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Research Article

Scrub Typhus: Vector Surveillance and its Control

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A B S T R A C T

Scrub Typhus is an important emerging vector borne disease being reported now in many parts of the country. This is also known as Chigger Borne Typhus or Tsutsugamushi Fever. Scrub Typhus is caused by bacteria called *Orientia tsutsugamushi* and is transmitted to people through bites of infected chiggers (larval mites). Recently, it has been reported in the state of Mizoram on wide scale. However, the states of Rajasthan, Jammu & Kashmir, Vellore, Sikkim, Nagaland & Manipur, Mizoram, Tamil Nadu, Maharashtra, Kerala, Himachal Pradesh and Meghalaya have also reported cases of scrub typhus. Scrub typhus is an infectious disease that is transmitted to humans from field mice and rats through the bite of mites that live on the animals. This is a rural disease occurring preferentially in spring and in autumn. Scrub Typhus is an occupational health concern for farmers, park rangers, military personnel, geologist, miners as well as oil palm workers. The life cycle of the *trombiculid* mite is very complex. The duration of mites' life cycle depends on species and environment, but normally last 2 to 12 months. Trombiculis mites go through a life cycle of eggs, larva, nymph and adult. Mites have a very patchy distribution over small areas because of their special requirements. The nymphs and adults need certain soil conditions for their survival and development while the larvae require host animals, such as wild rats, other small rodents and birds. Suitable habitats are found in grassy fields, shrubby areas, forests, abandoned rice fields and cleared forests. An attempt has been made to describe the tools for mite surveillance and the possible methods of vector control.

Keywords: Chiggers, *Trombiculid*, Mite, Scrub Typhus, Surveillance, Chigger Index

Introduction

Scrub typhus is a vector-borne zoonosic infection caused by *Orientia tsutsugamushi*, which is transmitted to humans by the bite of infected chiggers (larvae) of *trombiculid* mites.[1] The name "tsutsugamushi disease" was given by Hashimoto in 1810.[2] The tsutsugamushi triangle is home to more than half the world's population,[3] with 2 billion at risk and 1 million cases of scrub typhus occurring per year.[4] Scrub typhus is not transmitted directly from person to person; it is only transmitted by the bites of vectors.[5] The vector responsible is the chigger of the *trombiculid* mite belonging to the genus *Leptotrombidium*, but recently newer vector genera have been discovered that are capable of transmitting this agent. Tilak et al reported that *Schoengastiella ligula* (northeast India) transmitted *O. tsutsugamushi* in tea-garden workers,[6] while Lee et al discovered this agent could be transmitted by *Euschoengastia koreaensis* in South Korea.[7] Knowledge

of the vector, including species, distribution, density, and habitats, is important to understand the epidemiology of scrub typhus in a given area or region.[8] Vector activity is related to temperature, rainfall (climate), land use (ecology), and various socioeconomic factors.[9,10] An increase in vector density contributes to increased transmission, due to more humans being bitten by infected chiggers.

Scrub typhus is an infectious disease that is transmitted to humans from field mice and rats through the bite of mites that live on the animals. Scrub typhus can occur in areas where scrub vegetation consisting of low-lying trees and bushes is encountered, and also in habitats as diverse as banks of rivers, rice fields, poorly maintained kitchen gardens,[11] grassy lawns which can all be inhabited by chiggers.[12] The chiggers (too small to be seen by the naked eye) feed usually on rodents and accidentally on humans. This is a rural disease occurring preferentially in spring and in autumn.

Epidemiological Situation

Scrub Typhus, also known as Chigger Borne Typhus or Tsutsugamushi Fever is a disease caused by bacteria called *Orientia tsutsugamushi*. Scrub Typhus is spread to people through bites of infected chiggers (larval mites). Rickettsial diseases have been documented in India since the 1930s with reports of scrub typhus from Kumaon region,[13] in soldiers during the Second World War in Assam[14,15] scrub and murine typhus from Jabalpur area in Madhya Pradesh[16] and of murine typhus from Kashmir.[17]

About one million human cases occur each year and an estimated one billion people are at risk of this disease.[18-20] There are considerable differences in virulence and antigen composition among individual strains of *O. tsutsugamushi* and has many serotypes (Karp, Gillian, Kato and Kawazaki). Among the different life stages of *trombiculid* mites, only larvae are parasitic, with rodents as the primary hosts and humans as the accidental hosts; nymphs and adults are free living in the soil, feeding mainly on arthropods.[21,22] Larval *trombiculid* mites (so called chiggers) are thus of significant medical importance because of their potential for transmitting scrub typhus to humans. Identification of chigger species is particularly fundamental for the evaluation of human risks because only a subset of chigger species, (mostly the genus *Leptotrombidium*[23,24] *a*re responsible for transmitting scrub typhus.

In India, Scrub typhus has been reported from Rajasthan, Jammu & Kashmir, Vellore, Sikkim, Nagaland & Manipur, Mizoram, Tamil Nadu, Maharashtra, Kerala, Himachal Pradesh and Meghalaya. In an entomological study in Himachal Pradesh, vector species *Leptotombidium deliense* and *Gahrliepia spp*. were recorded. As a medical casualty producer in some areas during the Asiatic-Pacific operations, 1941-1945, this disease was second only to MALARIA and was more dreaded by the men (Philip, 1948).

During 2016, a total of 304 cases and 3 deaths were reported from the states of Arunachal Pradesh, Gujarat, Mizoram and Rajasthan (Maximum in Rajasthan-257 cases & 1 death). During 2017, scrub typhus cases were reported from 7 states i.e. Assam, Maharashtra, Manipur, Nagaland, Rajasthan, Sikkim and Tripura (Maximum in Sikkim-29 cases and 2 deaths). During 2018, a total of 628 cases and 8 deaths were reported i.e. Mizoram (467 cases and 2 deaths), Puducherry (94 cases), Maharashtra (63 cases and 6 deaths).

Signs and Symptoms

The main symptoms of the disease are fever, a wound at the site of the bite, a spotted rash on the trunk, and swelling of the lymph glands. A papule develops at the site of inoculation. The papule ulcerates and eventually heals with development of a Black Eschar. General symptoms are sudden onset of fever [>40°C (104°F)] with relative Bradycardia, severe headache, apathy, myalgia, generalized Lymphadenopathy, photophobia and a dry cough. Approximately one week later, a spotted and then maculopapular rash appears first on the trunk and then on the extremities and blenches within a few days. Complications are interstitial pneumonia (30% to 65% of cases), Meningo encephalitis and Myocarditis. Symptoms generally disappear after two weeks even without treatment. In severe cases with pneumonia and myocarditis, the mortality rate may reach 30%.

Incubation Period: 1-3 weeks.

Transmission

Scrub Typhus infection is transmitted to humans through the bite of infected *Leptotrombidium* mites' larvae (chiggers). The vector mites inhabit sharply demarcated areas in the soil where the micro ecosystem is favourable (mite islands). Human beings are infected when they trespass into these mite islands and are bitten by the mite larvae (chiggers). The mite feeds on the serum of warm-blooded animals only once during its cycle of development, and adult mites do not feed on man. The microbes are transmitted transovarially in mites. Scrub typhus normally occurs in a range of mammals, particularly field mice and rodents. The typical vector *L. deliense* is generally found associated with either established forest vegetation or secondary vegetation after clearance of forest areas. This species is generally abundant on grasses and herbs where bushes are scarce. It can also be transmitted through unscreened blood transfusions and unhygienic needles. It does not spread from person to person.

Risk Factors

Travellers undertaking outdoor activities such as visiting

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farms, camping, backpacking, hunting, archaeological digs or participating in eco-tourism are at risk of getting bitten by chiggers. Scrub Typhus is an occupational health concern for farmers, park rangers, military personnel, geologist, miners as well as oil palm workers. The presence of Scrub Typhus is related to increasing deforestation and urbanisation. It typically occurs during the rainy season but can be present throughout the year.

transmit Scrub Typhus. The disease is closely associated with the distribution of *Leptotrombidium deliense* group of mites which have wide distribution in India. The disease is transmitted by *Trombiculid* mites, also called as Chiggers belonging to the *Leptotrombidium deliense* group.

Trombiculid mites pass through four stages of life cycle i.e. eggs, larva, nymph and adult. The larval mites feed on

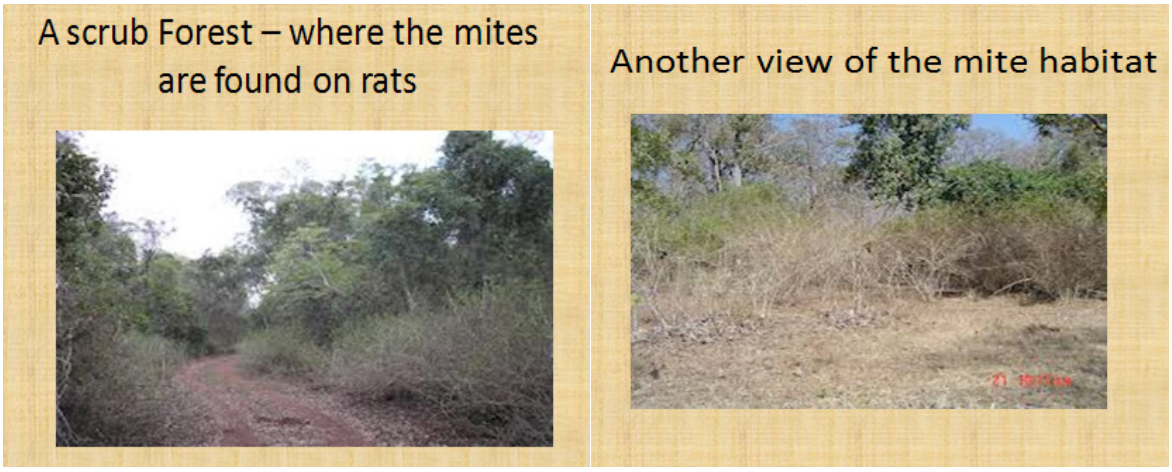

Figure 1.Habitats for Rodents/ Mites

Trombiculid Mites

Mites are of medical and veterinary importance in three ways: 1. Through transmission of pathogenic agents either as *Vectors* or as *Intermediat*e Hosts, 2. By causing dermatitis or other tissue damage directly. 3. Through loss of blood or other tissue fluids. An infestation of mites is called *ACARIASIS.*

History

*Trombiculid*ae, from Greek ("to tremble") and Latin culex, gen. culicis ("gnat" or "midge"), was first described as an independent family by H. E. Ewing in 1944. But, references to chiggers go as far back as sixteen century China, and by 1733, the first reorganization of trombuculid mites in North America were made. In 1758, Linnaeus described a single species *Acarus batatas* (Now *Trombicula batatas*). However, most information about chiggers came from the problems arose during and after World War II.

*Trombiculid*ae is a family of mites called *trombiculid* mites (also called berry bugs; harvest mites; red bugs; scrub-itch mites and in their larval stage, chiggers). They live in the forests and grasslands and also found in low, damp areas vegetations. They are most numerous in early summer when grass, weeds and other vegetations are in abundant. Mites' are minute animals and barely visible to the naked eye. They are found virtually worldwide. There are over 29,000 species of mites, but only a few of them attack humans. They are medically important because certain species the skin cells, but not blood, of animals including humans. The six-legged larva feeds on a large variety of animals i.e. rabbits, rodents, animals including human beings. They do not actually bite but form a hole in the skin called a stylostome and chew up tiny parts of the inner skin which causes severe irritation and swelling.

After feeding on host, the larvae drop to the ground and become nymphs, then mature into 8 legged adults and harmless to humans.

Chiggers *(Trombiculid Mites)*

This is the common chigger or "red bug." Its bite causes an intense itching and infection can result from scratching the bites. In the Asiatic-Pacific area, certain species of this mite are vectors of scrub typhus.

Mites infect man, horse, goat, sheep, cattle, dog etc. They are very tiny about 0.1-2.0 mm, oval in shape and pale to greyish in colour. Adult possess 8 stubby legs while larvae are 6-legged. Eyes are absent. Mouth parts are piercing and sucking type. Some species burrow in skin and make galleries or wounds which causes intense itching. Later, fluid-filled pimples are formed which are covered with scabs. These contain abundant mites and are the chief sources of infection by contact. Host may lose hairs due to infection. Like ticks, they have eight legs and a body with little or no segmentation. In most species there are eggs, larval, nymphal and adult stages. The immature stages are similar to the adults but smaller (Figure 2).

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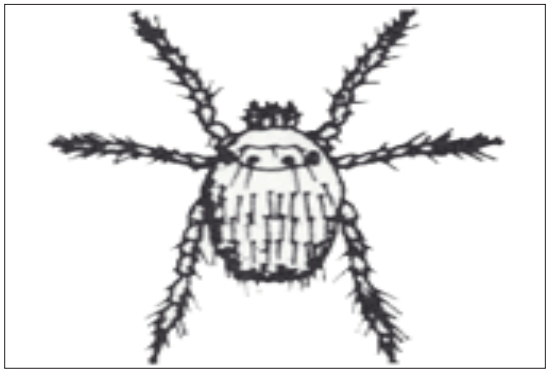

Figure 2.Adult *Trombiculid* mite

Life Cycle of *Trombiculid* Mite

The life cycle of the *trombiculid* mite is very complex. The duration of mites' life cycle depends on species and environment, but normally last 2 to 12 months. Trombiculis mites go through a life cycle of eggs, larva, nymph and adult. Females lay eggs singly in the soil. Eggs are round in shape and laid 15 eggs per day. The eggs are dormant for 6 days, after which the non-feeding pre-larvae emerge, with only three pairs of legs.

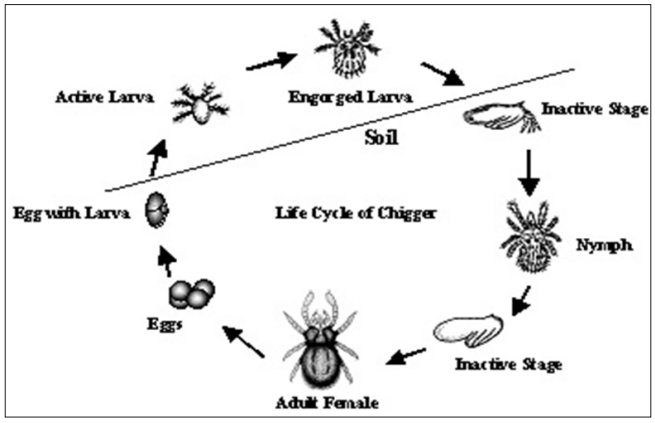

Figure 3.Life cycle of *Trombiculid* mite

The larval stage is the only parasitic stage of the mites' life cycle. They are parasites to many animals. The larval mites feed on the skin cells, but not blood, of animals, including humans. In about 2 weeks, the six-legged larva hatches and crawls into nearby vegetation or along the ground in search of a host. Many species feed on a wide variety of vertebrate hosts including reptiles, rodents, large mammals and humans. The larva feeds at the surface of the host skin, usually requiring 1 to 3 or more days for engorgement. The larva remains attached to a suitable host for 3-5 days before dropping off to begin its nymph stage. Then, the fully fed larva drops off the host, burrows into soil, and molts to an eight-legged nymph. Chiggers do not like sunlight or humidity. During the wet season, chiggers are usually found in tall grass and other vegetations. During dry season, chiggers are mostly found underneath brush and shady areas.

Once the larva has engorged itself on the skin and has fallen off its host, the larva develops to its nymph stage. Like the larva, the nymphs are also sexually immature, but more closely resemble the adult. This stage consists of three phases; the protonymph, deutonymph and tritonymph respectively. The protonymph and the tritonymph morphology are unusual in species of *Trombiculid*ae. The protonymph phase combines larval and protonymph characteristic with deutonymph and tritonymph morphology. The protonymph is an inactive transition stage. The active deutonymph develops an additional pair of legs for a total of eight). Lastly, it re-enters inactivity during its transitional tritonymph phase before growing to adulthood.

The nymph and later the adult feed on immature stages of other arthropods, frequently the eggs of grasshoppers. Chigger larvae, the only medically important stage, do not disperse far from the point they hatched in their search for a host (Figure 3). Thus, they tend to be much clumped in distribution, forming what are referred to as "chigger islands," in areas of tall grass, weeds, and brushy vegetation.

Mites have a very patchy distribution over small areas because of their special requirements. The nymphs and adults need certain soil conditions for their survival and development while the larvae require host animals, such as wild rats, other small rodents and birds. Suitable habitats are found in grassy fields, shrubby areas, forests, abandoned rice fields and cleared forests. The mites are also found in parks, gardens, lawns and moist areas alongside lakes and streams. The larvae wait on leaves or dry grass stems until an animal or human pass by. People usually become infested after walking or standing in mite-infested areas. Bamboo bushes are favoured by the mites in the tropics and subtropics. The main differences between ticks and mites are elaborated in table 1.

Treatment

Anti-itching ointments containing benzyl benzoate is often recommended to reduce itching. Hydrogen peroxide and capsaicin cream has also been quite effective. The most effective way of removing chiggers is by washing the affected areas with warm water and soap.

Mite Surveillance

Mites can be surveyed using the "black plate" method. The "black plates" (~12-inch square) dark-coloured construction paper, paper plates, rigid plastic, or similar objects) are placed on the ground in mite habitat such as grassy or brushy areas with high rodent populations. The mites are primarily rodent parasites and run around in these areas when not feeding on the rodents. Plates should be placed directly on the ground or ground cover. The plates have no particular attraction for the mites, but they crawl randomly on the plates and can be seen against the dark surface (Figure 3).

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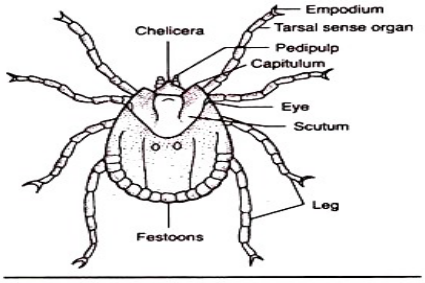
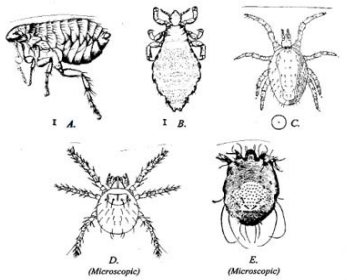
Table 1.Differences between ticks and mites

S. No.	Ticks	Mites
1.	The tick can be seen with the naked eye and are generally 1 mm long, but can expand up to 3 cm in length after feeding	Mites are microscopic creatures that are generally less than a mm and are difficult to see with the naked eye
2.	All of them are parasitic	Some of them free living and others are parasitic on plants
3.	Ticks have short hair or none at all on their bodies	Mites have long hairs on their bodies.
4.	Covered by scutum	Scutum not present and the skin is leathery
5.	Armed hypostome	Not armed hypostome
6.	Lay its egg on the ground in cracks or under the rocks	Lay its eggs in tunnels at the site of infection on the body of the host
	 Fig. 15.11: Tick (Dorsal view)	

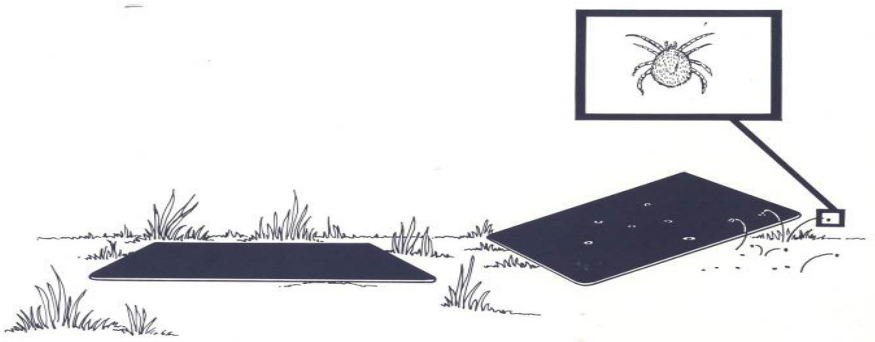


Figure 4.An illustration of the black plate method of sampling mites

The plates should be deployed for no more than one hour. Upon retrieval, examine both sides of the plates for small (smaller than a pin head), rapidly moving white, yellow, orange or red spots.

A hand lens or magnifying glass is useful for seeing the mites. Observed mites can then be removed with a small camelhair (or similar) brush and place in alcohol for subsequent identification. Mites may be removed from an inflexible surface by wetting a small paint brush in alcohol, touching it to the mite, and then dipping the brush with the adhered mite into a vial of alcohol. The mite will float free in the alcohol. If construction paper or other flexible material is used, roll in a cone, place the small end of the cone over the vial and tap sharply. Mites will fall into the vial.

Another efficient method of sampling chigger is to trap their rodent hosts and examine them for the presence of these mites. Chiggers are usually yellowish or orange and concentrated in the ears or in the groin area of their hosts. The density of chigger on a host species is evaluated in terms of Chigger index, which represents the average number of chiggers per host individual examined and may be calculated by the following formula.

$$\text{Chigger Index} = \frac{\text{Total Number of chigger collected}}{\text{Total number of hosts examined}}$$

The chigger index has relevance to the presence of vector *trombiculid* mite i.e. *Leptotrombidium deliense* gp.

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Chigger Index of ≥0.69 (Critical Value) is an Indicator for implementation of vector control measures.

Outbreak Investigation

During outbreaks, there is need to investigate the index case and the mode of transmission validating with the vector population at that point of time. The clustering of cases shall indicate the presence of infected vector population in that particular area. Investigating the outbreak of Scrub Typhus, two important parameters need special attention:

- Total No. of confirmed cases
- Chigger Index

These two parameters are to be correlate with respect to the time of the year when cases occur. The chigger index has relevance to the presence of vector *Trombiculid* mite i.e. *Leptotrombidium deliense* group. Mite collection should be made both from domestic and wild situations as per the method described earlier.

Chigger index (no. of chiggers infested a single host) necessary for a single case of scrub typhus to occur in a month was estimated to be 0.69 chigger per *Suncus murinus* and 0.68 chigger per *Rattus* spp. It is therefore essential index of 1 may be taken as critical value necessary for the occurrence of single case of Scrub Typhus.

Vector Control

Prevention

Chiggers are commonly found on the tip of blades of grasses to catch a host, so keeping grass short and removing the brush and wood debris, where potential mites' hosts may live can limit their impact in an area. Sunlight that penetrates the grass will make the lawn drier and make it less favourable for chigger survival.

Chiggers seem to affect warm covered areas of the body more than drier areas. Thus, the bites are often clustered behind the knees. Areas higher in the body can be easily affected in small children. Application of repellents are useful to avoid the chigger bites.

Dusting sulphur is used commercially for mites' control and can be used to control chiggers. Dusting of the shoes, socks and trouser legs with sulphur can be highly effective in repelling chiggers.

Community Awareness

Awareness should be provided among the community, especially in endemic areas regarding mite borne diseases. A variety of agencies can be contacted to obtain information or speakers for the training of medical, pest management, or other personnel. Additional educational methods include: making brochures, pamphlets and fact sheets available for in-processing personnel; publishing periodic notices in the installation newspaper or plan of the day, particularly warm months and the fall hunting season; and posting warning signs in tick-infested woods or other areas frequented by troops, hunters or hikers.

Personal Protection

- Proper clothing should be used to limit access of ticks to the skin, thereby helping to prevent bites.
- Pants should be tucked into the boots or socks, and the shirt should be tucked into the pants.
- Avoiding sitting or lying on scrubby areas.
- Avoiding hanging clothes on scrubs or trees.
- Disinfesting your pets regularly.
- Long sleeves will help, and a hat will be useful if crouching or crawling in bushes or undergrowth. Light-colored clothing should be used to make ticks much easier to detect.
- Repellents like DEET 33% (N, N-diethyl-m-toluamide or N, N-diethyl-3-methylbenzamide), Permethrin should be used to prevent tick bites. These repellents provide protection for up to 12 hours, depending on environmental conditions. It should be applied in a thin film over exposed skin surfaces, according to label directions.
- Permethrin should be applied to the lower pant legs, crotch, waistband, shirt sleeves, collar, front placket and lower edge of shirt never to skin.
- Permethrin aerosol contains 0.5% permethrin should be sprayed liberally, to the point of dampness, over the entire outside surface of the uniform.

Environmental Management

- Where acceptable, clearing of edge habitats by leaf litter removal, mechanical brush control, and mowing or burning vegetation are effective means of tick and mites' control in residential areas and certain recreational areas.
- Removal of low-growing vegetation and brush eliminates the structural support that ticks need to contact hosts, thereby reducing the incidence of tick attachment.
- Removing leaf litter and underbrush also eliminates tick habitats and reduces the density of small mammal hosts, like deer mice and meadow voles.
- Mowing lawns and other grassy areas to less than 6 inches (16 cm) greatly reduces the potential for human-tick contact.
- When environmentally acceptable, controlled burning has been shown to reduce tick abundance for six months to one year.
- Another habitat modification technique is to thin early successional shrubs and grasses in early to mid-fall, stressing the overwintering tick population and reducing survivability. This should be done late enough in the season that regrowth does not occur.

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Chemical Control

Essentially involve clearing of vegetation allowing the area to dry for a few weeks and then being sprayed with malathion specially when outdoor camping of troops etc. are to be chigger bites repellents can be used before venturing for activity inside forest areas.

Conclusion

Scrub Typhus, also known as Chigger Borne Typhus or Tsutsugamushi Fever is a disease caused by bacteria called *Orientia tsutsugamushi*. Scrub Typhus is spread to people through bites of infected chiggers (larval *Trombiculid* mites belonging to the *Leptotrombidium deliense* group. *Trombiculid*ae is a family of mites called *trombiculid* mites (also called berry bugs; harvest mites; red bugs; scrub-itch mites and in their larval stage, chiggers). They live in the forests and grasslands and also found in low, damp areas vegetations. They are most numerous in early summer when grass, weeds and other vegetations are in abundant. The mites are primarily rodent parasites and run around in these areas when not feeding on the rodents.

Prevention from the chigger bites can be ascertained by personal prophylactic measures, environmental management, community awareness and chemical control in the areas of heavy infestations of the chiggers.

Conflict of Interest: None

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