MOSQUITO PENETRATION TESTS WITH LOUVER SCREENING [1]

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Prior to World War II, the 16 x 16 mesh per square inch wire screening was widely used for excluding flies and mosquitoes from homes and buildings. It was not entirely satisfactory, as Herms and Gray (1944) had stated that many *Aedes* and some *Anopheles* mosquitoes would pass through it. Earle (1932) had approved the use of 16 x 16 mesh screening for use in malaria control in Puerto Rico. The U. S. Army (1945), however, specified 18 x 18 mesh screening.

During World War II, a wire screening with 18 vertical wires by 14 horizontal wires was produced to replace the 16 x 16 mesh as the new size could be manufactured more rapidly. Today, this mesh is a standard size and has replaced the 16 x 16 mesh screening. Tests comparing the 18 x 14 mesh with the 16 x 16 mesh were discussed by Bacon (1946) and reported in detail by Block (1946). Block found that *Anopheles quadrimaculatus* and *Culex quinquefasciatus* were unable to pass through either size mesh. When *Aedes aegypti* was used fourteen per cent of the normal sized mosquitoes escaped through screens of both sizes although the tolerances permitted the manufacturer would result in the 18 x 14 mesh screen being slightly less effective. From 30% to 50% of undersized *A. aegypti* escaped through these screens. No differences were noted whether the 18 x 14 mesh screen was mounted vertically or horizontally.

Louvered screening is produced with the purpose of excluding sunlight as well as insects. The louver screening used in the following tests was of copper, painted black, and had vertical wires spaced ½ inch apart and with 17 or 23 louvers to the inch. Each louver was from .048 to .050 inches wide and .006 to .007 inches thick. The 17 mesh screening had the louvers tilted at an angle of about 35° while the louvers of the 23 mesh were tilted about 25°. To determine the effectiveness of this type of screening, the 17 mesh louvered screening was compared with an 18 x 14 mesh copper screen and the 23 mesh louvered screening with a 22 x 22 mesh fiber-glass screen.

MATERIALS AND METHODS

The louvered screening was installed in a position to simulate the obstacles that would be encountered by a mosquito while it is trying to penetrate a louvered screen in a window. Confined mosquitoes had to pass upward between the downward sloping louvers in order to escape. The interior surface of the louvered screen covering the cage thus represented the exterior surface of the screen as it is usually installed. The 18 x 14 mesh screen was tested with the 18 mesh wire vertically and the 14 mesh wire horizontally.

Two methods were used to test these screens. In the first method, pint mason jars were used to hold the mosquitoes. A ⅜ inch hole was bored in the side of the jar and a circular piece of screening replaced the

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jar lid and was held in place by the mason jar ring. As the screening was cut into circular pieces, the louvers were distorted along the edges where not supported on either side by a vertical wire. Therefore a paper disc with a 1½ inch by 1½ inch hole was placed between the screen and jar ring of all jars to expose only the central portion of the screen. A small cotton pad moistened with water was placed in each jar to maintain a suitable level of humidity.

A sheet metal cylinder, 19 inches in diameter and 10 inches high, had holes, each just large enough to insert a mason jar ring, cut into it midway about the circumference. In the center of the cylinder was either a 25-watt frosted light bulb or a 17-inch circular cage containing a rabbit, to serve as attractants.

Eight female mosquitoes were blown into the pint jars through the hole bored in the side which was then closed with masking tape. The jars were wrapped in several thicknesses of black cloth so only light that had passed through the screen could enter the jar. The jars were placed in a horizontal position around the outside of the cylinder by inserting the jar ring in the hole in the cylinder and placing a support under the bottom. Each jar then faced inward toward the attractant and with the jar ring fitted into the hole in the cylinder.

The second method to test the screens used large cages with dimensions 2 feet on each side. The cages were constructed entirely of wall board except for one side which was covered by the screen to be tested. All inside joints were sealed with masking tape to make a smooth interior. A ⅜ inch hole in the side of the cage was used for putting mosquitoes into the cage and a large door in the rear made it possible to insure complete removal of the mosquitoes at the end of a test. Each cage contained only a cotton pad moistened with water. The cages were arranged in pairs, face to face and about 12 inches apart. A rectangular rabbit cage, 10 inches wide, 20 inches long and 12 inches high was placed between the cages.

One hundred female mosquitoes were placed in each cage at the start of a test. At the completion of the test the front of the cage was covered with a sheet of clear celluloid, sealed with masking tape, and the mosquitoes knocked down with carbon dioxide. They were then collected with an aspirator, killed and counted.

The mosquitoes used in these tests were adult females of *Aedes aegypti* and *Aedes taeniorhynchus*. The *A. aegypti* were of normal size and were secured from a laboratory strain. The *A. taeniorhynchus* were collected in the field as immatures and allowed to emerge in a cage. The mosquitoes were at least 3 days old before use, although during those tests when light was used as an attractant, the addition of new adults into the stock cage made it possible that a small proportion of the adults could have been less. All adults were three days of age or older whenever a rabbit was used as the attractant.

The tests were made at a constant temperature of 25° C. and each test lasted from twenty to twenty-four hours. The percentage of mosquitoes which escaped was determined by the formula $\frac{X-A}{X-B}$ where X = the total number of mosquitoes placed in a cage, A = the total number recovered

TABLE 1. SCREENING EFFECTIVENESS FOR MOSQUITOES CONFINED IN PINT JARS.

Type of* Screen	No. of Tests Run	No. of Mosquitoes		Per cent Escaped	
		Tested	Escaped	*A. taenio-rhynchus*	*A. aegypti*
		Light as Attractant			
L 17	6**	44	0	0	
	4	30	2		6.7
C 18 x 14	6	47	0	0	
	4	26	0		0
L 23	6	46	0	0	
	4	30	0		0
FG 22 x 22	6	44	0	0	
	4	29	0		0
		Rabbit as Attractant			
L 17	12	94	2	2.1	
	12	96	42		43.8
C 18 x 14	12	93	0	0	
	12	95	0		0
L 23	12	95	2	2.1	
	12	95	3		3.2
FG 22 x 22	12	95	0	0	
	12	96	0		0

* L = Louvered; C = Copper; FG = Fiber glass.
** Upper number for *A. taeniorhynchus;* lower for *A. aegypti.*

TABLE 2. RESULTS OF CONFINING MOSQUITOES IN LARGE CAGES USING A RABBIT AS AN ATTRACTANT.

Type of Screen	No. of Tests Run	No. of Mosquitoes		Per cent Escaped	
		Tested	Escaped	*A. taenio-rhynchus*	*A. aegypti*
L 17	5	481	204	42.4	
	9	893	111		12.4
C 18 x 14	5	440	114	25.9	
	9	895	13		1.5
L 23	5	398	10	2.5	
	9	892	4		.4
FG 22 x 22	5	355	2	.6	
	9	899	1		.1

from the cage and B = the number of mosquitoes dead at the termination of the test.

Experimental Results

The results of the two tests with mosquitoes confined to pint jars and large cages are given in Tables 1 and 2, respectively. In Table 1 the results of using light and a rabbit as attractants are shown separately as it was noted that about six times as many *A. aegypti* would escape when the rabbit was used instead of the light. With the rabbit used as the attractant, 43.8% of the *A. aegypti* escaped through the 17 mesh louvered screening while none penetrated the 18 x 14 mesh copper screen. The differences between these screens are significant, with a P value of less than .01. There is no statistical significance to the differences found between the 23 mesh louvered screen and the 22 x 22 fiber-glass screen.

Table 2 presents the results from tests using the large cages. Again the loss of *A. aegypti* through the 17 mesh louvered screen was significantly different ($P = < .01$) from the escape through the 18 x 14 mesh copper screen. Large losses of *A. taeniorhynchus* through both coarser screens are apparent. These adults were noticeably smaller than those used in the jar tests, although both groups were collected in the field as mature larvae or pupae. The conditions in the breeding area did not appear to be unfavorable at the time of collection, so the cause of the smaller size is not known. However, adults of *A. taeniorhynchus* smaller than those used in these tests have been frequently observed to occur naturally so that the use of these mosquitoes is not considered prejudicial to the results. The intraspecific variation in size of mosquitoes is just as important in screening performance as size differences between species. The few escapes (Table 2) reported for the 22 x 22 fiber-glass screen are probably due to errors made when counting mosquitoes as occasionally more than 100 would be removed upon completion of a test.

Within the louver type of screening, the 17 mesh permitted far more mosquitoes to escape than the 23 mesh. It is also to be noted that the 23 mesh louvered screen was superior to the copper 18 x 14 mesh screen in retaining the smaller-sized *A. taeniorhynchus* ($P = .01$).

Aside from the retention and escape features of louver screening, it showed itself in this testing to be rather fragile in the sense that minor pressures distort and spread the louvers, resulting in larger openings at those points which could in practical use diminish or nullify their mosquito exclusion value. Such injuries to the louver screening were not present in the testing above reported.

Conclusion

These experiments demonstrate that the 17 mesh louver screening is not adequate for exclusion of the mosquitoes common in Florida. The 23 mesh louver screening may be satisfactory as long as it remains undamaged, i. e. never pushed against or crushed in any manner.

Literature Cited

Bacon, R. W. 1946. Effectiveness of insect wire screening. Mosq. News, 6(2): 85-88.

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One of our Florida entomologists, Lewis Maxwell, has just published a HANDBOOK OF FLORIDA INSECTS AND THEIR CONTROL. The handbook illustrates each species discussed with photographs taken by Mr. Maxwell. Copies can be purchased for $1.00 from the author or from the Great Outdoors Association, 4747 28th Street, St. Petersburg, Florida.

Dr. D. O. Wolfenbarger requests that all members of the Florida Entomological Society who expect to attend the International Congress of Entomology in Vienna in 1960 get together to make plans for the meeting. If you are interested in coordinating efforts with Dr. Wolfenbarger, he can be reached at The Subtropical Experiment Station, Route 2, Box 508, Homestead, Florida.

Some interest has been shown in the names of the Honorary Members of the Florida Entomological Society. The following list is current:

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