature ranges between 14° and 20°C. An additional favorable factor is the clayey, vegetable nature of the soil, the kind that clings longest to a certain degree of humidity. The same is not true of sandy soil—which explains one of the ecological factors preventing transmission to humans among the population of the northern desert and valleys, where there is next to no rainfall.

TABLE 1—Percentage distribution, by geographic zone, of 13,317 persons with *Ascaris lumbricoides* and *Trichuris trichiura* infections in Chile, 1948-1954.

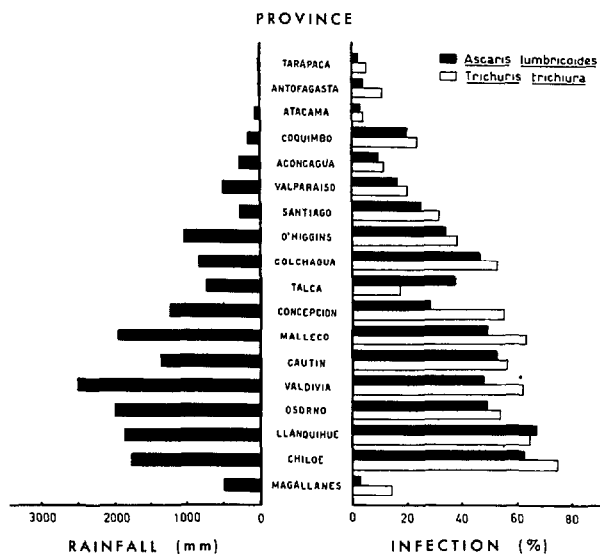
Geographic zone	Degrees latitude south	No. of persons examined	Percentage infected	
			<i>Trichuris</i>	<i>Ascaris</i>
I	18-27	1,654	1.3	4.8
II	27-32	674	16.3	19.3
III	32-38	5,089	23	25.2
IV	38-43.5	5,529	53.5	60.9
V	43.5-55	371	1.4	14.6

The problem of *Ascaris* and *Trichuris* in urban zones differs in scope from that in rural areas. In the former, in spite of the shortcomings of environmental sanitation and the persistence of large socially, economically and culturally underprivileged sectors, there has been marked progress in the last few years in housing and urbanization generally, and this has substantially altered the physical and chemical composition of the soil. Areas where the earth is humid and covered with vegetation have been gradually whittled away and in many sectors fecal pollution of the soil has been greatly reduced. A good example is the northern district of the city of Santiago, where the rate

of infection by these two helminths has fallen steadily over the last eight years (8, 9). It should be pointed out that apart from these factors there was a prolonged period of drought in the central part of the country. Nor can we discount the possible effect in this zone of the sustained educational campaign waged by students of the Medical School of the University of Chile, between 1950 and 1965 in particular.

When real progress is made in a community in basic sanitation, and more especially in sewerage, the relative degree of human infection will depend on whether proper use is made of these facilities. Unless there is a change in

FIGURE 2—Relationship between the prevalence of *Ascaris lumbricoides* and *Trichuris trichiura* and rainfall in Chile, by provinces, 1948-1954.



the hygienic habits of the people, especially the child population, there is a possibility of "ecological pockets" being formed by fecal pollution of the soil, combined with microclimates favorable to the maintenance of disease and producing fresh infections in persons living in the vicinity. Infection will also depend on fecal food contamination.

Another serious medical and sanitary problem in wide areas of the Hemisphere is hookworm disease. In many respects, *Ancylostoma duodenale* and *Necator americanus* resemble *A. lumbricoides* and *T. trichiura*, though their biological needs are different. The optimum temperature for *N. americanus* is 28° to 32°C, and for *A. duodenale* slightly less. The eggs of these helminths thrive best in sandy soil with plenty of vegetation to provide shade and maintain temperature stability and humidity of the soil. Infection does not take place when the environmental temperature is below 10°C, so that in Chile it is found only among workers in coal mines where the underground galleries are poorly ventilated and temperatures and humidity are high. On the other hand, infection by these parasites is widespread in tropical zones, which provide the ideal biotope for their successful evolution and growth. But unhygienic living habits among humans contribute to this same end, with the result that in the past the best laid schemes for eradicating such helminth infestations have failed because of man's ignorance—a factor common to all parasitic infections transmitted via the soil (12).

### Parasitic Zoonoses

This group of parasitic diseases likewise illustrates the part played by ecological factors in creating large endemic areas. Man has learned to domesticate animal species and uses them even today for food and clothing, as well as processing various by-products for industrial purposes. In the course of this domestication, the animal species in question have become permanently integrated into the local ecological system, so much so that in many areas they seek cover at night or in the rainy season in

shelters adjacent to human dwellings. Some animals—dogs, for example, which play a very important part in rural life—live side by side with man, sharing the hearth with him.

1. If we take the example of the cestode *Taenia solium* and *Taenia saginata*, we find that their geographic distribution is conditioned by a variety of factors:

a) The fact that they are found most frequently in agricultural and stockraising areas where there is a preponderance of cattle and pigs.

b) Poor or non-existent sanitation, which favors pollution of the soil and watercourses with human feces, thus carrying the infection to cattle and pigs.

c) Active participation by man in fecal pollution of the soil, and his food habits involving consumption of undercooked food; home slaughtering of various species of domestic animals without medical or veterinary inspection.

d) Ignorance of the problem and lack of adequate and timely treatment of human parasitosis.

2. In the case of *Diphyllobothrium latum*, the main points are:

a) The fact that it thrives in lake districts, in a temperate or cold climate.

b) Its presence in lakes harboring certain species of freshwater fish such as salmon and trout, and in crustaceans which can act as intermediate hosts.

c) Absence of diagnosis and treatment of teniasis in man.

d) Participation by humans in fecal pollution of the soil and watercourses.

e) The presence in these lake districts of wild and domesticated mammals constituting reservoirs of *D. latum*.

f) The food habits of the lakeside dwellers, who live on undercooked fish, thus encouraging diphyllobothriasis.

Chile has a vast lake district in the south (39° to 41° latitude) with a temperate climate, where salmon, trout, and crustaceans of the genera *Cyclops* and *Diaptomus* abound. This is the ideal biotope for the growth of diphyllobothriasis; yet it was only in 1950 that Neghme, Donckaster, and Silva (13) diagnosed the first indigenous case of this teniasis. The phenomenon had been forecast by Prof. J. Noé

several years before, in the light of the ecological conditions in those areas; he argued that all that was needed was a few infected persons, keen on fishing and coming from outside countries, to complete the contamination of the lake waters. This may possibly explain the focus of diphyllobothriasis which still persists in Chile.

3. A word should be said about trichinosis and cysticercosis in humans, which are fairly uncommon diseases in vital statistics, though clinically important. They are confined to zones where pig-rearing is carried on in unhygienic conditions, and hence they are bound up with the following ecological factors:

a) Large numbers of pigs reared in hygienically unsatisfactory conditions and in contact with rats.

b) Artificial biotopes created by man (c.g., garbage) for feeding pigs, especially raw offal. This biotope is a favorite habitat for rats, which are reservoirs for *Trichinella spiralis*.

c) In relation to cysticercosis in humans, poor basic sanitation, which helps to create fecal pollution of the soil.

d) The people's habit of eating undercooked pork, and unclean habits and practices which encourage infection in humans and in swine.

e) Ignorance of the problems in question.

f) Failure to diagnose and treat persons infected with *T. solium* in good time and properly.

For reasons not easily explained, even when these factors are present there are large areas in Latin America where human cases of trichinosis are not found. On the other hand, human cysticercosis is found in nearly all areas where environmental sanitation is seriously deficient.

4. Hydatidosis is a zoonosis affecting the stockraising countries of the extreme south of Latin America, especially Argentina, Chile, Peru, Uruguay, and southern Brazil. In several countries of South America there is no evidence of its existence. In the stockraising areas human beings, sheep, cattle and pigs, along with dogs, form an ecosystem. No exact assessment has been made of the real influence of climatic factors on hydatidosis, except that in this

Continent it is found more frequently in temperate or cold zones.

An important ecological characteristic of this type of region is that the rural population is widely scattered and is thus virtually deprived of the benefits of urban life, especially education. As a result, farming and stockraising, carried on in accordance with age-old patterns and poorly paid, lead to economic and cultural stagnation. Thus some of the factors fostering hydatidosis infection in humans and animals are easily traceable to: (14, 15)

a) Ignorance of the problem.

b) The large numbers of animals raised for food that are infected, especially sheep.

c) The large numbers of dogs that become infected as a result of traditional habits and practices of humans.

d) The close companionship between men and dogs.

e) The fact that on farms, in the home, and in unregistered slaughterhouses, offal from infected sheep is often fed to dogs. Cattle, and sometimes pigs, are also slaughtered in unregistered slaughterhouses or establishments which have inadequate medical and veterinary supervision or none at all.

This situation persists in the South American countries where hydatidosis is endemic, such as Argentina, Uruguay, and Chile. Control measures have been sporadic and merely on a local level, with the result that the disease has spread to other zones. The large numbers of stray dogs in rural areas and in towns, and the regular deliveries of cattle, sheep, and pigs from regions with a high incidence of hydatidosis, have created new sources of infection, even for city dwellers.

#### Arthropod-Transmitted Parasitic Diseases

##### *Malaria*

It has been our lot to witness the most amazing experiment in history: the campaign to eradicate malaria throughout the world by large-scale application of scientific and technical knowledge, especially in regard to the evolutionary cycle of plasmodia in man and the role played in their transmission by various

species of *Anopheles*; and the discovery of potent new chemotherapeutic drugs and insecticides with prolonged residual effects. In the course of the 15 years since the eradication campaign was launched, malaria has been virtually eliminated from vast areas. At the same time, however, new situations have arisen which are interfering with the plans to complete eradication within a given time, and further delays have been caused by the appearance in the mosquito vector of resistance to the insecticides currently in use, such as DDT, dieldrin, etc.; the emergence of plasmodial strains resistant to the new antimalaria drugs; and a whole series of problems created by human ecology, combined with others arising from the behavior of people living in malarious zones—what malariologists have called aggressiveness to spraying. The phenomenon of *Anopheles* resistance to insecticides has caused serious concern and has been the subject of much research. The crucial factor is the present lack of knowledge of the biochemical mechanisms governing the vector's susceptibility and physiological resistance to insecticides, and ignorance of many basic facts about the physiology, ecology, and habits of the various arthropod groups of medical interest. In certain zones, changes in the mosquito population's habits or the replacement of domiciliary vectors by *Anopheles* species which transmit plasmodia outside the human dwelling and are therefore difficult to reach with insecticides, are major drawbacks.

Nevertheless, the experts are optimistic, since there are other means of combating the residual foci of malaria transmission and new knowledge is being acquired through biological, biochemical, pharmacodynamic, and ecological research. Investigations on types of plasmodia in monkeys and their possible transmission to humans by mosquitoes, and on the role of *Anopheles* and other mosquitoes in transmitting malaria to man and monkeys, represent a valuable contribution to our knowledge of this parasitic disease, which is of considerable importance for public health. The application of this scientific knowledge is further hampered

by the problem of inadequacy or irregularity of funds to combat the disease—an affliction most common among the poorest sectors of the rural population. Added to all this are bureaucratic red tape and deficiencies in the structure and organization of health services, which are reflected in low rates of accomplishment among teams assigned to apply preventive methods (16).

Faced with the opposing arguments that the elimination of malaria makes for economic progress and social development, and that eradication will come about only when the economic and social level is sufficiently high (17), we bow to the former. But it must be stressed that the success of the enterprise calls for vast sums, a sound administrative organization, and efficient basic health services, especially health education for the individual and the community.

#### *Chagas' Disease*

Since 1909, when the eminent Brazilian researcher Carlos Chagas discovered *Trypanosoma cruzi* and its relationship with the disease which now bears his name, great advances have been made in our knowledge of this parasitosis. It is now acknowledged to be a major public health problem in extensive areas of Latin America. Estimates indicate that at least 35 million persons are exposed to the disease, that 7 million are suffering from it, and that considerable numbers die from the serious lesions it causes in the human organism.

In this connection, Puffer and Griffith (18), in their report on the Inter-American Investigation of Mortality, point out that they found "no other cause of death was more uneven in its distribution between cities" included in the study. No deaths were recorded in three Latin American cities (Cali, Lima, and Mexico City) nor, as might have been expected, in Bristol (England) and San Francisco, California. On the other hand, deaths occurred in Bogotá (Colombia), Caracas (Venezuela), Guatemala City, La Plata (Argentina), Ribeirão Preto and São Paulo (Brazil), and Santiago (Chile); 86 per cent of

the total were in Ribeirão Preto and São Paulo, while Caracas was the only city outside Brazil where the number of deaths exceeded eight.

These differences in the mortality figures reflect the irregularity of the incidence of Chagas' disease in the various parts of Central and South America, due to local ecological conditions, the differences in pathogenicity of *T. cruzi* strains, and other factors awaiting investigation. They also reflect the well-known fact that the disease occurs predominantly in rural areas, so that patients frequently do not attend medical care centers, these being mostly in the large cities.

Infestation of houses by the *Triatoma* vectors and infection with Chagas' disease are the result of primitive housing, unhygienic conditions, and socioeconomic and cultural shortcomings. The effect on large groups of economically underprivileged rural dwellers is to reduce their work capacity still further, since the disease has an impact on both their health and their well-being. Ways and means have been sought of eliminating the arthropod vectors. A number of residual insecticides have been found effective, the most commonly used being BHC. Other preventive measures involve new or improved housing—a basic prerequisite, along with adequate educational measures, for the elimination of the vectors. Nevertheless, there are still many biological, physiopathological, pharmacological, and ecological problems to be cleared up. There are large areas in Latin America where little or nothing is known about the vectors and reservoirs, the rates of domiciliary infestation, triatomid infection, or human infection, morbidity, and mortality (19).

### Man's Role in Parasite Ecosystems

Let us look more closely at the interaction between man and other living species and the natural or artificial environment constituting the ecosystem. The presence of humans and their role, both as individuals and as social beings, is an important factor in any ecological system where parasitosis occurs.

In the course of the millennia since man first

inhabited the earth, he has evolved in the same way as other living creatures. But unlike the rest, man has been able gradually and progressively, and generally for his own benefit, to adapt the natural environmental conditions surrounding him. With the advance of technology, this process of adaptation has become more and more marked, and since the Industrial Revolution it has accelerated rapidly. Over the last three centuries it has transformed the material way of life and the mental outlook of mankind, and it continues to do so all the time.

The changes brought about have not always been for the better, however, and in not a few instances they have encouraged the growth of parasite species which have found man-made conditions more favorable than those of the natural environment. The population explosion, urbanization, industrialization, and other such processes help to create conditions suitable for the emergence of ailments which have very aptly been called "diseases of civilization" (20, 21). This reinforces the argument of those responsible for public health in the Hemisphere that economic planning must be accompanied by adequate standards of social development, with the guidance of medical science (22).

Health administrators must make themselves familiar with the problems arising out of the relationship between man and his environment, the technological, social and economic changes affecting that relationship, and the trend and scope of those changes. Thus they will be alert to the consequences and plan their programs accordingly.

Progress in the natural sciences has been astonishing since the introduction of the experimental method, especially over the past few decades, which have brought a flood of scientific knowledge and data; and as this knowledge has gradually been applied to human life and health, man's way of life and health patterns have undergone a parallel improvement. At the same time, many of the infections that were once serious problems have become less virulent; child morbidity and mortality have been reduced; industrial hygiene and nutritional levels have been improved; and worldwide



campaigns have been undertaken for the eradication of various parasitic diseases, such as malaria.

The capacity of the human being to adapt to changes in his surroundings has played an important role in the process of interaction between man and the environment. It can now be stated that parasitosis in the human species is directly related to the way in which the process of human adaptation to the external environment takes place. It is the factor on which health and illness largely depend.

Within a human community's ecological system, education weighs heavily in the relationships and the interaction between man and the other components of his society and living creatures making up his ecosystem. But the interrelationship of agent, host, and environment in parasitic infection reveals, much more clearly than in the case of many other diseases, the real influence of human ecology in the genesis of communicable pathological processes.

It is no longer possible to ignore the essentially ecological nature of the problems of parasites as they affect human societies, and the importance of a whole series of environmental and social factors in the struggle to eradicate many parasitic diseases. It may be well to recall briefly a few of the factors that affect not only the number of persons suffering from parasitic ailments in a given community, but the intensity and severity of parasite attacks on the individual.

It is a well-known fact that the clinical response to a particular parasite can vary tremendously. Often the presence of a parasite will pass completely unnoticed. At other times, parasitosis will take on from the outset a violence or an intensity that can endanger the patient's life. The explanation of these variations is not far to seek if we regard parasitism as essentially an ecological state in which a dynamic balance is established between the capacity of the parasite to multiply and spread, and the resistance of the host. This balance depends on a large number of factors—the number and virulence of the parasites, the

genetic constitution and level of immunity of the host, etc.—which in turn are regulated by environmental, cultural, and social factors. This points to the need to distinguish between the concept of disease and that of infection, the latter term designating the mere presence of a particular parasite in the organism. It is now many years since Theobald Smith (2) brought this out clearly at a time when the tendency was still to consider that any pathological agent must necessarily produce disease when it infected a susceptible individual. Today we know that, on the contrary, disease will be produced only if the microorganisms or parasites are capable of overcoming the tendency to homeostasis in the host's biological system. What usually happens is that a dynamic balance is created, so that the parasite inhabits the organism without producing ostensible pathological disorders. This balance may be upset in one or another direction, in some instances producing symptoms of disease, slight or serious, and even causing the death of the patient. At other times it merely produces an asymptomatic infection, or the patient recovers and the parasite disappears.

Theoretically, all efforts should be concentrated on disturbing the balance between the parasite and the host, in such a way as to reduce the factors making for disease and death. The ideal solution is, of course, to eliminate the parasite; but since this is not always feasible, the logical course is to intensify action to ensure that asymptomatic or only slight attacks are the rule. An example to illustrate this is ancylostomiasis. When a population is well fed, there is a marked decline in severe clinical symptoms, and cases of infection are notably more frequent than those of disease. The opposite occurs in areas where there is malnutrition; here the parasite causes large number of cases of disease and death. Similar instances could be adduced for a number of other parasitic and bacterial diseases.

Leaving aside its clinical features and repercussions, parasitism is dependent on the results of whatever action the community may take to build up and improve the material and cultural

standards that enable it to develop and prosper. "Medically speaking," says Dubos (21), "man is in general more the product of his environment than of his genetic endowment. The health of a people is determined not by their race, but by the conditions of their life." There is no doubt that in a particular population group, parasitic diseases reveal very clearly the inequalities in such groups with respect to civilization and culture. This underlines the anomaly of a situation where some countries are thinking in terms of outer space or the prolongation of active life while communities elsewhere have not yet satisfactorily solved the problem of avoidable diseases. And it serves to emphasize once again that parasitic diseases are important medical and health problems for Latin America; of its close on 300 million inhabitants, more than half live in zones still at the underdeveloped stage. Within a stone's throw of ultra-modern urban centers equipped with the latest communication devices, abundant electric power, and large numbers of highly complex industrial plants, there are towns and rural areas with hardly any of the elementary facilities of basic health and without electricity generators or factories.

To solve these problems once and for all is not an easy matter; so much is certain. It calls for vast resources, will-power, and determination. For unlike certain communicable diseases for which immunization or chemical, biological, or other means of protection are available, prophylaxis in parasitic diseases involves the provision of the minimum material and spiritual comforts and amenities to which every civilized being is entitled. Everyone will agree with Dubos' contention that political and social reforms alone will not be enough; they must be combined with the application of scientific knowledge and be governed by "sound medical principles" (20).

The magnitude of the medical and public health problem resulting from parasitic infections in Latin America is such that it commands the attention of professional workers in the health sciences, particularly educators.

### Summary

Three closely related factors play a role in parasitic infections: the parasite, the host, and the environment. Endemicity requires that certain biological and ecological conditions which act on the parasite and its host occur in conjunction; that the parasites be present in specific numbers; that their pathogenicity and adaptability to the host and to the environment be suitable; that they produce a sufficient number of cysts, oocysts, eggs, or larvae to ensure that they spread through the environment; and that they survive its hardships and succeed in passing from one host to another. There must also be a sufficient number of susceptible hosts capable of contracting the infection and keeping it going.

Resistance or susceptibility to the parasitic infection in a host species depends on natural or acquired immunity factors which produce favorable or unfavorable biochemical and biophysical conditions. The host's age, state of nutrition, and genetic history also play a part. Highly virulent parasites succeed in destroying their hosts, jeopardizing their own existence in the process. Natural selection tends to eliminate the more pathogenic species and favor the survival of the less virulent types which can coexist with the host without causing serious harm.

Environmental conditions represent an inevitable nexus between parasite and host and may hinder or promote the survival and development of parasitic elements and the transmission of infectious forms to the hosts. These conditions are subject to climatic variables such as temperature and humidity; the structure and composition of the soil; sunlight; and the presence or absence of plants and animals. In the case of human parasites, sociological, economic and cultural factors are also important.

Endemic parasitic infections are fairly sensitive indicators of environmental conditions. A high prevalence of intestinal parasitosis reflects inadequacies in basic sanitation, in the general standard of living, and in hygiene.

In sectors with a high population density, or in groups of persons living in overcrowded conditions, *Entamoeba histolytica* and *Giardia lamblia* are the parasites most frequently seen. The prevalence of infections due to *Ascaris lumbricoides* and *Trichuris trichiura* is closely related also to increased environmental humidity and, in particular, to unhygienic practices leading to the fecal contamination of soil and food.

Parasitic diseases, with their interrelation-

ships between the agent, the host, and the environment, illustrate more clearly and objectively than most other diseases the important role played by human ecology in the genesis and evolution of communicable pathological processes. Parasitism is bound up with the community's efforts to create and improve the material and cultural factors on which its development and progress depend. Thus, the variations of intensity and extent with which parasitic diseases affect different population groups highlight the inequalities of these groups

with respect to civilization and culture, and the primary resources which protect man against natural agents, in particular, basic sanitation.

The final solution to this problem is not easy; it calls for vast resources, will-power, and determination. Whereas for other communicable diseases there is immunization or chemical, biological, or other types of protection, prophylaxis in parasitic diseases involves the provision of the minimum material and spiritual comforts and amenities to which every civilized being is entitled. □

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