I. C. ECOLOGY OF LOUSE-BORNE INFECTIONS

INTRODUCTION

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The word “ecology” has become a cliche through excessive and inappropriate use, but the term is still particularly appropriate in dealing with the relationships between the environment and the various organisms that are factors in human diseases borne by ectoparasites. In such infections, there are complex associations not only between the causative agent, the vector, the hosts of the vectors (including the patient), and the sundry habitats of all these organisms, but also with other members of the community. The ecology of louse-borne diseases is especially fraught with interest because it is the environmental circumstances that account for the difference between devastating outbreaks that affect, or even cost, the lives of millions, or change the course of history; and smoldering infections or scattered cases in remote areas which arouse little outside concern. Unlike most arthropod-borne diseases, in typhus it is the actual doings of man that set the stage for epidemics, and probably even perpetuate the infection in nature.

It had been the conviction of scientists that man is the sole reservoir of epidemic typhus, i.e., the infection in interepidemic periods was maintained only in humans, and not in rodents or other mammals as is the case with so many arthropod-borne diseases. Thus, typhus was ordinarily restricted to relatively small areas where people were chronically infested with the vectors, lice and epidemics occurred only in times of violent upheaval, such as war, famine, pestilence, and other scourges, when enough nonimmune people became heavily infested with lice and were exposed to contact with infected individuals.

In ordinary times, however, typhus can exist only where poverty, ignorance, or superstition permits lousiness to occur. Since lice are the ectoparasites most intimately associated with humans, it is not surprising that man’s beliefs, customs, and practices affect the distribution and incidence of louse-borne diseases more than they do many other infections. The methods and frequency of bathing or changing clothes, the mere possession of extra clothing to don, and the belief that having large numbers of lice, associated with being heavily haired, are correlated with virility in males; all are relevant examples. Education and a rise in the standard of living are among our most promising weapons for the control of diseases borne by lice and other arthropods.

Of the various artificial impediments to medical progress, one of the most troublesome is cultural or religious beliefs that run counter to the recommendations of health authorities. In many parts of the world, patients object strenuously to being bled for

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diagnosis, and collecting serum for study is out of the question. In other regions, even minor surgery is regarded as a threat to one's hereafter. (Oddly enough, injections and administration of pills, regardless of their nature, are generally regarded in such areas as tantamount to magic or panaceas and are avidly sought.)

The forms, depths, and sincerity that such creeds may entail strain the credulity of the uninitiated, as happened to me when serving in Bengal as a malarialogist during World War II. In those days before the advent of DDT, prime measures for the control of malaria consisted of the destruction of larval or adult mosquitoes by draining, filling, or oiling ditches and other bodies of water, spraying latrines and villages, and the like. By diligent application of such old-fashioned methods in a hyperendemic zone, it was possible to reduce the malaria rate nearly twentyfold in one year.

Accordingly, I was appalled when most of our best crews of workers presented notice that they felt obligated to resign, and since this was during the height of the famine of 1943, when several million people died in Bengal, I was astounded that laborers would leave a job that included rice at legal rates as a fringe benefit. Since rice was unobtainable outside except at 20 to 50 times the governmental price and other jobs were nonexistent, I asked what possible reasons there could be for choosing almost certain death instead of continuing employment they admittedly enjoyed. The answer was that our employees simply must resign because of their religious beliefs. They had just realized that their unusual activities on our behalf were not merely unfathomable Western practices, or propitiation of strange deities, but that they were killing mosquitoes. This was utterly unacceptable to them since they were Jains, to whom all life was sacred—even an insect might harbor the soul of a deceased relative. On inquiry I learned that such was indeed their belief, and that a wealthy Jain might employ someone to sweep the path in front of him as he walked so as to prevent his inadvertently treading upon an ant or spider, or might pay people to sleep in his bed in the daytime to satiate the bedbugs and thus lessen the chances that the owner might accidentally kill a feeding bedbug in his sleep at night. These antimalarial crews actually did all leave their jobs, for to have done otherwise would have jeopardized their eternity and their chances of returning in a future life at a higher social level. We had to respect such faith and determination, even though we could not understand it. Of course, it is not necessary to go to the Orient to encounter firm and unswerving beliefs opposed to accepted medical practices, for in this country there are faiths whose adherents forego surgery and will not seek the attendance of a physician, regardless of the need or cause.

There was good reason to believe that only man and lice comprised the cycle in epidemic typhus. The role of lice as vectors had been indubitably determined (and at the cost of the lives of some of the investigators). There was no evidence even to suggest that other arthropods were involved, or that mammals other than man became ill or harbored infection, even in the midst of massive outbreaks. Experimental work indicated that lice could not be important in the transmission of other rickettsial infections (restricting the term in the sense that today the agent of trench fever is not considered a true rickettsia) (14). Further, while other laboratory studies indicated that experimentally-induced Rickettsia prowazeki infection in ticks might be passed transovarially to the next generation of ticks (13, 14, 15), none of the various articles on the subject really incriminated any other arthropods (save lice) as likely vectors.

One of the most cogent arguments for regarding lice as the sole vectors was the
absolute conviction that lice were the most host-specific of all ectoparasites, and that they would inevitably perish if they attempted to feed on another species. It is true that the pubic louse, *Pthirus pubis*, had been reported as infesting dogs (4), but such reports were rare indeed, and did not refer to *Pediculus humanus*, the body louse, which is the vector. It was therefore difficult for scientists to adjust to the idea that strains of human lice could be adapted to feed on rabbits, to say nothing of the fact that rabbits could actually be used as regular laboratory hosts in maintaining louse colonies. Once this became an established fact, the concept no longer seemed impossible that in nature, infected lice, leaving a typhus patient with fever, as is their wont, might attach to other kinds of mammals in proximity, and that such hosts, e.g., livestock, might in turn infect their own ectoparasites such as ticks. It was also appreciated that in certain endemic areas, people resided in close physical contact with their domestic animals.

For these reasons, Reiss-Gutfreund’s reports of isolations of *R. prowazeki* from ticks in Ethiopia (9, 10, 11) and the suggestion that extrahuman cycles of typhus existed, in which ticks and livestock played roles, were noted with interest, and research on this subject proliferated. Supportive serologic data were advanced from a number of countries in support of such hypotheses (1, 2, 5, 6, 7, 12), and considerable debate has raged since then as to the validity of the concept of an extrahuman cycle of typhus. Doubts about the significance of some of the serologic data and procedures, coupled with confusing reports about the course of experimental typhus infection in ticks and in domestic animals, have militated against widespread acceptance of the hypothesis. It was because of such doubts, and the belief that a basic study of the sera of domestic animals might clarify some of the clouded issues, that our Department of Microbiology started a project on epidemic typhus in the laboratories of the U.S. Naval Medical Research Unit No. 3 in Cairo. The studies at the U.S. National Institute of Allergy and Infectious Diseases’ Rocky Mountain Laboratory on typhus were also launched to shed light on this important concept of a possible extrahuman cycle.

Relapsing fever is a disease transmitted by both ticks (Argasidae) and lice, albeit with different species of *Borrelia* spirochetes as etiologic agents, and hence it is both pertinent and interesting to consider the possibility of an extrahuman cycle of this infection.

There is one important consideration in the ecology of louse-borne diseases that unfortunately will not be treated during the Symposium, and that is the possibility of the transmission of *R. mooseri*, the agent of murine typhus, by lice. There has been speculation in the literature that cases of flea-borne murine typhus may occur in lousy individuals, and that the lice may thereafter be responsible for transmission to members of the family, and that a louse-borne outbreak may ensue. Kalra (3) reported in 1959 the isolation of *R. mooseri* not only from the fleas *Xenopsylla cheopis* and *X. brasiliense* in Kashmir, but also from “lice,” and wondered about the possibility of a family chain of louse-borne infection. Such a series of events was suggested in 1942 as the cause of a large number of cases of murine typhus in Shanghai (8). Discussion of this hypothesis, as well as the theory that *R. prowazeki* actually evolved from louse-borne *R. mooseri*, has been omitted from the program because of lack of new and concrete data, and not merely because of severe limitations of time.
REFERENCES


