On the Mode of Dissemination of the Two-Spotted Spider Mite, Tetranychus telarius (L.) (Acarina: Tetranychidae)¹

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In a recent paper Fleschner et al. (1956) review the literature on dispersal of tetranychid mites by air currents and present the results of original research on these four species: *Metatetranychus citri* (McGregor), the citrus red mite; *Oligonychus punicea* (Hirst), the avocado brown mite; *Eotetranychus sexmaculatus* (Riley), the six-spotted mite; and *Tetranychus telarius* (L.), the two-spotted spider mite.

These authors found that the first three species listed above behaved similarly in regard to dissemination by air currents. As mite populations on infested trees reached high levels or peaks, large numbers of adult females were observed to spin down from leaves and hang freely suspended in air, each by a single silken filament. The mites were then disengaged from the trees and dispersed by gentle to moderate breezes, often to heights much greater than the trees, with the silken filaments presumably acting much like parachutes and imparting considerable lift to the mites. It was noted that the main direction of mite dispersal was sometimes contrary to that of the prevailing winds. This was particularly true of the avocado brown and six-spotted mites, which were studied in an area where the gentle nocturnal breezes—in this case the dispersing currents—blew in the opposite direction of the strong diurnal winds and where spinning down of the mites occurred in the early evening when the air was relatively still. An important conclusion of the authors was that more dispersion of mites, in the case of the three species under consideration, is accomplished by gentle air currents than by strong winds as a result of the mites' habit of spinning down only during relatively calm atmospheric conditions. Moreover, wind-drift dispersal appeared to be limited to adult females.

The findings of these authors regarding the two-spotted spider mite are limited to the statement that "in no instance was this mite observed to spin down free from the leaves or to drift away from the infested plant."

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Experiments on the mode of dispersal of *telarius* were conducted in Hawaii by the present author from November 18, 1955, to June 4, 1956. Observations presented here agree with those of Fleschner *et al.* that *telarius* does not spin free of the infested plant on silken filaments, but they strongly indicate that this species is normally disseminated by wind. They also furnish good evidence that stronger wind currents are necessary to transport *telarius* than those species that spin down—perhaps because the parachute-like filament is lacking—and that wind drift is not limited to the adult female.

The species studied here agrees well with all the characters listed by Boudreaux (1956) for *T. telarius* (L.) except for the color of the adult summer female, which appears invariably to be carmine as in *cinnabarinus* (Boisduval).

Terminology used here regarding plant infestation by *telarius* is as follows: an uninfested plant is one entirely free of mites; an incipient infestation is the presence of a small number of mites of any stage on one or two leaflets of a plant or hill; and a heavily infested plant is one with more than half of its leaves bearing mites.

**Terrestrial Migration**

*Laboratory experiments*

An experiment was performed indoors to determine whether or not *telarius* migrates from plant to plant by crawling over non-plant surfaces. An uninfested, potted, bush-bean plant was brought indoors, and a single leaflet was infested artificially by placing several adult females on it. Six days later, eggs and motile young were present on the infested leaflet in good numbers. At this time, a piece of white cardboard some 18 inches square was perforated in the center with a hole of approximately the diameter of the plant stem and was slit from this hole to the perimeter of one side. The cardboard was fitted around the plant, with the stem passing snugly through the center and the pot supporting the board. A strip of Scotch tape was then applied along the entire length of the slit to obtain a smooth union of the board there. In order to ensnare any mites attempting migration from the plant, "Tree Tanglefoot" was applied to the board as a half-inch-wide band in a large circle around the plant, and the enclosed area beneath the plant was divided into a number of small, closed areas by similar sticky bands. A single 100-watt lamp with reflector was placed a few inches above the plant to provide light for photosynthesis.

Subsequent daily observations over a period of several weeks failed to reveal evidence of mites migrating from the bean plant. One or two mites were occasionally found on the board beneath the plant, but these seemed to have accidentally fallen off the plant. Some of them were dead, and some were entrapped near the middle of the sticky bands, which, in itself, indicated that they had fallen onto the material, for "Tree Tanglefoot" is such a viscous substance that mites remain permanently ensnared where they first
contact it. Observations were continued until all of the leaves on the plant were dead and began to drop. On a few of the more heavily infested and nearly dead leaflets mites congregated into spherical masses some 3 to 5 mm. in diameter at the leaflet apices. They bound themselves together with silken filaments in such masses and finally died in this condition. No mites were observed to spin free of the plant at any time. By the time leaves were dead and fell onto the board below, most mites on them were dead. Few mites were observed to crawl away from leaves after they had fallen, even though some mites actively crawled along leaflets and petioles for several hours before dying.

While the two-spotted spider mite thus does not appear to migrate from plant to plant via the terrestrial route, it does, of course, migrate from leaf to leaf via petioles and stems on a given plant or from one plant to another where these have their foliage in contact. But this foliar migration apparently occurs only under certain environmental conditions or at special times during the mite's life cycle. In the experiment on terrestrial migration described above, the plant was originally infested artificially by placing ten mature females on different portions of a single leaflet. Within a few hours all had migrated to the lower (abaxial) surface of the leaflet and had congregated in a small area approximately 15 mm. in diameter. Here they remained in close association until many eggs had been laid and many of these had hatched. Only after the nymphs had begun to move freely over the lower surface of the leaflet did the surviving adults do likewise to any extent. No migration to the adjacent two leaflets of the same leaf or to other leaves on the plant occurred until some of these first-generation progeny had become adults and most of the remainder deutonymphs. At this time the leaflet was heavily infested and migration happened all at once. The lamp above the plant was turned on one morning at the usual eight o'clock, and migration began within a few minutes. The mites scurried along petioles and stems to other leaves and within 4 hours had infested all the leaves on the plant by thus moving from the single originally infested leaflet.

Observation of numerous other incipient infestations, both natural and artificial, in the laboratory and in the field, indicate that these peculiarities of behavior are normal for telarius. Adults tend to band together on newly infested leaves or leaflets possibly because they benefit from each other's webbing. And perhaps their progeny experience a gradually increasing stimulus to migrate as a result of food shortage or "population pressure" and are eventually stimulated to action by a sudden increase, or approach to the optimal, in temperature and/or light.

**Field experiments**

Tests conducted on terrestrial migration in the field were simple and produced negative results. Stems of infested plants were ringed basally with
"Tree Tanglefoot," and microscope slides coated with the same material were placed flat on the ground, sticky-side upward, beneath infested plants to trap any mites dropping from above. Daily observations failed to reveal mites trapped on the plant stems, but a few were caught on the slides. These latter, however, appeared in all cases to have been dislodged from the plant by rain, wind, or possibly by insects.

**Wind Dissemination**

*Laboratory experiments*

Brief experiments were performed indoors to test the likelihood of wind dissemination of *telarius* in nature. An upright frame was constructed of \( \frac{1}{2} \times 1 \)-inch boards slotted with a saw at an angle of 45° on their facing surfaces so that 30 microscope slides could be suspended in 3 vertical rows of 10 slides each. Slides coated on their upper surfaces with "Tree Tanglefoot" and inserted in this frame were held with their lengths in the horizontal plane and their widths tilted at an angle of 45°. When loaded with slides the apparatus gave much the appearance of a Venetian blind adjusted to the half-open position, with each slat composed of 3 slides placed end to end (except for the supporting frame members separating them by \( \frac{1}{4} \) inch). The lowermost slides were suspended 3½ inches and the uppermost 18 inches above the base of the frame.

The slide-loaded frame was placed on a table along with a potted, heavily infested, bush-bean plant and a 12-inch electric fan. These three objects were oriented to allow the fan to blow a current of air around and through the infested plant directly toward the frame, with the coated slide surfaces in the latter deflecting the air current upward. The distance between the frame and the center of the plant was 3 feet, and that between the center of the plant and the fan blades was 4 feet. The fan was regulated to deliver a moderate breeze to the plant and allowed to run for 30 minutes under room conditions of 81° F. and "average" fluorescent lighting from the ceiling. The 30 slides were then examined by means of transmitted light under a binocular dissecting microscope. A single mite was found on a slide in the second row below the top of the frame.

Another test was made immediately. The distance between the frame and the center of the plant was reduced to 28 inches and that between the center of the plant and the fan blades to 34 inches so that the fan delivered a stiff breeze or light wind to the plant. The fan speed and room conditions remained as before and the same plant was used. After 1 hour of fan operation the slides were examined as before. Five slides were found to have trapped a total of 15 mites of both adult and immature stages, 2 to 6 mites being stuck to each slide. It thus appeared probable that moderate to heavy winds could disperse *telarius* in the field.
Field experiments

Field plots were set up at the Waimanalo Experimental Farm on windward Oahu to investigate wind dissemination of *telarius* in nature. This area receives gentle to moderate, occasionally strong, trade winds, which come directly off the ocean from the northeast and remain rather constant throughout the year. This characteristic of relatively constant wind from one direction seemed to be ideal for the experiments contemplated. Moreover, the mild Hawaiian climate allows the production of many truck crops like beans the year around, and it was decided to conduct field experiments during the cooler and wetter months when natural infestations of *telarius* are at a low level in Hawaii and less likely to contaminate artificially infested field plots.

Three plots were set up. Each plot consisted of three 50-foot rows of Wade bush beans. The rows were 4 feet apart, and each row contained approximately 60 hills of beans spaced 10 inches apart, with generally 2 plants 1 to 2 inches apart in each hill. All three plots were laid out in an east-west direction and were thus so oriented that the prevailing northeasterly wind intersected the rows at an angle of about 45°. It was planned to initiate an infestation at the center of the middle row of one plot and along the entire middle row of another plot. Observations would then be made as often as necessary to record the progress of the infestation over each plot in relation to wind direction.

Five plantings were made on the three plots between November 18, 1955, and June 4, 1956. These were rotated to prevent contamination of an infestation in one plot by that of another. Of the five plantings and subsequent infestations initiated, however, only two were carried through to completion because of storms that destroyed one planting and insect pests that destroyed two others. (One of these was destroyed by the nocturnal, leaf-eating adult of *Adoretus sinicus* Burmeister, the Chinese rose beetle; the other was ruined by larvae of *Hylemyia cilicrura* (Rondani), the seed-corn maggot, which killed exactly 50% of the young plants as they emerged from the soil.)

One of the plantings on which experiments were successfully concluded was of the type in which a single hill near the center of the middle row was infested. The plants at this time were of such age that the first trifoliate leaf on each was approaching full size. In this case it was found necessary to protect the infested hill against storms to prevent eradication of the developing population. Consequently, a miniature greenhouse was constructed of an orange crate, with a waterproof, translucent cover of plastic-coated wire screen over the sloping top and south side. This was firmly secured over the artificially infested hill and an adjacent uninfested hill and allowed to remain in place for eight weeks—until the mites had undergone five or six generations and the originally infested hill bore a very heavy population. After the greenhouse was placed over the 2 hills, 28 days passed before mites were detected on the originally uninfested hill. This delay in the spread of mites from the
infested to the uninfested hill was apparently attributable to restriction of air movement around the two hills to convection currents and light breezes, the latter caused by some wind entering the ventilation openings in the greenhouse. Moreover, on the day when the greenhouse was removed, incipient infestations were discovered on three plants immediately adjacent to the originally infested hill on the west side and on one hill in the southernmost row at a point directly down wind from the originally infested hill.

After removal of the greenhouse from over the two hills, the progress of the infestation over the plot was observed to bear a close relation to the direction of the prevailing wind, i.e., toward the southwest. The infestation immediately began spreading to the west along the middle and southernmost rows. Although the infestation did progress eastward (partially up wind) along the two rows, this movement was much slower than that to the west. The northernmost row also became incipiently infested one to two weeks later at several points, but the mites were likely carried there by reverse gusts of wind during mild storms which occurred in this period. Hills were spaced far enough apart in the rows to prevent contact between plants even at maturity; thus no direct migration from hill to hill via foliage could occur. When the planting finally matured and died, most of the plants (approximately 80%) were mite infested, and nearly all of the uninfested plants were in the northernmost, or windward, row.

During the course of this experiment, tests were also made with sticky microscope slides. These tests were made immediately after the greenhouse was removed from the originally infested hill. Twenty-four slides were coated with tanglefoot and fastened with thumbtacks to 10 slender wooden stakes 18 inches long. The stakes were then placed upright in the soil in a semicircle on the leeward side of the infested hill at distances of from 10 to 36 inches from it. After an exposure of 48 hours the slides were examined microscopically, and, although a rain had splashed soil on the coated surfaces, they were nevertheless found to have trapped six mites. The experiment was immediately repeated, with an exposure period of 24 hours without rain. Examination revealed that 20 of the 24 slides had trapped a total of 153 mites. This included all motile stages, in approximately equal numbers, and three eggs as well. The count per slide ranged from 1 to 48; and those slides closest to, and most directly down wind from, the infested hill yielded the largest counts.

Results of the second successful field planting were similar to those of the first. In this case, however, the entire middle row was infested by transferring mites to a single leaflet of a first trifoliate leaf in each hill. One week later, incipient infestations were discovered in the south or down-wind row, and within another week both the middle and south rows began to show considerable mite damage. Incipient infestations were discovered in the north or up-wind row at this time, but at the time of maturity and death of the
planting some weeks later the north row still contained several uninfested
hills.

Interestingly enough, field investigations on dissemination of tetranychid
mites by wind were made by E. E. Munger of Yuba City, California, more
than half a century ago (reported by Stabler, 1913). Munger worked with an
unidentified species, but it appears to have been one of those that spin down
from foliage on silken filaments and are then blown about by air currents.
Munger exposed sheets of fly paper at various heights and distances from an
infested almond orchard and trapped many specimens at a height of 50 feet
and a distance of 650 feet from the orchard.

Conclusions

The evidence that the two-spotted spider mite is normally disseminated by
wind seems incontrovertible. This species, however, does not spin down from
foliage on a silken filament as do those discussed by Fleschner et al. (1956);
thus its dispersal probably requires much stronger air currents and likely
occurs more slowly, especially in the absence of strong winds, than in the
case of those species that spin a silken filament with a parachute-like effect:

Two additional aspects of tetranychid dissemination seem worthy of con
sideration and remain to be investigated. These are possible dispersal by rain
splash and possible egg dispersal by insects. If tetranychids are dispersed by
rain splash at all it is probably only for extremely short distances, except
perhaps when rain is accompanied by heavy wind. Dispersal of spider mite
eggs by insects (accidental phoresy) seems especially likely to occur. For
certain tetranychids, including telarius, spin a webbing of fine silken fila
ments over themselves on leaf surfaces and regularly suspend their eggs on
such threads. It is difficult to visualize an insect walking over such a leaf
without picking up a certain amount of webbing and eggs on its body or
appendages, or its failure to leave some of the these eggs on other leaves
visited, especially if the leaves be somewhat pubescent.

Summary

Experiments were conducted both in the laboratory and in the field to
determine whether Tetranychus telarius (L.) is disseminated by wind or com
monly migrates overland between host plants.

Laboratory experiments demonstrated that telarius will increase to a heavy
population on a bean plant, kill the plant or hasten its death, and then die on
the plant or its fallen leaves without any attempt to migrate therefrom.
Indoor experiments also showed that air currents generated by an electric
fan at moderate speed could carry individual mites from an infested bean
plant to adhesive-coated microscope slides 3 to 4 feet distant.
Field experiments showed that the spread of a mite infestation from a given locus within a bean plot occurred in direct relation to the direction of the prevailing wind; i.e., the infestation advanced relatively fast in the direction of the wind and much more slowly against the wind, the latter being probably due to reverse gusts. Moreover, as many as 48 mites, of all stages, were trapped on individual sticky microscope slides held vertically within 3 feet and down wind of infested plants in the field.

It is suggested that experiments be done to test the possibility of tetranychid dissemination by rain splash and the dissemination of tetranychid eggs by insects.

References

