Appendix A:
PROBABILITY OF INSECT TRANSMISSION

I. PROBABILITY OF MOSQUITO TRANSMISSION OF HIV, BASED ON HAMSTER ANIMAL MODEL FOR RIFT VALLEY FEVER VIRUS (RVFV):

It is known that inoculation of less than 1 infectious unit of RVFV will infect hamsters 100 percent of the time.

In mechanical transmission experiments, when 10^8 units of virus per ml of blood was present in the first animal and the blood meal completed on a susceptible animal within 1 hour, actual RVFV transmission rates to hamsters by mosquitoes were approximately 15 percent.

Therefore, if $1/10^9$ milliliter (10^{-9}, or 0.000,000,001 ml) of blood had been inoculated, 100 percent of the hamsters would have become infected.

Thus, mosquitoes must have inoculated less than 10^{-9} ml, or approximately 10^{-10} ml of blood during an interrupted feeding.

If we assume that an HIV-infected person has an HIV concentration of 10^3 units per ml of blood (which is about 100 times the concentration usually found in an HIV-infected person without symptoms of disease), the probability of a mosquito that began feeding on an HIV-infected person and completed its feeding on a susceptible person inoculating one unit of virus would be 103/1010, or 10^{-7}, or 1 in 10 million.

(Provided by Char!es Bai!ey, Chief, Department of Arboviral Entomology, U.S. Armv Medical Research Institute, Ft. Detrick, Maryland)

II. PROBABILITY OF BEDBUG TRANSMISSION OF HIV, BASED ON AMOUNT OF BLOOD ON THE MOUTHPARTS OF A BEDBUG:

Volume of blood on bedbug mouthparts = 7×10^{-5} ml

Number of lymphocytes on bedbug mouthparts:

= (number of lymphocytes in blood) x (vol. in bedbug mouthparts)

= (2.5×10^6 lymphs/ml) x (7×10^{-5} ml)

= 175 lymphocytes/bug

(Continued...)

Concentration of virus in HIV-infected person's blood:

serum = usually less than 10 tissue culture infectious doses per ml

lymphocytes = usually about 1 in 1 million (10^{-6})

= (2.5 x 10^{6} lymphs/ml) x (1 x 10^{-6} infected lymphocytes)

= 2.5 tissue culture infectious doses per ml

Total tissue culture infectious dose per bedbug bite:

From serum: 1 to 10

From lymphocytes: 2.5

= (3.5 to 12.5 tissue culture infectious doses/ml) x (7 x 10^{-5} ml)

= *(24.5* to *87.5) x* 10^{-4} tissue culture infectious doses per bite

# of bites required so that at least one bite will transfer 1 tissue culture infectious dose:

= 1/((24.5 to 87.5) *x* 10^{-4})

= 4,082 to 1,143

Therefore, at each bite, there is a 1/1,143 to 1/4,082 chance that 1 tissue culture infectious dose of HIV will be transmitted.

These estimates are based on the assumptions that serum usually contains less than 10 tissue culture infectious doses per milliliter of HIV (54,56) and that only about 1 in 1 million (10^{-6}) lymphocytes are infected (56,63). However, an occasional HIV-infected person has been shown to contain up to 25,000 tissue culture infectious units of HIV per ml (54), and lymphocyte infection has been estimated by others to range from 1 in 1,000 to 1 in 1 million (47), and averaging less than 1 in 10,000 (10^{-4} to 10-5). On the other hand, only 20 to 30 percent of HIV-antibody positive persons have recoverable virus in their serum at any one time (see text).

The volume of blood injected through an accidental needle-stick injury has been estimated at 0.001 ml (10^{-3} ml) (57), and the rate of HIV infection through needle-stick injuries has been estimated at 0.3 percent (1/333)(48,56,75). The volume of blood injected through a needle-stick injury is about 14 times greater than the amount of blood on the mouthparts of a bedbug and 100 times greater than on a mosquito's proboscis (56). Therefore, the risk of infection following a single mosquito transfer would be 0.003 percent (1/33,000), and the risk following a bedbug transfer would be 0.02 percent (1/4,667). The bedbug estimate is similar to the estimates derived above from the amount of blood on a bedbug's mouthparts, when the assumptions are that serum contains less than 10 tissue culture infectious doses of HIV per ml, and that only about 1 in 1 million lymphocytes are infected.

(Modified from estimates provided by Thomas Monath, Director, Division of Vector-Borne Viral Diseases, Centers for Disease Control, Ft. Collins, Colorado)

III. PROBABILITY OF A HORSE FLY TRANSFERRING FROM AN HIV-INFECTED HOST TO AN UNINFECTED HOST DURING INTERRUPTED FEEDING:

When horse flies are interrupted in feeding, they will usually return to the original animal to continue feeding rather than move to another animal. Even when the animals are close together, horse flies move to another animal only about 2 percent of the time (20,37). If we assume that horse flies will move to another host 2 percent of the time if interrupted in their feeding and that horse flies and HIV-infected humans are randomly distributed, what are the probabilities of an uninfected person being bitten by a horse fly that had been feeding on an HIV-infected person when the horse fly was interrupted in its feeding? The probabilities would vary with the prevalence of HIV infection in the target population.

In the first example, the prevalence of HIV infection is 1 percent. If a horse fly first bit an HIV-infected person, the probability of its then completing feeding on an uninfected person would be: 0.01 x 0.99 x 0.02 = 0.000198, or about 1 in 5,000. The probabilities associated with different prevalence rates of HIV infection are also presented.

1 Percent Prevalence of HIV Infection:

Bite #1	Bite #2
1% HIV positive	1°/o HIV + = (0.01 x 0.01 x 0.02) = 0.000002
	99% HIV - = (0.01 x 0.99 x 0.02) = 0.000198
99% HIV negative	1% HIV + = (0.99 x 0.01 x 0.02) = 0.000198
	99% HIV - = (0.99 x 0.99 x 0.02) = 0.0196

5 *Percent Prevalence of HIV Infection:*

Bite #l	Bite #2
5% HIV positive	5% HIV + = (0.05 x 0.05 x 0.02) = 0.00005
	95% HIV - = (0.05 x 0.95 x 0.02) = 0.00095
95% HIV negative	50/0 HIV + = (0.95 x 0.05 x 0.02) = 0.00095
	95% HIV - = (0.95 x 0,95 x 0.02) = 0.018

(Continued...)

10 Percent Prevalence of HIV Infection:

Bite #1	Bite #2
10% HIV positive	10% HIV + = (0.1 x 0.1 x 0.02) = 0.0002
	90% HIV - = (0.1 x 0.9 x 0.02) = 0.0018
90% HIV negative	10% HIV + = (0.9 x 0.1 x 0.02) = 0.0018
	90% HIV - = (0.9 x 0.9 x 0.02) = 0.016

50 *Percent Prevalence of HIV Infection:*

Bite #1	Bite #2
50% HIV positive	50% HIV + = (0.5 x 0.5 x 0.02) = 0.005
	50% HIV - = (0.5 x 0.5 x 0.02) = 0.005
50% HIV negative	50% HIV + = (0.5 x 0.5 x 0.02) = 0.005
	50% HIV - = (0.5 x 0.5 x 0.02) = 0.005

These calculations show that even if the prevalence of HIV infection was 50 percent, if horse flies are interrupted in their feeding, only 5/1,000 of the time would the horse fly have bitten an infected person first and an uninfected person second. The chance of transmitting HIV would be much less, because only 20 to 30 percent of those infected would have HIV in their blood. Furthermore, most bites would involve an insufficient amount of blood to transmit an infectious dose of HIV when in fact the virus was present in the blood of the first person bitten. These probabilities are also only for interrupted feeding and do not account for the times, which would probably be in the (great) majority of cases, that insects did not bite two persons in quick succession.

Appendix B:

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Can the AIDS Virus be Transmitted by Insects?

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