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Head Lice/Typhus
Research Project
Deborah Z. Altschuler

The following is a review of materials translated and interpreted by Dr. Morris F. Shaffer for this project and in regard to available knowledge on head lice and their ability to transmit typhus.

In Nicolle's paper of 1909 (Ann. Inst. Pasteur, 24, pp. 243-275) describing the experiments in Tunis which demonstrated the role of the human body louse in transmission of classical typhus, he did not implicate or even mention head lice as a possible alternative vector. Nicolle did state that:

a. he had negative results in preliminary attempts to directly infect M. cynomolgus and M. sinicus individuals with the blood of typhus patients;

b. he was successful in producing disease by inoculation of a chimpanzee with blood collected from another patient within a few hours after the appearance of exanthem;

c. using human body lice collected from normal patients and fed on the chimp he was able to transmit the disease to bonnet monkeys;

d. blood from the latter was infectious for other individuals of this species.

In section IV of the paper (with Comte and Conseil) he discusses in some detail the transmission of typhus by the body louse, pointing out that: the human louse feeds with equal voracity on man and monkeys, consuming blood rather than epidermal debris; lice must be fed daily if they are to be used for biting purposes; special methods must be employed to maintain lice in captivity. No mention is made here concerning head lice.

The second article is from the *Bull. Inst. Pasteur* (Paris, 1920; pp 49-59). It is a review on the "State of our Experimental Knowledge of Exanthematic Typhus - an outline of the methods used and problems remaining to be resolved." Nicolle presents his views, with few technical details or references to prior literature. The following points are noteworthy:

1. Typhus exanthematicus is a *single* disease, world-wide. Reciprocal vaccinations (cross-immunity tests in animals) have shown the identity of typhus of Parisians with that of North Africans, Mexican typhus with that of Brill's Disease, etc.

N.B. In *Rats, Lice and History*, Dr. Zinsser corrects or updates this notion, saying (page 173 in the Bantam Classic edition):

"There are two distinct types of true typhus virus. The diseases they cause in man are identical and both are transmitted from one individual to another by human *body and head lice*...they can be distinguished... Before these distinctions had been recognized, typhus had been regarded all over the world as a single disease perpetuated by man-*louse-man* transfer...(page 174), most of the work we are discussing has been done since 1928, a good deal is hardly off the presses, and some of it is not yet in print as these paragraphs are being written." Dr. Z. uses here and elsewhere the term "virus" as synonymous with "microbe."

2. In human typhus transmission, no other arthropod than the louse is implicated - not fleas, not bed bugs, not biting flies nor mosquitoes or ticks. Only lousy people are affected. It is linked to their skin and rags, goes with them and stays until they come to the threshold of the hospital where they find soap, water and clean clothing. Endemic foci are linked with dirty people and the outbreak of epidemics is linked seasonally with the number of lice found on the person.

3. The louse does not become infective until several days after a blood meal. There seems to be proliferation of the typhus agent in the louse. At the time the bite becomes infective, the agent is in the gastro-intestinal tract since the louse dejecta are infectious (for monkeys or guinea pigs). Hereditary transmission of the agent in the louse is not demonstrated, contrary to the situation in relapsing fever.

4. Two factors control typhus transmission:

- A. man, the sole reservoir in nature, where the agent circulates in the blood during more than the extent of the illness;
- B. the louse, of which the bite becomes virulent at least 7-8 days after it has fed on a diseased person. The virulence of louse dejecta permits a second, indirect mode of contamination - excoriation by scratching of skin soiled with louse dejecta.

5. Children play an important role in the etiology of typhus, since in them the disease is generally mild or inapparent.
6. "The head louse transmits typhus like the body louse."
(Nicolle, page 55)
7. Patients freed of their lice are no longer dangerous for others. In well-maintained hospitals, cases of typhus contagion were not observed except in the personnel at the entrance who could not defend themselves against the vermin on patients and their rags which they were obliged to contact. However, cases of laboratory contamination or accidents even among doctors have been recorded.
8. If instead of allowing them to bite, one injects infectious lice under the skin of monkeys or guinea pigs, the results are constantly positive; this non-natural route must be a more severe challenge. (Nicolle, page 54)

In *Rats, Lice and History*, Zinsser states: "The body louse and the head louse carry the infection from one human being to another (page 165). (He accepts and confirms Nicolle's claim (item 6 above) though no experimental data on his specific point has been located.) In speaking of the murine variety, Dr. Zinsser writes (page 166): "From the bite of infected fleas, the human being contracts typhus. This is the sporadic or endemic case. If the victim is lousy, group infection may occur. If he lives in a louse-infected community, the consequences is an epidemic." Zinsser conjectured (page 131) that "...from the several head varieties arose the body louse, when naked man began to wear clothing" and he accepted (page 131)...the relatively recent discovery by Bacot that the head lice of man would intermarry with the body lice and give fertile progeny."

Dr. Shaffer noted at the end of this first summary that "I am convinced that Zinsser in the early 1930's concurred with Nicolle's view, expressed more than a decade previously, as to the capability of human head lice to transmit typhus. Since both men believed strongly in the importance of the experimental method as the basis for scientific conclusions, I presume that they were aware of actual trials on this point, although I don't know where the pertinent data are recorded."

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Review of additional literature:

From 1910 to 1912, Anderson and Goldberger who had worked chiefly in Mexico published in USPHS Public Health Reports, a series of papers summarizing their results; these were re-published as a monograph (Collected studies, Bull. of the Hygienic Lab #86). Paper 5 states "Although all the important features of the epidemiology of typhus are satisfactorily explained on the basis of its transmission by means of the body louse (*P. vestimenti*), nevertheless an account of the close relationship between this insect and the head louse (*P. capitis*) it seemed desirable to test the possibility of the transmission of the disease by this latter species..."

In one of 3 experiments a monkey bitten by head lice collected from typhus patient proved resistant on later challenge with virulent typhus blood. Also, a monkey inoculated with ground-up head lice which had fed on typhus patients showed an extended fever and was subsequently refractory to inoculation with virulent typhus blood.

They stated, "In this paper we present the first evidence incriminating any insect other than the body louse as an intermediary in the transmission of typhus fever..." They concluded, "the head louse (*P. capitis*) may become infected with typhus. The virus is contained in the body of the louse and may be transmitted by subcutaneous inoculation of crushed insect and, we believe, also by its bite."

In 1915 Foster reported the study of an outbreak of clinically mild typhus (resembling Brill's disease) among adults in their 20's seen in a military hospital on Mindinao. The patients were seen during the rainy season, in a temperate (rather than tropical) region, when blankets were required at night; patients lived or visited in a filthy, overcrowded, verminous environment and the heads of many individuals in the families were infected with head lice. Since the body louse had not been previously recognized by government entomologists to be found in the Philippines, Foster was convinced that the head louse was the means of transmission. Inoculation of patients' blood produced a febrile reaction in 2 of 3 local monkeys, without eruption. (There were no laboratory methods available to test the specificity of the results.) No attempt was made to experimentally transmit infection from patients via lice to monkeys.

In Topfer's 1916 study of the typhus agent in the louse/*Deutsche-Med* 1916, 42-1251-54), he reported chiefly on microscopic examination of Giemsa-stained smears of teased preparations (or sections) from the gut of the arthropods (over 5000 in total, including controls). He described developmental forms of a morphologically and tinctorially distinctive microbe which he regarded as a bacterium (*bacillus*) rather than as a new variety of microorganism category (*a la* Rocha Lima). His organisms were found

profusely in cells of lumen of the gut, also in the dejecta. (Unfortunately he had no way to identify or 'tag' the organisms serologically or otherwise, as Murray and Torrey could do many years later.) He had previously worked with body lice; here his focus was on head lice.

Topfer was successful in demonstrating "his" organism in head lice from female typhus patients or convalescents who had ostensibly been deloused but whose hair had not been shorn. To eliminate the objection that the insects might be body lice which had taken up residence on the head, he personally supervised the collection of lice from patients in whom no body lice could be found. He was also able to distinguish head from body lice by differences in the morphology of abdominal segments. The lice showing organisms were 'red ones' as in body lice, i.e. which had sucked up appreciable quantities of blood. He found infected adult head lice on 12 patients, which he considered to plead against a mixture of the varieties; immature forms of lice were uniformly negative and there was no evidence that the agent was transmitted hereditarily. He was successful in artificially infecting head lice maintained on strips of felt. He concluded that head lice were more susceptible and observed that they die off more rapidly; therefore they may play a lesser role than body lice but sanitary anti-typhus measures should be directed against both varieties. He considered "his" organisms from head lice, as well as from body lice, to be etiologically responsible for typhus. They multiplied abundantly in the louse gut and could enter the human host via bit but also by rubbing the feces on the skin, squashing the insect, or occasionally by other means (e.g. conjunctiva). Experimental data were limited, though he did inoculate a few guinea pigs with louse gut organisms and found that fever was provoked. (I [Dr. Shaffer] conjecture that there may have been difficulties in publishing in a clinical journal during wartime.)

In Nicolle's review article on the status of experimental work on typhus, published in two parts early in 1920 in Bull. Inst. Pasteur, he specifically avoided citations of the prior work of others and presented the facts as he saw them. Part I dealt with evaluation of the susceptibility of various laboratory animal species and the methods for working with them .. there is no mention of lice. It is in part II that he stressed the important role of body lice as the vector in typhus - but acknowledged the ability of the head louse to likewise transmit infection, in a single sentence on page 55.

In the monograph published later that year, Strong and his co-authors (including Dr. Zinsser), cited the foregoing reports as furnishing some support for the thesis that head lice may sometimes transmit typhus - but they indicated that further experimental work on this matter would be desirable.

In Dr. Zinsser's "As I Remember Him", he recounts his 1928 visit

to Tunis to work in Nicolle's lab on the transmission of typhus to monkeys via lice. Subsequently the two men traveled together in France and maintained regular correspondence. He also tells the amusing anecdote about collecting head lice in Boston for typhus studies. Thus he (and Nicolle) must have had no doubts about the vector potential of head lice and he expressed this in "Rats, Lice and History."

The work of Murray and Torrey in 1975, employing methods which enabled them to demonstrate that head lice can acquire infection by feeding on a mammalian host previously inoculated with rickettsiae, also that the organisms proliferate in the gut to an extent which results in the insect's death, led them to a similar conclusion. (They may have been inhibited from attempting to transmit the disease via head lice to primates by the cost and logistics of maintaining such animals.)

In summary, even without availability of the Nicolle-Zinsser correspondence, the published evidence points to the undesirability of head lice as an associate in man's immediate environment, particularly if conditions were to favor proliferation and dissemination of the insect among populations including individuals who might be rickettsemic.