Poster Session | Others (including the category of JSAM and SASJ)
[6-1130-P] Other Categories (6th)
Fri. Sep 6, 2019 11:30 AM - 12:30 PM Poster Place (Entrance Hall)

[6-1130-P-16] Behavioral Study of Vibrational Sensitivity in Whitefly

*Yasuhiko Nishijima[1], Koichi Mizutani[1,2], Tadashi Ebihara[1,2], Naoto Wakatsuki[1,2], Kenji Kubota[3], Hiroyuki Uga[4]
(1. Graduate School of Systems and Information Engineering, University of Tsukuba(Japan), 2. Faculty of Engineering, Information and Systems, Division of Engineering Interaction Technologies, University of Tsukuba(Japan), 3. Agriculture Research Center, National Agriculture and Food Research Organization(Japan), 4. Saitama Prefecture Agriculture Research Center(Japan))
Keywords: whitefly , vibrational sensitibity, mating behavior

Whiteflies are major pests that damage a wide variety of plants such as tomatoes and cucumbers. Whiteflies suppress the growth of plants and reduce crop quality by acquisition feeding. Furthermore, they carry various viruses such as tomato yellow leaf curl virus (TYLCV) and cucurbit chlorotic yellows virus (CCYV). For this reason, control of whiteflies is an urgent matter for farming. The current control method is spraying pesticides. However, whiteflies acquire pesticide resistance early because it performs a generation cycle within one month. For example, *Bemisia tabaci* (biotype Q) has high resistance to most pesticides. Hence, the development of a new technology to control whiteflies is required. Focusing on the behavior of whiteflies, it has been reported that they communicate using leaf substrate-borne vibrations by oscillating their abdomens in their courtship behavior. Besides, our research group has clarified that their courtship behavior can be controlled by applying the artificial vibration of 200-1500 (Hz). However, the effective amplitude of artificial vibration has not been clarified yet. Hence, in this paper, we clarify the vibration sensitivity of whiteflies by experiments. The experimental condition is as follows. *Bemisia tabaci* (biotype Q1) (five males and five females) were released in a rectangular plastic case of approximate size 60×60×100 (mm^3). The case has a hole with a diameter of 41 mm at its top and is covered with perilla leaf. The leaf was vibrated with various amplitudes (vibrational amplitude: 1.0, 0.6, and 0.3 μm), and the number of courtship behavior was measured by analyzing video recorded by the camera (FDR-AX45/SONY). The experiment was performed twice (each is for 1.5 hours) at each amplitude in an anechoic chamber. During this experiment, the temperature was 27-31 °C, and the humidity was 27-39 %. From experiments, we found that ratio of the number of mating behavior to that of courtship behavior is small (0 %) when vibration amplitude is 1.0 µm, although that is large (about 30 %) when vibration amplitude is 0.6 µm or less. Hence, we found that the sufficient amplitude of artificial vibration is about 1.0 µm. This result can be expected to contribute to the development of novel whitefly control technology.

Behavioral Study of Vibrational Sensitivity in Whitefly

Yasuhiko Nishijima[1], Koichi Mizutani[1,2*], Tadashi Ebihara[1,2*], Naoto Wakatsuki[1,2], Kenji Kubota[3], Hiroyuki Uga[4]

[1] Graduate School of Systems and Information Engineering, University of Tsukuba

[2] Faculty of Engineering, Information and Systems, University of Tsukuba

[3] Agriculture Research Centre, National Agriculture and Food Research Organization

[4] Saitama Prefecture Agriculture Research Centre

*mizutani@iit.tsukuba.ac.jp

ABSTRACT

Whiteflies are major pests that damage a wide variety of plants such as tomatoes and cucumbers. The current control method is spraying pesticides. However, whiteflies acquire pesticide resistance early because it performs a generation cycle within one month. Hence, the development of a new technology to control whiteflies is required. Focusing on the behavior of whiteflies, our research group clarified that their courtship behavior can be controlled by applying the artificial vibration of 200-1500 (Hz). However, the effective amplitude of artificial vibration has not been clarified yet. Hence, in this paper, we clarify the vibration sensitivity of whiteflies by experiments. Specifically, *Bemisia tabaci* (biotype Q1) were released on a perilla leaf in a rectangular plastic case. The leaf was vibrated with various amplitudes, and the number of mating behavior was measured by analyzing video recorded. As a result, we found that the sufficient amplitude of artificial vibration is about 1.0 μm.

Keywords: Whitefly, *Bemisia tabaci*, Mating behavior, Vibration sensitivity

1. INTRODUCTION

Whiteflies (*e.g.*, *Bemisia tabaci* and *Trialeurodes vaporariorum*) are major pests that damage a wide variety of plants such as tomatoes and cucumbers (Azab *et al*., 1970; Zhang *et al*., 2005; Martin *et al.*, 2007). Whiteflies suppress the growth of plants and reduce crop quality by acquisition feeding and emitting a honeydew to the plants (Matsui, 1992; Nelson, 2008). Furthermore, they carry various viruses such as tomato yellow leaf curl virus (TYLCV) and cucurbit chlorotic yellows virus (CCYV). TYLCV and CCYV are one of the most well-known tomato and cucumber infecting begomoviruses transmitted by *Bemisia tabaci*, and they cause severe economic loss worldwide (Navot *et al*., 1991; Czosnek *et al*., 1997; Jones, 2003). For this reason, control of whiteflies is an urgent matter for farming.

To control whiteflies, various tactics –such as physical barriers (*e.g.*, insect screen), chemical controls and biological controls (Matsuura *et al*., 2005; Kodandaram, 2018; Nomikou, 2001, 2002, 2010)– have been considered. Focusing on physical barriers, it has been clarified that an insect screen with mesh size of 0.4 mm can efficiently reduce the entrance of whiteflies, in exchange for increasing difficulty regulating temperature of the greenhouse due to limited air flow (Mihara *et al*., 2005). Focusing on chemical controls, numbers of chemical pesticides have been proposed, However, whiteflies quickly develop resistance to chemical pesticides (Wardlow *et al.*, 1972) and *Bemisia tabaci* (biotype Q) has high resistance to popular pesticides now (Horowitz *et al*., 2005). Focusing on biological controls, *Nesidiocoris tenuis* and *Typhlodromips swirskii* have been found to become a biopesticide of whitefly. However, *Nesidiocoris tenuis* has a risk to damage the plants (Nakaishi, 2013), and *Typhlodromips swirskii* is not livable on the plants that discharge sticky secretions such as tomatoes (Sakamoto, 2012). Hence, current control techniques have both advantages and disadvantages, and innovative combination of control techniques are necessary to achieve effective pest management. Furthermore, development of a new technology to control whiteflies can contribute to broaden pest management.

Focusing on the behavior of whiteflies, Kanmiya (1996) has reported that they communicate using leaf substrate-borne vibrations by oscillating abdomens in their courtship behavior. Furthermore, the communication signal of whiteflies has been found to be unique to each species and biotype (Kanmiya *et al.*, 2002; Nakabayashi *et al.*, 2017). This means that the communication of whitely play an important role in mating behavior, considering the fact that hybrid of different species or biotype remains rare (Matsuura, 2010). Hence, we may control the mating behavior of whiteflies by applying artificial vibration on the leaf. As preliminary study, we have clarified that their courtship behavior can be controlled by applying the artificial vibration of 200-1500 (Hz) (Nishijima *et al.*, 2019). However, the effective amplitude of artificial vibration has not been clarified yet. Hence, in this paper, we clarify the vibration sensitivity of whiteflies by experiments.

2. MATERIALS AND METHODS

In this study, we put whiteflies on a perilla leaf, vibrate the leaf at specific amplitude, and observe the behavior of whiteflies. The test was performed in a laboratory with the temperature and humidity of 25-31°C and 27-39%, respectively. We used adult whiteflies (*Bemisia tabaci*, biotype Q1) of 5 pairs (5 males and 5 females, collected from a colony) for the test. The whiteflies were put on the underside of a perilla leaf, and the leaf was put on a rectangular plastic case of size 60×60×100 (mm^3), as shown in Figure 1. The leaf was set to cover a hole of the case (diameter: 41 mm) so that the whiteflies can be monitored from the bottom of the case using a video recorder (FDR-AX45/SONY). Also, a polypropylene sheet was placed between the leaf and the case to keep the whitefly within a field view of the camera. To capture the behavior of the whiteflies clearly, the underside of the leaf was illuminated by a desk light. The leaf was vibrated artificially, and its vibration was monitored by a laser Doppler vibrometer (LDV) (AT2300 and AT3700, Graphteck). During the test, the leaf was vibrated artificially (vibrational direction: vertical for surface of leaf), and a behavior of the whiteflies was monitored for 1.5 hours. The test was conducted by changing the vibrational amplitude [maximum amplitude of 1.0, 0.6, 0.3 and 0 (μm)], and the test was repeated twice at each amplitude. We then analyze the video and count the number of "mating success" and "mating failure". Note that the mating behavior of whiteflies consists of three steps; (1) searching a female, (2) forming a pair (close contact with female) and (3) mounting (males overlap his hips with hers and shack his wings rapidly) (Kanmiya, 1998). Hence, we define the following labels could count each occurrence;
(a) Mating success: mounting is clearly observed after pair forming.
(b) Mating failure: mounting is not observed (they get a divorce after pair forming).
(c) Unknown: mounting is not clearly observed after pair forming (*e.g.*, they form a pair continuously.

Figure 2 shows a flowchart to perform labeling from the video, where *Np, Ns, Nf, Nu* are the number of pair forming, mating success, mating failure, and unknown, respectively, and "Ratio of *Ns*" represents *Ns* per *Np* (%).

3. RESULTS AND DISCUSSIONS

The experimental results are shown in Table 1. From the table, we couuld observe pair forming (*Np*) in each trial. However, it was found that the ratio of successful mating (ratio of *Ns* in the table) becomes 0 when the vibrational amplitude of the leaf is 1.0 μm, while the ratio of successful mating increases 28-35 (%) when the ampltude is 0-0.6 μm. This means that the effective amplitude of the artificial vibration to control the mating behavior of whiteflies is more than 1.0 μm.

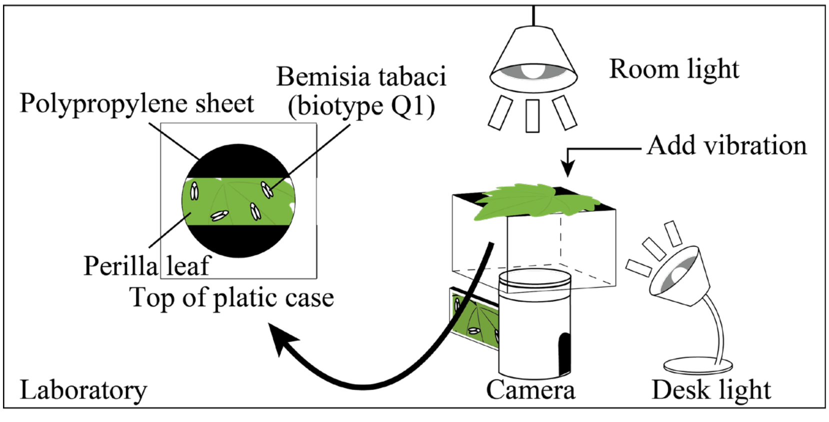
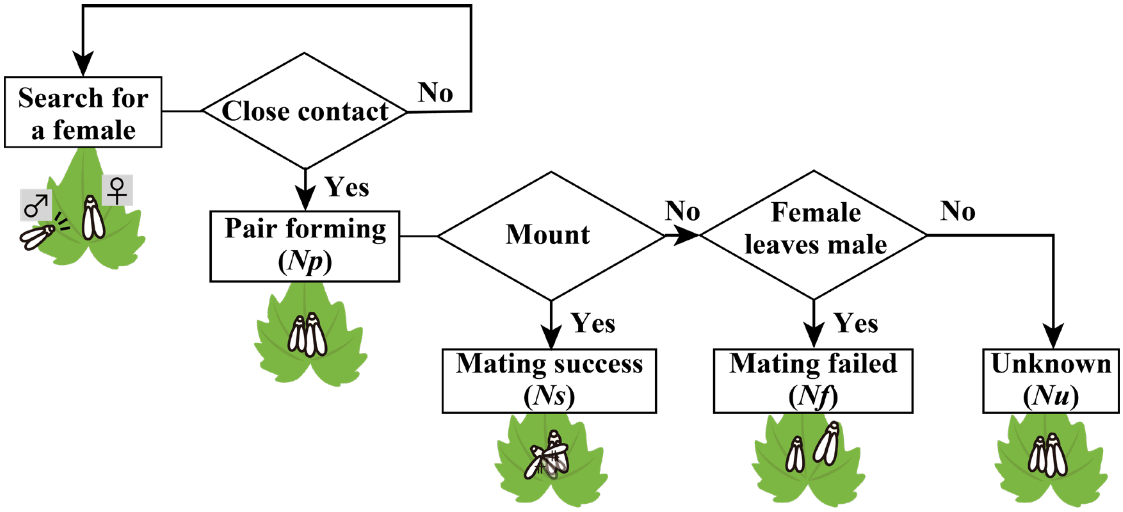


Figure 1. Overview of experimental system



※ $Np = Ns + Nf + Nu$

Figure 2. Determination method of mating behavior

Table 1. Numbers of pair forming and Mating under various amplitudes

Amplitude	Trials	*Np*	*Ns*	*Nf*	*Nu*	Ratio of *Ns* (%)
1.0 μm	①	11	0	9	2	0
	②	10	0	8	2	0
0.6 μm	①	3	1	1	1	33
	②	7	2	3	2	28
0.3 μm	①	19	6	12	1	31
	②	14	5	8	1	35
0 μm	①	3	1	1	1	30
	②	6	2	2	2	30

4. CONCLUSIONS

Control of whiteflies that cause severe economic loss is an urgent matter for farming. Focusing on the behavior of whiteflies, our research group clarified that their courtship behavior can be controlled by applying the artificial vibration of 200-1500 (Hz). However, the effective amplitude of artificial vibration has not been clarified yet. Hence, in this paper, we clarify the vibration sensitivity of whiteflies by experiments. The whiteflies (*Bemisia tabaci*, biotype Q1) of 5 pairs (5 males and 5 females, collected from a colony) were put on the underside of a perilla leaf. Also, the leaf was vibrated artificially (vibrational direction: vertical for surface of leaf), and a behavior of the whiteflies was monitored for 1.5 hours. The test was conducted by changing the vibrational amplitude [maximum amplitude of 1.0, 0.6, 0.3 and 0 (μm)], and the test was repeated twice at each amplitude. As a result, it was found that the ratio of successful mating becomes 0 when the vibrational amplitude of the leaf is 1.0 μm, while the ratio of successful mating increases 28-35 (%) when the ampltude is 0-0.6 μm. Hence, the effective amplitude of the artificial vibration to control the mating behavior of whiteflies is at least 1.0 μm. This result can be expected to contribute to the development of novel whitefly control technology.

ACKNOWLEDGMENT

This work was supported by Cabinet Office, Government of Japan, Cross-ministerial Strategic Innovation Promotion Program (SIP), “Technologies for creating next-generation agriculture, forestry and fisheries” (funding agency: Bio-oriented Technology Research Advancement Institution, NARO)

REFERENCES

Azab, A. K., M. M. Megahed and H. D. El-Mirsawi. 1970. On the range of host-plants of Bemisia tabaci (Genn.)(Homoptera: Aleyrodidae). *Bulletin de la Societe Entomologique d'Egypte*, 54: 319-326.

Czosnek, H. and H. Laterrot. 1997. A worldwide survey of tomato yellow leaf curl viruses. *Archives of virology*, 142(7): 1391-1406.

De Barro, P. J., S. S. Liu, L. M. Boykin and B. A. Dinsdale. 2011. Bemisia tabaci: a statement of species status. *Annual review of entomology*, 56: 1-19.

Jones, D. R. 2003. Plant viruses transmitted by whiteflies. *European Journal of Plant Pathology*, 109(3): 195-219.

Kanmiya, K. 1996. Discovery of M-ale Acoustic Signals in the Greenhouse White-fly, Trialeurodes vaporariorum (WESTWOOD) (Homopetera: Aleyrodidae). *Appl. Entomol.Z-ool*, 31(2): 255-262.

Kanmiya, K. 1998.Mating Behavior and Vibratory Signals on Whiteflies. *Japan Plant Protection Association*, 52(1): 17-22.

Kanmiya, K. and R. Sonobe. 2002. Records of two citrus pest whiteflies in Japan with special reference to their mating sounds (Homopetera:Aleyrodidae). *Entomol.Zool*, 37(3): 487-495.

Kodandaram, M. H., B. A. Rai and B. Singh. 2018. Efficacy of newer and neonicotinoid insecticides against whitefly Bemisia tabaci on vegetables. *Indian Journal of Entomology*, 80(3): 559-562.

Martin, J. H. and L. A. Mound. 2007. An annotated check list of the world's whiteflies (Insecta: Hemiptera: Aleyrodidae). *Zootaxa*, 1492(1): 1-84.

Matsui, M. 1992. Irregular Ripening of Tomato Fruit Caused by the Sweetpotato Whitefly, Bemisia tabaci (GENNADIUS) in Japan. *Jpn. J. Appl. Entomol. Zool.* 36: 47-49.

Matsuura, A. 2010. Hybridization possibility and difference in ability to produce pumpkin silverleaf between Q and B biotypes of Bemisia tabaci (Gennadius)(Homoptera: Aleyrodidae). *Kyushu Pl. Prot. Res.* 56: 72-76.

Matsuura, A., M. Tamura and S. Shima. 2005. Relationship between mesh size of insect-proof nets and invasion prevention effect for the silverleaf whitefly. *Kyushu Pl. Prot. Res.* 51: 64-68.

Mihara, J and T., Ishida. 2005. Influence of insect control netting and roof shading of raising seedling house on the growth of tomato plants. *Kyushu Okinawa Agricultural Research Center* 67(144): 671-676.

Navot, N., E. Pichersky, M. Zeidan, D. Zamir and H. Czosnek. 1991. Tomato yellow leaf curl virus: a whitefly-transmitted geminivirus with a single genomic component. *Virology*, 185(1): 151-161.

Nakaishi, K. 2013. Study of ecology of Nesidiocoris tenuis (Reuter) and Campylomma chinense Schuh, and practical evalation of those mirid stinkbugs as a biological control agent. *Special bulletin of the Kochi Agricultural Research Center*, (13): 1-51.

Nakabayashi, H., K. Mizutani, T. Ebihara, N. Wakatsuki, H. Uga, K. Kubota and M. Ishii. 2017. Biotype identification of Bemisia tabaci by acoustical method. *Journal of Agricultural Informatics (ISSN 2061-862X)*, 8(3): 11-22.

Nelson S. 2008. Sooty mold. *Honolulu (HI), University of Hawaii.* 6. (Plant Disease; PD-52).

Nishijima, Y., K. Mizutani, T. Ebihara, N. Wakatsuki, K. Kubota, H. Uga. 2019. Verification of Whitefly's Vibration Sensitivity (in Japanese), *Spring Conference of the Society of Agricultural Structures*: 12, P-27.

Nomikou, M., A. Janssen, R. Schraag and W. M. Sabelis. 2001. Phytoseiid predators as potential biological control agents for Bemisia tabaci. *Experimental & applied acarology*, 25(4).

Nomikou, M., A. Janssen, R. Schraag and W. M. Sabelis. 2002. Phytoseiid predators suppress populations of Bemisia tabaci on cucumber plants with alternative food. *Experimental & applied acarology*, 27: 57-68.

Nomikou, M., W. M. Sabelis and A. Janssen. 2010. Pollen subsidies promote whitefly control through the numerical response of predatory mites. *Biocontrol*, 55(2): 253-260.

Sakamoto, S., Y. Sakamaki, S. Oosako and K. Tsuda. 2012. Effects of trichomes and glandular trichome exudates of cultivated tomato on survival of the predatory mite, Amblyseius swirskii. *Kyushu Pl. Prot. Res.* 58: 59-65.

Tokumaru, S and Y. Hayashida. 2010. Pesticide Susceptibility of Q-biotype Bemisia tabaci (Hemiptera: Aleyrodidae). *Jpn. J. App l. Entomo l. Zool.* 54: 13-21.

Wardlow, L. R., B. A. F. Ludlam and N. French. 1972. Insecticide resistance in glasshouse whitefly. *Nature*, 239(5368): 164.

Zhang, L., W. Zhang, G. Zhang, Z. Liu, Q. Wang and H. Yan. 2005. Investigations on the host plants of {\sl Bemisia tabaci} and evaluation on their occurrence in Shanxi Province. *Plant Protection*, 31(1): 24-27.