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VECTOR TRANSMISSION OF SCRUB TYPHUS AND CONTROL OF VECTOR MITES

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Summary

Scrub typhus is transmitted by the larvae of trombiculid mites, known as chiggers. Three species, all somewhat habitat specific, are known to be vectors within Malaysia: *Leptotrombidium (Leptotrombidium) fletcheri* are found primarily in the lalang fields; *L (L) deliense* usually occur in forested areas; and *L (L) arenicola* are along sandy beaches. Due to the complex life cycle of chiggers and the types of habitats in which they are found, standard arthropod control practices, such as the application of insecticides, are not practical. However, the personal use of chigger repellants is recommended for personnel entering suspected vector areas.

Long before the true nature of the causative organism of scrub typhus was known, mites were associated with the disease. In Japan, where the disease was first recognized, effigies in the form of the mite were constructed to ward off the mite and thus the disease.[1] The role of chiggers, or larvae of trombiculid mites, in the transmission of scrub typhus has since been documented in numerous publications.

GENERAL CONSIDERATIONS

Mites are arthropods belonging to the class Archnida and subclass Acari.[2] In addition to the mites, the subclass Acari also includes the ticks (order Parasitiformes; suborder Metastigmata). It has been estimated that over a half a million species of mites and ticks exist, and of these less than 10 percent have been described to date. Mites and ticks can be readily distinguished from most other members of the class Archnida by their lack of abdominal segmentation. In other words, their body is comprised of a single body segment (the idiosoma) with legs attached and anteriorly attached mouthparts (the gnathosoma). Within the arachnids only the spiders (subclass Araneae) bear any resemblance to mites and ticks. Spiders can be easily separated, as both the legs and mouthparts are attached to a fused cephalothorax which is attached to the abdomen.

Mites are an extremely diverse group of animals and may be found in virtually every type of habitat. Numerous parasitic mites are involved in the transmission of diseases of both medical and veterinary importance, as well as causing numerous types of allergies. Non-parasitic mites are also known for causing skin irritation and allergenic responses.

Chiggers are the larval stage of members of the family Trombiculidae (order Acariformes; suborder Prostigmata). The vast amount of information available on chiggers has resulted primarily from studies of different medical problems in diverse geographical areas. These include (1) the scrub typhus vectors of Asia, (2) the pest chiggers of man of North and Central America, and (3) the pestiferous "harvest" mite of England and the European continent. The adult trombiculid mites, like most other mites, possess four pairs of legs, but as larvae have only 3 pairs. Chiggers feed parasitically on an animal host only during the larval stage and usually only feed once. They feed with only their mouthparts imbedded in the skin, feeding on digested tissues.

In addition to transmitting scrub typhus, some chiggers, other than scrub typhus vectors, cause extreme irritation when they feed on mammalian hosts. In southeast Asia this condition is often referred to as scrub itch.[3] Recently, a species of chigger in the Northwestern United States has been reported to cause lesions on horses.[4]

VECTOR MITES

The known vectors of scrub typhus are found within a single genus and subgenus of trombiculid mites: *Leptotrombidium (Leptotrombidium).* Although over 150 species of this subgenus have been described from Asia,[5] less

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than 10 are known vectors.[6] Within Malaysia 3 species are known to be vectors, and each is somewhat habitat specific.

Throughout the lalang fields of Peninsular Malaysia, *L (L) fletcheri* is the primary vector.[7] These chiggers can most often be found in the litter under leafy plants interspersed within the lalang.

L (L) deliense is widely distributed throughout Southeast Asia and is found in a wide variety of forest types in Malaysia. Recent studies have shown this species to be the major vector within oil palm plantations (Dohany, unpublished data).

L (L) arenicola has been found along sandy beaches of Peninsular Malaysia,[8,9] but not along rocky shores. This species has not been found along the sandy beaches of East Malaysia,[10] but was recently reported from beaches near Jakarta, Indonesia.[11]

Two primary means of collecting vector chiggers are utilized. The most common is from trapped rodents. The second method is the black plate technique which involves placing black formica or acrylic (10 x 12 cm) plates in suspected chigger habitats.[12] If chiggers are present they can be seen crawling across the plates. This usually provides a single species of chigger per location and provides data as to the specific microhabitat preferences of the chigger. Recently an immunofluorescent technique has been developed to identify infections in chiggers and antigenically characterize the strain(s) of *R. tsutsugamushi* causing the infections.[13] This technique will provide important data on the vector transmission of scrub typhus.

The life cycle of the scrub typhus vector, *Leptotrombidium (L) fletcheri* (formerly *akamushi* in Malaysia) was studied by Neal and Barnett.[14] The life cycle is fairly complicated as compared with most other mites. The egg is deposited by the adult female in the soil or litter. After development the egg splits, leaving an inactive deutovum. The larva emerges from the deutovum, moving onto leaves or grasses to await a host. The larva is the only stage that actively parasitizes a vertebrate animal. Upon becoming fully engorged the larva drops to the ground and develops into an inactive nymphophane afterward emerging into an active nymph. After feeding sufficiently on soft-bodied arthropods, the nymph then develops into another inactive stage, the telieophane. Following this developmental stage, the adult emerges.

Vector chiggers tend to accumulate in small foci termed "mite islands".[15] If the chiggers of such islands are infected with the causative organisms of scrub typhus, the foci are often referred to as "typhus islands". The development of these foci, which may be as small as a square meter, depend upon the availability of suitable micro-habitats and the movement of the rodent hosts. Laboratory studies have shown that an infected adult can produce virtually 100 percent infected offspring.[16] Thus it is possible that a "mite island" producing offspring from a single or a number of infected individuals could contain a high percentage of infected chiggers. Individuals, walking through or resting in such a location, would have a high risk of acquiring the infection. A high percentage of a group of individuals moving single file through scrub or forested terrain as in usually the case, could become exposed by walking through the same mite island.

MODE OF TRANSMISSION

As the larva is the only stage that feeds on a mammal, this is the only time within the life history of the mite when it can transmit or possibly acquire the infection. Feeding normally occurs only once within this stage, and then the engorged chigger drops to the ground to complete its life cycle. Thus, if the chigger is to act as a vector, it must pass the infection through each developmental stage to the adult and then transmit it through the egg to the larvae in the next generation. Stage to stage transmission is termed transtadial transmission, and transmission to the next generation via the egg is termed transovarial transmission.[17] Both forms of transmission have been demonstrated from naturally infected colonies of *L (L) fletcheri*[16] and *L (L) arenicola.*[18] Although transtadial transmission occurs, it has not been possible to demonstrate in the laboratory transovarial transmission in chiggers that have fed on infected rodents. This supports the hypothesis that chiggers may act as reservoirs as well as vectors of *R tsutsugamushi.*

CONTROL MEASURES

As chiggers are found in scrub and forested

habitats over very large areas, an effective control system has been difficult to develop. Chiggers may easily be killed by chemical sprays,[19,20,21] but such control is effective only in limited situations because of the difficulty in using common dispensing methods.

Cultural control methods include clearing of the ground-cover and control of the host animals within a given area.[22] Removal of the ground-cover removes the dwelling places for many of the hosts and allows for drying of the ground, making the habitat unsuitable for all stages of the mite. Harrison[23] concluded that burning grasslands in Malaysia had only a temporary effect in eliminating the habitat of scrub typhus vectors, and that, in fact, it tended to perpetuate the grassland and provide conditions that were actually more favourable to the scrub typhus vector. The removal of the hosts, ie rats, will make an area unsuitable for the chiggers. However, as pointed out by Harrison,[24] the natural hosts should not be replaced by man; otherwise the only thing accomplished by removal of the rodent host is a possible increase in the chances of man being infested with the chiggers and, in turn, an increased chance of acquiring scrub typhus.

Currently the only practical means of controlling scrub typhus in personnel entering highly endemic areas is through the use of chigger repellants. For this purpose benzyl benzoate and mixtures of toluamides have proven effective.[25,26,27] These repellants, which actually are effective killers of the chiggers, are applied by either impregnating clothing or spraying around the ankles, waist and other openings of clothing before an individual goes into a suspected chigger-infested area. Repellants, although effective, are often not acceptable as they are relatively expensive, require frequent application, have an oily consistency and often an offensive odor.

CONCLUSION

The chiggers which serve as vectors of scrub typhus are widely distributed in multiple habitats throughout the endemic area. The complexity of their life cycle combined with their wide distribution make control difficult. Current recommended procedures for prevention of chigger bites, and thus prevention of scrub typhus, emphasise the use of personal protective measures including chemical repellants.

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