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The Weaving Pattern and Structure of the Guy Ropes in Citrus Red Mite, *Panonychus citri* (McGregor) (Acari: Tetranychidea)

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Abstract: The pattern of weaving by guy ropes in association with egg stalk was observed under scanning electron microscope in *Panonychus citri* (McGregor). The egg stalk was vertical having a base of 15.5 µm wide and its length was 146 µm. Initially few guy ropes extended from the tip of the stalk to the leaf surface of host plant. The ropes rolled up to 125 µm on the stalk tip and were stretched towards the surface. Several thin ropes combined together to form strong strand. The ropes were roughly surfaced and possessed granular materials. The development of new net was accomplished with further extension of thinner ropes, which were twisted over the thicker ones and pasted on the leaf. Mites used adhesive material for the fixation of threads on the leaf as well as for webbing. The thick guy ropes were segregated before sticking on the leaf surface. The surface of the leaf was covered with adhesive, which was invisible. Several ropes overlaps the hatching egg vertically and horizontally.

Key words: Adhesive, egg stalk, fixation, guy rope, webbing

Introduction

The first spider mite was described as 'telarus' the weaver or spinner. This also refereed to the other terms which has similar meanings (Gerson, 1985). They spin their silk from spinneret representing an evolutionary phenomenon. Mites and pseudoscorpions have modified salivary glands, which prodt4e webs (Hazan *et al*., 1975). There are few species and a handful of families in a single order of mites the Prostigmata - web. It can be argued that the acarine spinning has been evolved from that of the pseudoscorpions. The amino acid of spider mite and pseudoscorpion silk was similar in composition (Tiedt and Ueckermann, 1996).

Several members of the families Bdellidae, Camerobiidae and Cheyletidae cover their eggs with webs (Avidov *et al*., 1968; Wallace and Mahon, 1972; Bolland, 1983). This is also the only known spinning activity of *Tenuipalpoides dorychaeta,* a member in the primitive tribe Tenuipalpoidini in the sub-family Tetranychinae (Singer, 1966). *Aponychus corpuzae* Rimando and *Eurytetranychus japonicus* Ehara are two primitive tetranychids whose webbing revolves around the eggs. The main function of this webbing is probably to protect eggs from mite predators, which are voracious egg feeders (Saito, 1983). *Tetranychus cinnabarinus* (Boisduval) revealed a very close correlation between estimated amounts of webbing and numbers of eggs deposited (Hazan *et al*., 1974). By comparing hatching percentages between eggs left in the webbing and eggs removed a slight but significant decline was found in the latter at low and high relative humidifies (Hazan *et al*., 1975). Gerson and Aronowitz (1981) and Penman and Chapman (1983) observed pesticide-induced spin down of *T. cinnabarinus and T. urticae,* respectively. This may enhance mite dispersal well.

P. citri produces several generations in summer and increased population rapidly. It took about two weeks to complete life cycle. Citrus red mite lays eggs on Satsuma mandarin leaves (Jeppson, 1989). There are several reports about the ecology of leaves, reproduction and control of *P. citri* while the information on the structure and pattern of webbing is lacking. The present experiment was conducted to elucidate the webbing pattern and the structure of the guy ropes in *P. citri* on Satsuma mandarin leaves under scanning electron microscope.

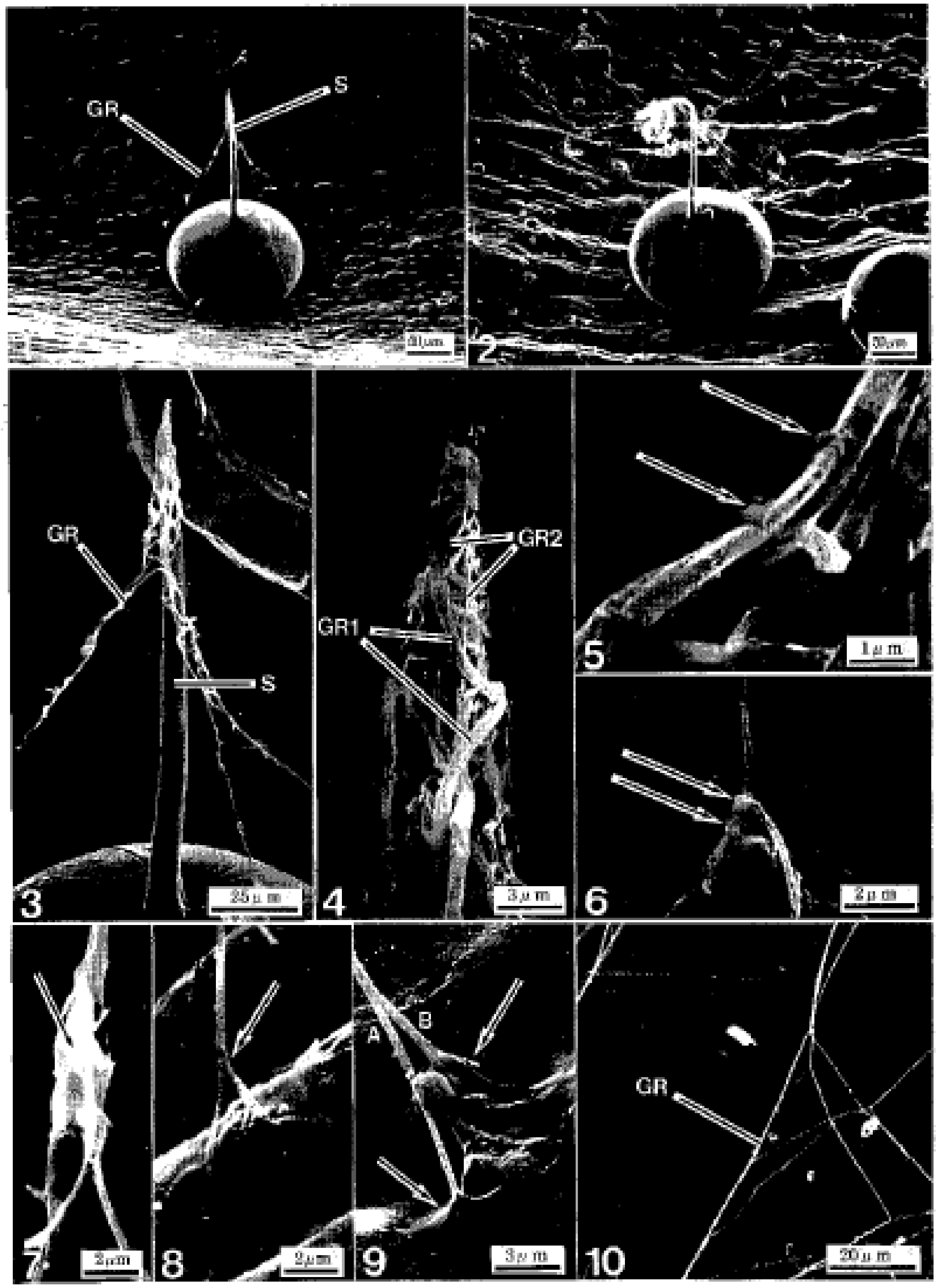
Materials and Methods

The experiment was conducted in the Citriculture Laboratory, Faculty of Agriculture, Ehime University, Japan. The leaves of citrus plants occupied by several citrus red mites and eggs were collected. Initiation of webbing was observed under the stereoscope and the leaves were cut into 3 mm pieces around the egg.

Samples were pre-fixed in 4% glutaraldehyde in 0.1 M phosphate buffer in pH 7.2 for 48 hours, followed by rinsing in the same buffer and were post-fixed in 1% osmium tetroxide for 1 hour. Dehydration was carried out with a graded ethanol series and were dried in a Vacuum Device Inc., VDF-20 freeze dryer, Dried samples were mounted on the specimen stubs, coated with gold using Eiko Engineering Co., LTD., 19-2 ion sputter and finally were viewed under Hitachi S-2250N Scanning Electron Microscope at 20 kV and photographed.

Results

The webbing pattern of guy ropes and their structures secreted by *P. citri* were clearly observed under scanning electron microscope. Initially only few guy ropes (GR) were found which gradually spread on the egg stalk (S) to cover the egg (Fig. 1). The stalk was about 15.5 µm wide at the base and 146 µm long (Fig. 1). With the passage of time the spinning activity increased and at maturity of egg it reached the highest level. The stalk bent and highly stretched with guy ropes. These ropes covered the egg completely from their top up to the leaf surface (Fig. 2). Mite started secreting of silk on the top of the egg stalk (5) and few guy ropes (GR) extended towards the leaf surface (Fig. 3). The threads curled, became thinner and spread irregularly. The ropes rolled up to 125 µm and stretched to the surface of the leaf (Fig. 3). At the stage of maturity the tip of the stalk was invisible due to the presence of densely rolled, thick (GR1) and thin (GR2) guy ropes (Fig. 4). The twisting of thread was not in regular pattern. The ropes stretched from the lower portion (Fig. 4). Thicker ropes were formed by the combination of many thinner threads. The thinner threads were twisted and fixed



Figs. 1-10: Scanning electron micrographs showing the formation and structure of guy ropes on Satsuma mandarin leaves by *Panonychus citri* (McGregor). 1: Initiatial spinning of guy ropes (GR) extending from the stalk (S). 2: Net formation by highly stretched ropes on the leaf. 3: Extension of the guy ropes (GR) from the top of stalk (S). 4: Thick and thin guy ropes (GR1, GR2) twisted on the terminal part of the stalk. 5: Thicker ropes formed by the twisting thinner ones and using granular material (arrow). 6: New net formation started with twisting thin ropes on thick rope (arrow). 7: Adhesive substances applied for joining several threads (arrow). 8: Newly fixed guy rope (arrow) on the leaf spreading sticky material. 9: The ropes separated (A, B) for its fixation on the leaf depositing thick layer of sticky substance (arrow). 10: The hatching egg protected with strongly formed net of guy ropes (GR)

with the sticky material. The ropes had rough surface and two granular bodies were found on it (Fig. 5). The formation of new net was initiated by twisting thinner silk on the thick ropes (arrow) (Fig. 5). These small ropes gripped the big ropes and were fixed on the leaf surface (Fig. 6). The mite deposited huge amount of sticky materials for the connection of several thinner ropes (arrow) (Fig. 6). They further stretched to the leaf for strengthening (Fig. 7). The thick rope again divided (arrow) and attached to the leaf surface using pasty material. The leaf surface was invisible due to presence of this material (Fig. 8). In other cases the thick ropes (A and B) were attached to the leaf with abundance of adhesive (arrow) substances (Fig. 9). This adhesive substance was mounted on the surface of the leaf (Fig. 9). The hatching egg was extensively covered with the guy ropes (GA) (Fig. 10), The thicker ropes were connected with the thinner ones to make a protective net around the hatching eggs. They were stretched in vertical and horizontal axis of the egg (Fig. 10).

Discussion

Guy ropes web the eggs of *P. citri* poorly. Eggs of nearby weavers are invariably covered by webbing (Saito, 1983). One of the functions of webs would be the regulation of humidity in the immediate vicinity of eggs (Hazan *et al*., 1975). In contrast, we found that the spinning phenomenon was slower on the freshly laid eggs and increased with the maturity of eggs. Finally all eggs were completely covered with the guy ropes. The silk spun by male surrounds the molting nymphs as a form of territoriality. During intra specific fights between waiting males they may apply strands of silk to the mouthparts and legs of their opponents, forcing them to withdraw (Potter *et al*., 1976). We postulated that the guy ropes were used for, the anchoring of eggs with the host leaves and protection of the hatching eggs from the predators. The threads serve as 'lifelines' throughout the mites' lives on their host plants (Saito, 1979). These 'lifelines' are used by blown-off or dispersing mites, as the threads taken up by winds and the animals drift along in the air streams (Fleschner *et al*., 1956). In our study, we found thick and thin ropes, The thicker threads extended from the top of the stalk and divided before fixation with the host leaves. This could be the balancing mechanism of webbing.

Spider mites may form silk ropes in greenhouses when leaving heavily infested plants (Hussey and Parr, 1963). Mites concentrate at the upper plant apices to form a silken ball, and when they start dropping off, they spin threads, which thicken as more and more mites descend (Hussey and Parr, 1963). Less roping took place under saturation conditions as compared to somewhat lower relative humidifies (Hussey and Parr, 1963). Our experiment revealed that *P. citri* weaves the guy ropes around the laid egg area. Mite used adhesive materials to provide strength to the fixed threads. The ropes were sparsely spread at the hatching stage.

The eggs were deposited under the webs. The emergent larvae and nymphs spin likewise. Consequently, a canopy of silk formed on the substrate. This canopy increased as the mite family become abundant, which served as a nest to live in the colony (Foott, 1962). The amount of silk spun depends on various factors, which include humidity, temperature, substrate smoothness and species of host plant (Hazan *et al*., 1974; Saito, 1977). In contrast, we found that the eggs were laid on the leaf and the spinning activity was presumed to cover and protect. It was increased by the interval of time. Gerson and Aronowitz (1981) reported that seven host plant species elicited seven different spinning patterns from *T. cirtnabaririus* under similar conditions. Although most silk was produced by mites feeding on the best host, and least on the worst, the amount of webbing spun on the intermediate plants appeared to be affected by other unknown factors. Finally, spinning is not necessarily dependent on feeding, as starving females were observed to produce much silk (Hazan *et al*., 1974). Similarly, we found *P. citri* was a pest of citrus plants and its spin production was rapid. The hatching eggs were covered by the silken threads.

In conclusion, *P. citri* spin gradually on the egg up to the hatching stage. The webbing was formed using the thicker and thinner threads. These ropes were twisted and fixed applying sticky materials on the leaf surface for strong holding of eggs.

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