The number of house rodents examined was not large enough to form a basis for definite conclusions, but the evidence so far as it goes is against domestic rodents being concerned with the spread of kala-azar.

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Attempts to transmit kala azar by means of rodent lice, haematopinus sp.

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On account of the susceptibility of the Chinese hamster to infection with kala-azar we have considered in another paper[1] the possibility of these and other rodents being reservoirs of the disease, the transmission in such case being effected by means of their ectoparasites from the rodents to other rodents and man. In this connection a number of rodent ectoparasites have been studied with regard to their capabilities as transmitters of kala-azar. The rodents examined have been chiefly the striped hamster *(Cricetulus griseus)*, the giant hamster *(Cricetulus triton)*, a vole *(Microtus* sp.*)*, the Asiatic house mouse *(Mus wagneri)* and the house rat *(Mus rattus)*. Their ectoparasites have been limited chiefly to fleas, bloodsucking mites *(Gamasidae)*, ticks, non-bloodsucking mites *(Myobia)* and lice (Pediculidae, *Haematopinus* spp.). The fleas, Gamasid mites and ticks have been found only on the house rodents, while the lice have been found on both field and house rodents, each having its own species of louse. The present paper is a summary of the studies made on the respective species of *Haematopinus* of the two hamsters.

In addition to the possible rôle of lice in connection with the rodent-ectoparasite hypothesis, a further reason for studying these insects lay in the fact that our stock animals tended to more

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[1] Young, C. W., and Hertig, M., PROC. SOC. EXP. BIOL. AND MED., 1925-6, xxiii, 395.

or less lousiness. No practicable method was discovered of ridding the hamster completely of their parasites. Dipping in warm two per cent Izal solution was fairly effective with negative hamsters, but the inoculated animals seemed unable to withstand the inevitable chilling. It was thus important to discover whether it was possible to disregard the presence of lice in our other studies.

We have endeavored to determine (1) whether *Leishmania donovani* in any stage may be demonstrated in lice from positive hamsters, and (2) whether lice can transmit kala-azar.

I. *Occurrence of Leishmania in lice from positive hamsters.* Leishman-Donovan bodies are frequently demonstrable in smears of peripheral blood of human patients, and Young[2] has shown by cultural methods that the organisms are usually present in the peripheral blood. This point has not been determined directly for the hamsters, although heart-blood smears from heavily positive hamsters at autopsy are usually positive for Leishmania. However, in another study to be reported later, we have shown that sandflies *(Phlebotomus* sp.*)* fed on both striped and giant hamsters may develop flagellates of Leishmania in their intestines (thus confirming for Chinese sandflies the general phenomenon of exflagellation of Leishmania as described by Knowles, Napier and Smith.[3]) These parasites are thus shown to be present at least at times in the peripheral blood of both hamsters. Lice constantly present on the hamsters and feeding frequently would seem to have an opportunity for ingesting Leishmania.

Microscopic examination. Smears from many lice from heavily positive hamsters have been made, but in no case has even one Leishmania been found. A total of 153 striped-hamster lice and 329 giant-hamster lice have been thus examined and found negative.

Inoculation Experiments. Lice from positive hamsters were teased up in Locke's solution and injected intraperitoneally into tested negative striped hamsters. The lice were usually teased up individually in small drops of water on a slide, most of this suspension then being transferred to a larger volume for injection. Sufficient cellular debris remained behind in the little indi-

[2] Young, C. W., and Van Sant, H., *J. Exp. Med.*, 1923, xxxviii, 233.

[3] Knowles, R., Napier, L. E., and Smith, R. O. A., *Indian Med. Gaz.*, 1924, lix, 593.

vidual drops to serve as control smears for the actual lice injected. The results are summarized as follows:

Striped-Hamster Lice. Twelve lots of lice, taken usually after death, from seven heavily positive striped hamsters were injected into 13 tested negatives. The lots consisted of 7-35 lice each, of all stages from young nymph to adult, and the period from removal to injection was 1 to 26 hours, the lice being kept at room temperature or in an incubator at 22° C.

Results. Positive results were secured in three instances as follows:

(a) Two tested negative hamsters were injected with a suspension of one lot of 35 lice about two hours after removal from carcass. At death after 143 and 193 days respectively autopsies showed both hamsters to be heavily positive. Smears of 35 other lice taken at the same time from the same hamster failed to reveal any Leishmania.

(b) A lot of 15 lice held at 22° C. 24 to 26 hours, were dead but the tissues were still fresh. A tested negative hamster inoculated with these was found to be positive +++ when sacrificed after 265 days. Another hamster was inoculated with a suspension of 21 living lice of the same lot, but since it died after only 32 days the negative findings at autopsy are inconclusive. Smears from the lice actually injected were negative.

(c) A tested negative hamster injected with a lot of 25 lice held 3 to 6 hours, on being sacrificed after 211 days was positive ++++. Control smears of the lice injected were negative.

The other eight hamsters were all negative at autopsy after 28, 34, 138, 206, 261, 297, 297 and 298 days respectively.

Giant-Hamster Lice. Nineteen lots of lice from nine positive giant hamsters were injected into 22 tested negative striped hamsters. The lots consisted of 6 to 42 lice each (average 21) of all stages, and were held at room temperature or at 22° C., six hours or less in five cases, 20 to 30 hours in nine cases and 48 to 72 hours in the remaining four. Control smears, made in all but two cases, were negative.

Results. Three hamsters, still living, were negative on liver puncture after 71, 71 and 78 days respectively. Autopsies of the remaining 19 hamsters were completely negative after 36, 63, 157

and 192 days respectively in five cases, and after 216 to 279 days in the other 14 cases.

Discussion. The failure to find Leishmania in smears of lice from positive hamsters indicates that there is no development of the parasites in the louse, but the positive inoculation results show that at least in the case of the striped-hamster louse the organisms may be present in such small numbers as to escape detection in smears, but nevertheless be capable after two to 26 hours of giving rise to infection when injected into negative hamsters.

II. *Attempts to transmit kala-azar by means of hamster lice.* The method used was to bring into close contact with one another a tested positive and a tested negative hamster, which were naturally lousy, or to which lice were added. Each pair of hamsters was kept in a porous earthen pot with fine sand in the bottom. Muslin tied over the top, with vaseline smeared liberally around the edge of the pot, prevented insects from either entering or escaping. Unfortunately the hamsters could not be left free within the pot because of their cannibalistic habits in captivity. Each pair was confined in a cubical, woven-wire cage, 10 cm. on each side, the animals being separated from one another by a central, vertical partition made of wire window screen. The sand and porous walls absorb any excessive moisture and the accumulation of dry feces and remains of the beans given for food, seem to have no ill effects. The extent to which the lice migrated from one hamster to the other was not determined. That the lice left the hamsters at times was shown by the fact that they were frequently to be found on the sand under the cage, and that in those cases where lice were at first present on only one hamster, they could soon be demonstrated on the other. At any rate, the opportunities for exchange of lice were excellent since in spite of the screen partition the hamsters were kept virtually in contact with one another.

Striped hamster series. A total of 15 tested negatives were kept in pots with lousy positive hamsters until they died or were sacrificed, the periods of time being 24, 30, 78, 90, 145, 158, 210, 233, 235, 264, 276, 286, 295, 308, and 357 days respectively. All were negative at autopsy.

Two tested striped hamsters received each about 75 lice taken from a heavily positive carcass, and were kept separately in earthen pots, there being no exposure to positive hamsters. The

two were sacrificed after 271 days of such isolation and were both found to be negative.

Giant hamster series. A total of ten tested negative giant hamsters were kept in pots with lousy positive giant hamsters. In two cases the animals died and carcasses were decomposed. The other eight at autopsy after 22, 23, 52, 63, 116, 125, 231 and 286 days were found to be negative. The giant hamsters withstood the conditions of the pots much less successfully than the striped hamsters due in large part to their extreme lousiness, which hastened their death.

A tested negative giant hamster received 15 to 20 giant-hamster lice, a few of which had fed on a heavily positive striped hamster. This giant hamster was kept by itself in a pot and at autopsy after 229 days was found to be negative.

Discussion. It is thus seen that there was no demonstrable transmission of kala-azar from lousy positive to negative hamsters kept in close proximity over relatively long periods of time.

Summary. (1) No development of *Leishmania donovani* in the two species of hamster lice studied was demonstrated, but these organisms occasionally survive for a short period in the striped-hamster louse.

(2) Attempts to transmit kala-azar from hamster to hamster by means of hamster lice were completely unsuccessful.

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Attempts to transmit kala azar by means of bedbugs (cimex sp.).

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Since Patton in 1907 demonstrated that *Leishmania donovani* would develop into the flagellate stage and multiply in the intestine of the bedbug, a number of investigators have studied the bedbug as possible vector of both kala azar and oriental sore.

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