Testing of Security Steel Mesh on Mosquito Prevention

Yaowaluk Chanbang*

Department of Entomology and Plant Pathology, Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200, Thailand

**Corresponding author. E-mail: yaowaluk.c@cmu.ac.th*

ABSTRACT

Using screen doors and windows is one of common environmentally friendly insect control measures as an alternative to insecticide use. The objective of this study is to evaluate the effectiveness of security steel mesh produced for screen doors and windows against dengue fever mosquito, Aedes aegypti (Diptera: Culicidae). In experiment 1, the test arena composed of the 2-partition cage separated with 4 types of the steel mesh count: per inch: 14x17 (normal screen), 16x16, 11x10.5 and 8x8 openings with the weft and warp wire at diameter of 1.8 mm. Mosquitoes were released in one side of insect cage, the other side was empty. The result showed that mosquitoes could not penetrate through all steel mesh except on 8x8 openings, with 0.58% of mosquitoes found in the other side. In experiment 2, two mice were introduced in the opposite side of insect releasing in with the test arena as insect attractant. The result found that with the normal screen no mosquito penetrated through the mice side, while in the security steel mesh at 16x16 and 11x10.5 opening found that 1.00 and 0.50% of mosquitoes penetrated through mice side 72-h after releasing. In experiment 3, a rabbit was used as an insect attractant. The rank order of mesh size that number of mosquitoes penetrated through the tested screens to the rabbit side was 14x17 = 16x16>11x10.5, and 8x8. The findings revealed that the security steel mesh with wire 16x16 can be used to prevent blood feeding Ae. aegypti mosquitoes with the same effect as normal screens in laboratory conditions.

Key words: Security steel mesh, *Aedes aegypti,* Insect control

INTRODUCTION

Door and window screens, the classical and contemporary method to control mosquitoes, have been used worldwide. Insect pests in the urban area such as flies and mosquitoes can be prevented by window and door screens. Various types of screens have been developed with bigger wire mesh and openings for better robbery prevention, heavy storms and better ventilation as required. In general, insect pest protection ability has been reduced with an increasing of screen wire openings. With these threats the major concern the tenants would be able to trade off between the benefits of insect protection, good ventilation and safety purposes. Normally tight screen 16 to 18 mesh, are able to exclude nuisance insects such as flies and mosquitoes. The small sized mosquito, *Aedes aegypti* (L.) (Diptera: Culicidae) is one of the important mosquitoes that causes the serious dengue haemorrhagic fever in many countries. The adult is a small size, and a slender abdomen, and with the wing length 2.16 to 2.79 mm (Schneider et al., 2007). In this test, Ae. aegypti was used as the representative of insects for insect proofing.

MATERIALS AND METHODS

Mosquito rearing

Ae. aegypti was reared and followed by the standard laboratory condition from Biology and Ecology section, National Institute of Health, Thailand. The eggs of *Ae. aegypti* were introduced from National Institute of Health, Department of Medical Sciences, Nonthaburi province to Ento-

mology Laboratory, Department of Entomology and Plant Pathology, Faculty of Agriculture, Chiang Mai University, Chiang Mai province. Eggs were put in the pan (20x28x5 cm) with de-chlorinated tap water which rested in the container for at least 3 days. After the eggs hatched mosquito larvae were fed with dog food and about 500 larvae were separated in each pan. Dog food was fed *ad libitum* for 2 times a day and the water was drained and clean water was added in the rearing pan every two days. Larvae were fed up to 7-10 days until the larvae stopped feeding and turned to be pupae known as tumblers. Mosquito pupae take 2 days and then turn to be adults. Mosquitoes (adults) were fed with 10% solution of sucrose added 5% of vitamin B complex on the cotton wool. Usually female mosquitoes will lay eggs after blood feeding at about 36 hours after emerging from pupae.

Tested steel mesh arena

Experiment 1: Mosquito preventive steel mesh with 2-live-mouse host

The tested screen arena was an insect cage (40x40x60 cm) comprised of normal screen (14X17 openings). Inside the cage there were 2 partitions separated by various tested steel mesh. In tested arena; there are 2 partitions in insect cage separated by given steel meshes (Table 1), 2 mice were put in the a part of cage, and a hundred of *Ae. aegypti* mosquitoes which fed only 10% of sugar solution were put in the other side of cage. Tested steel mesh with 16x16, 11x10.5 and 14x17 or normal screen (Table 1) were put in the arena to prevent mosquitoes escape to the other side. Usually mosquitoes are going to seek their host for blood feeding prior to lay eggs. Number of escaped mosquitoes from mosquito side to the mice side was counted after mosquitoes released for 24, 48 and 72 hours. The experiment was replicated 4 times with different batches of mosquitoes.

Experiment 2: Mosquito preventive steel mesh without any attractant host

This objective of experiment was to evaluate capability of preventing mosquitoes. The steel mesh with various wire sizes of mesh were tested comparing to the normal window and door screen (14x17 openings). The arena test was composed of the insect cage of 60x50x80 cm. The cage was separated to 2 parts with regular screen or other tested screens inside. Exposure area of tested screen (Table 1) inside was 40x70 cm. Four hundred mosquitoes at pupal stage in water were introduced in one side of cage. When adults emerged, they were fed only 10% of sugar solution. The measurement of mosquitoes penetrating the other side of cage through the exposure screen was started when adult mosquitoes were 36-48 hours old. The further measurement was done after the accumulated hours of 24, 48 and 72. The experiment was replicated 3 times with different batches of mosquitoes.

Table 1. Screen types used in the tested arena.

	Screen type	Warp x Weft wire (mm)	Mesh count per inch (No. of openings)	Cage size (cm^3)	Screen area inside tested arena (cm^2)	Number of mosquitoes
Experiment 1 (with mice)	Normal screen	N/a	14.0 x 17.0*	40x40x60	25x25	200
	Security mesh	1.5x1.6	16.0 x 16.0	40x40x60	25x25	200
	Security mesh	1.6x1.8	11.0 x 10.5	40x40x60	25x25	200
Experiment 2 (without mice and a rabbit)	Normal screen	N/a	14.0 x 17.0	40x40x60	40x70	400
	Security mesh	1.5x1.6	16.0 x 16.0	40x40x60	40x70	400
	Security mesh	1.6x1.8	11.0 x 10.5	40x40x60	40x70	400
	Security mesh	1.8x2.1	8.0 x 8.0	40x40x60	40x70	400
Experiment 3 (with a rabbit)	Normal screen	N/a	14.0 x 17.0	60x50x80	40x70	400
	Security mesh	1.5x1.6	16.0 x 16.0	60x50x80	40x70	400
	Security mesh	1.6x1.8	11.0 x 10.5	60x50x80	40x70	400
	Security mesh	1.8x2.1	8.0 x 8.0	60x50x80	40x70	400

*scale measured by regular ruler

Experiment 3: Mosquito preventive steel mesh with a live rabbit host

This objective of this experiment was to evaluate the capability of preventing mosquitoes with security steel mesh when the tenants are in their residence. The tested screen arenas were insect cages with the size of 40x40x50 cm, and 60x50x80 cm cages comprised of normal screen. Inside the cage there were 2 partitions separated by tested mesh with various wire sites (Table 1). Two hundred to four hundred mosquitoes at pupal stage in water were introduced in a side of cage and then allowed them to emerge as adults. They fed only 10% of sugar solution for 36-48 hours and then a rabbit was put in the other side of cage (Figure 1). Usually mosquitoes are going to seek their host for blood feeding prior to lay eggs. Number of mosquitoes penetrating to the rabbit side was counted when the rabbit was released after the accumulated hours of 24, 48 and 72.

All mice and rabbits used in this investigation conformed to the international and national guidelines for ethical conduct on the care and use of animals, Faculty of Agriculture, Chiang Mai University. This experiment was replicated 3 times with different batches of mosquitoes. Factorial design was employed to evaluate the time, mesh size and their interaction.

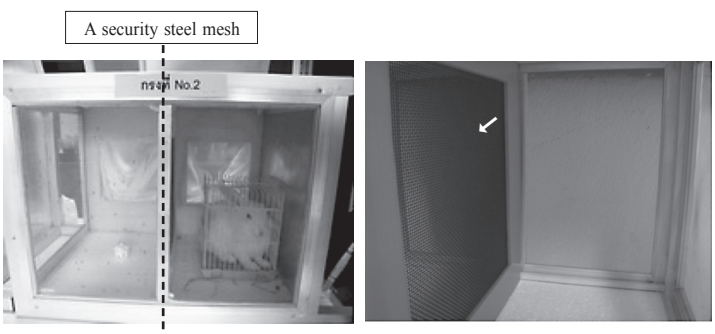

Figure 1. Mosquito preventive steel mesh test with a live rabbit host; the rabbit or mice were introduced in to a side of arena test and 200-400 mosquitoes were introduced into the other side of cage. The security steel mesh was put between rabbit side and mosquito side.

RESULTS AND DISCUSSION

Experiment 1: Mosquito preventive steel mesh with 2-live-mouse host

There was no *Ae. aegypti* mosquitoes escaped through the normal tested screen at 24, 28 and 72 hours after releasing in tested arena while the tested steel mesh at 16x18 and 11x10.5 opening showed 0.5 to 1.00% mosquitoes escaped through the other side which attracted by 2 mice in the other side (Table 2). In other words there are 4 male mosquitoes of 400 mosquitoes (both sexes) were escaped from the mosquito side to mice side. Mosquitoes which escaped through the tested steel mesh seemed to be under size (wing length = 2.25 to 2.50 mm). Female *Ae. aegypti* has wing length ranged from 2.32 to 2.76 mm (Reyes-Villanueva, 2004) or 2.47 to 2.76 mm (Nasci, 1986). Ponlawat and Harrington (2007) reported that the 1-day-old large male *Ae. aegypti* was 2.23 mm and the 10-day-old large *Ae. aegypti* was 2.32 mm. Thus, the potential size of *Ae. aegypti* mosquitoes which is able to escape through the steel mesh would be under size especially male *Ae. aegypti* which is no needed blood feeding. The results showed that the 16x16 and 11x10.5 steel mesh were able to prevent *Ae. aegypti* mosquitoes at 99% in laboratory condition. Compared to the normal wire screen (14x17 openings), the number of screen openings of the 16x16 and 11x10.5 steel mesh which greater than those in normal screen with the wider openings (Figure 2). The field test or real situation of security steel mesh uses is needed to be tested to ensure mosquito prevention due to the mosquito behavior would involve in their flight and host seeking.

Table 2. Average number of mosquitoes escaping from the releasing side from the tested steel mesh through the other side attracted by 2 mice.

Mesh count per inch	Mosquitoes escaping through the tested screen after releasing in the arena (%)		
	24 hours	48 hours	72 hours
(Normal screen) 14x17	0	0	0
16x16	0.25	0.75	1.00
11x10.5	0.25	0.50	0.50

Normal screen widely uses in Thailand. The opening is 1x2 mm with thin wire (Figure 2).

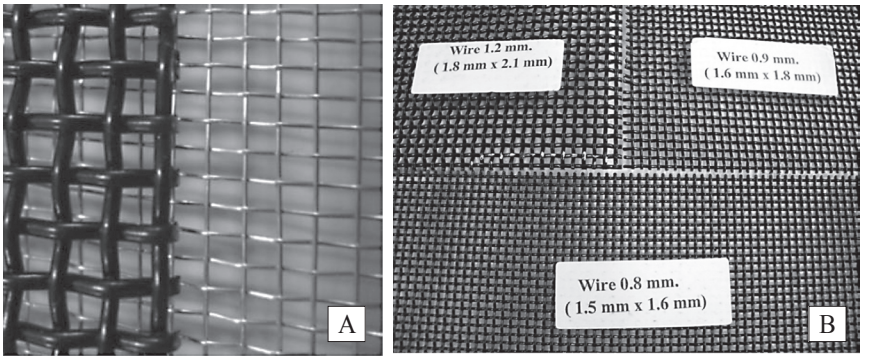

Figure 2. Steel mesh (16x16 openings) (left) and normal screen (14x17 openings) (right) (A) were used in the experiment; and 3 types of steel mesh (B) the 8x8 openings (upper left), 11x10.5 (upper right) and 16x16 openings (lower).

Experiment 2: Mosquito preventive steel mesh without any attractant host

Number of mosquitoes penetrated through normal screen was not found as well as through the tested steel mesh. On the steel mesh with 8x8 openings, the mosquitoes in the other side were found 3, 5 and 7 insects or 0.25, 0.42 and 0.58% (Table 3) after 24, 48 and 72 hours. After releasing

the result indicated that the security steel mesh with 16x16 and 11x10.5 openings were able to prevent mosquitoes and other bigger flying insects.

Experiment 3: Mosquito preventive steel mesh with a live rabbit host

Number of mosquitoes escaped from mosquitoes side through steel mesh to the rabbit side increased significantly ($P<0.05$) with the *time* of insect confined and *mesh size* increasing. The *time x mesh size* interaction was found. With the density of 600 cm^3 per insect, the number of mosquitoes got through normal screen ranged from 1-2 mosquito (es) or 0.08 to 0.33% at 24, 48 and 72 hrs. The greatest number of mosquitoes got through steel mesh was 3.67% in the treatment of 8x8 opening steel mesh which was significantly different from 16x16 and 11x10.5 steel mesh (Table 4).

Mosquito density assessment has been classified in various ways. Density of cage volume per female done by Barmard and Xue (2007) showed 640, 128 and 49 cm^3 per female mosquito was the low, medium, and high density of mosquitoes. Comparing to experiment done by Thavara et al. (2002) the female mosquitoes had been in the cage then was tested with phytochemicals as the repellent against 3 species i.e. *Ae. aegypti, Culex quinquefasciatus* and *Anopheles dirus*. The density of female mosquitoes was 256 cm^3 per female which would be the middle range of high and medium density in Bernard and Xue (2006) study. In this test the mosquito density was able to ranged in low density if the sex ratio of *Ae. aegypti* by average was about 1:1 (male : female). The result indicated that the security steel mesh reduce degree of mosquito protection due to the host attractant as a rabbit. However, there were many factors involved since the mosquitoes were stress from starving for 36 hours and young age of mosquito because those mosquitoes were in high competitive condition. In addition those mosquitoes were almost the same in age and nulliparous status which tried to get first biting faster than other parous females or one who is having given birth (Ungureanu, 1974). Moreover a rabbit, a large size host was more attractive to mosquitoes than mice, small-size hosts because mosquitoes prefer large body surface area (Kweka et al., 2010). Thus the seeking host activity of those mosquitoes could perform strongly enough to penetrate through the bigger opening steel mesh.

Table 3. Number of Aedes aegypti mosquitoes penetrated from the mosquito side to the other side. Insect density was 600 cm^3 per insect of the tested volume.

Mesh count per inch	Number of mosquitoes released in the arena	Mosquitoes penetrated through the tested screen after releasing in the arena (%) (actual number)		
		24 hours	48 hours	72 hours
14x17 (normal screen)	400	0	0	0
16x16	400	0	0	0
11x10.5	400	0	0	0
8x8	400	0.25 (3)	0.42 (5)	0.58 (7)

Note: Normal screen widely uses in Thailand. The opening was 1x2 mm with thin wire.

Table 4. Number of Aedes aegypti mosquitoes penetrated through the tested steel mesh in the area test with the live rabbit at the mosquito density of 400 and 600 cm^3 per insect.

Mesh count per inch	Number of mosquitoes released in the arena	Mosquitoes penetrated through the tested screen after releasing in the arena (%)[1]		
		24 hours	48 hours	72 hours
14x17 (normal screen)	400	0.08h	0.33h	0.33h
16x16	400	0.42gh	0.92fg	1.00f
11x10.5	400	1.58e	2.33cd	2.75bc
8x8	400	2.00de	2.92b	3.67a

Note: Normal screen widely uses in Thailand. The opening was 1x2 mm with thin wire.
[1]Means followed by the same letters in the same column and row are not significantly different at 95% confidence.

According to the results, an effective mosquitoes protection of steel mesh would share usefulness when produced doors and window while prevented from intruders and robbery and ventilation purposes.

CONCLUSION

Steel mesh with the 16x16, 11x10.5 and 8x8 openings showed an ability of mosquito prevention in condition with host attractant. The number of insects penetrating increased with decreasing mesh count per inch. The steel mesh with 8x8 openings, which was the biggest opening size in this test, showed 96.33% effectiveness in preventing mosquitoes, *Ae. aegypti* with both sexes from getting through the steel mesh for 72 hours. However the further field tests of mosquito exclusion for practical uses needs to be conducted.

ACKNOWLEDGEMENT

This research was supported by Meshtec International Co., Ltd., Chiang Mai, Thailand.

REFERENCES

Barnard, D. R., and R. D. Xue. 2007. Biometrics and behavior in mosquito repellent assays. p.111-124. In M. Debboun, S.P. Frances and D. Strickman (eds) Insect repellents: principles, methods, and use. CRC Press, Boca Raton.

Kweka, E. J., B. J. Mwang'onde, L. Lyaruu, F. Tenu, and A. M. Mahande. 2010. Effect of different hosts on feeding patterns and mortality of mosquitoes (Diptera: Culicidae) and their implications on parasite transmission. Journal of Global Infectious Diseases 2(2): 121-123.

Nasci, R. S. 1986. The size of emerging and host-seeking *Aedes aegypti* and the relation of size to blood-feeding success in the field. Journal of the American Mosquito Control Association 2(1): 61-62.

Ponlawat, A., and L.C. Harrington. 2007. Age and body size influence male sperm capacity of the dengue vector *Aedes aegypti* (Diptera: Culicidae). Journal of Medical Entomology 44(3): 422-426.

Reyes-Villanueva, F. 2004. Egg development may require multiple bloodmeals among small *Aedes aegypti* (Diptera: Culicidae) field collected in Northeastern Mexico. Florida Entomologist 87(4): 630-632.

Schneider, J.R., A. Mori, J. Romero-Severson, D.D. Chadee, and D. W. Severson. 2007. Investigations of dengue-2 susceptibility and body size among *Aedes aegypti* populations. Medical Veterinary Entomology 21(4): 370-376.

Thavara, U., A. Tawatsin, and J. Chompoosri. 2002. Phytochemicals as repellent against mosquitoes in Thailand. p. 233-242. In U. Thavaraed (eds) Scientific publications relating to insect vectors from 1995-2004. Biology and Ecology Section. Medical Entomology Group, National Institute of Health, Department of Medical Sciences, Ministry of Public Health, Bangkok.

Ungureanu, E.M. 1974. Population dynamics and age grading of mosquitoes. Bulletin World Health Oganization 50(3-4): 317-321.

none