SOME OBSERVATIONS OF ANTIMOSQUITO SCREENING AND SCREENING MATERIALS

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In regions such as the coastal section of Puerto Rico where the malaria problem is so difficult, it is necessary to use all methods possible for its control. Protection by screening from the bites of infected mosquitoes as an antimalaria measure is accepted in many countries as an efficient method, particularly wherever the people are intelligent enough to appreciate its benefits and the construction of houses is of such a type as to permit of mosquito proofing. In Puerto Rico, as a whole, relatively little screening is done with the exception of that installed by the larger sugar companies, which have screened the houses of the officials and of some of the other salaried employees. Studies were made to determine why more screening was not done, and if possible to overcome the difficulties encountered.

Numerous reasons were advanced for not screening, among which were a feeling of being shut in, of the screens not being ornamental, etc., but three reasons seemed of special importance:

(1) That the screening obstructed the breeze and caused the houses to be much hotter.

(2) That the cost of screening was high, not only originally, but of maintenance as well, because of the short life of the wire near the ocean.

(3) That even with complete screening the mosquitoes could not be kept out.

The first objection could only hold during the day time, for at night it is common practice among the less enlightened classes to shut all the doors and windows and to crawl under a mosquito net which often is of such a fine weave that air passes through with the greatest difficulty. Some rough tests were performed to try and determine the amount of obstruction to wind caused by the various screens. A fan and anemometer were placed at the same level on a long table in the laboratory and the velocity of the wind produced by the fan

was determined. Then samples of the various screens were placed, one at a time, between the two and the velocity of the wind again determined. In another series of trials a set of wet and dry thermometers was substituted for the anemometer and the time necessary to lower the wet bulb thermometer to its minimum was determined, first with the fan alone and then with the various screens between the fan and the thermometers. It will be noted in the accompanying table that while the results of the two sets of trials are not in entire agreement, with the anemometer the least obstruction was caused by the No. 12 mesh galvanized and then the Monel metal. The greatest reduction in wind velocity was caused by the cloth screen. It is difficult to get the cloth screen stretched tightly and when wet it sags considerably and the spaces fill up with water so that practically no air passes through at all.

DATA ON OBSTRUCTION TO WIND CAUSED BY VARIOUS TYPES OF SCREENS—USING ELECTRIC FAN AS SOURCE OF WIND.

			Without screen	1 16 Mesh copper .01 in. wire	2 16 Mesh copper .015 in. wire	3 16 Mesh bronze .015 in. wire	4 16 Mesh bronze .01 in. wire	5 16 Mesh copper .01 in. wire	6 16 Mesh Monel metal .009 in. wire	7 12 Mesh galv. wire	8 Cot. cloth screen 16 Mesh
I.	With Anemometer	Screen at right angle to direction of wind	10	6	5	5.5	6	6.5	7.0	8.5	2.5
		Screen at 45° angle	.....	.....	6.5	6.5	6	6.5	7.0	8.5	6.5
II.	With Thermometer	Screen at right angle to direction of wind	35	35	52	48	35	35	38	40	60
		Screen at 45° angle....	.....	35	43	.....	.....	.....	.....	.....	40

I. Numbers represent velocity of wind in miles per hour.
II. Numbers represent time in seconds necessary to reduce temperature of wet bulb to minimum.
Dry temperature at beginning 85. Wet=78.5
Dry temperature at end of experiments 87.5. Wet=78.8.

The second series of trials showed in agreement to the first, that the greatest obstruction was caused by the heavier grades of wire in the No. 16 mesh and by the cloth screen,

but that in the others the temperature of the wet thermometer reached the low point as quickly with the screens in place as without any screen at all. These experiments were performed with the screen always at right angles to the direction of the breeze. It was noted that when it was put at any other angle there was no change in results noted in these which had produced the least obstruction at first, but with the cloth screen much more air apparently went through so that the apparatus registered a velocity more than twice as fast as it did when the screen was at right angles.

It is apparent that screens offer some resistance to the wind, especially those with the fine mesh and of the heavier wire or made of cloth, but that those with finer wire, or coarse mesh and heavy wire, reduce the velocity only about one third. The movement of air was not reduced sufficiently, however, to show an appreciable difference in time of lowering of the wet bulb of thermometer, so that the effect upon human comfort probably is not as great as would be indicated by the velocity readings.

There are three types of insects which it is desirable to keep out:

(1) The small *Culicoides* which are especially abundant near the ocean. They will enter when 16 mesh screens are used and I believe it is generally recognized that it is not practical to screen against this insect. Strong winds protect more than anything else.

(2) House flies are easily kept out with any type of fine screening.

(3) Mosquitoes. The *Anopheles* of Puerto Rico are as a rule quite large and are certainly warded off by anything that will keep out certain species of *Aedes* which are the smallest and also most abundant when heavy breeding takes place in mangrove swamps. General experience on the island, personal as well as by others who have screened for years, indicates that there is no need for anything finer than 16 mesh in the .01 inch wire. In the past few years since heavier wires have been used I have found no need of anything finer than 12 mesh using a wire of .015 inch diameter, especially since it is not long before a certain amount of dust collects on the screen and reduces the size of the opening. The accompanying table shows the width of aperture when heavy wire and fine wire are used with varying meshes.

TABLE

Width of aperture	Mesh	Diameter of wire
.068 inch	12	.015
.056	14	.015
.0525	16	.01
.0456	18	.01

It will be seen that the size of the opening in a 14 mesh screen with heavy wire is practically the same as the opening in the 16 mesh with the customary fine wire. The 12 mesh and heavy wire has an opening slightly larger, but for practical purposes it would seem to serve its purpose. One increases comfort by using the largest mesh possible and the size of wire is an important factor in determining what mesh should be used, and is of importance also in determining the life of the screen.

In the matter of cost of screening, which has been one of the most serious complaints, there are several factors to be considered among which are:

(1) The material used for making the screen.
(2) The type of house to be screened.

I have had an opportunity of studying screens made of
waxed cotton thread,
stainless steel,
galvanized wire,
aluminum,
copper,
bronze and Monel metal.

All of these were tried in the usual diameter of wire of .009 or .010 of an inch while galvanized wire, copper, bronze and Monel metal have been tried or are being tried in the .015 inch wire as well.

Some tests were performed by placing frames with the various screens out in the open and exposed to the ocean breeze. It was soon found however that even ordinary galvanized wire would last 1-2 years in this type of experiment when it was common knowledge that on houses its life was very short. Experiments were then performed with samples

in actual use on houses near the ocean where the trade winds were continuously blowing.

Cotton netting was only used in the original experiment for it gave such poor results then that it did not seem worth while to continue further with it.

In the tests of screens in actual use it was found that ordinary galvanized wire screening, that is, with .009 or .010 inch wire was rusting through in from 3-6 months time.

The sample of stainless steel screen with .01 inch wire gave very poor results, for under the severe conditions of the test it had rusted through in 2½ months. It is possible that more resistant material can be developed later on.

Aluminum wire lasted about 6 months under the same conditions.

Copper and bronze in the .010 inch wire were breaking through, in one instance in 8 months, and at the end of 18 months most screens were so weak that the slightest pressure caused them to break. Samples of copper wire were analyzed and shown to be practically pure copper.

Monel metal in .009 inch wire lasts anywhere from 3-5 years though under the most severe conditions it may be necessary to change some under 3 years.

Because of the fact that a screen often is made useless because of mechanical injury and also the fact that longer life should be expected, experiments were continued with the heavy grades (that is .015 inch wire) of galvanized wire, copper, bronze and Monel metal.

Some of these observations are still in progress but it has been determined that the heavy galvanized wire will last about 1 year or as long as the lighter weight of copper. At the end of the year the heavy copper has shown slight evidence of wear, the heavy bronze is in excellent condition, and of course the heavy Monel metal is as good as new.

Four to five miles back from the ocean the life of screens is much longer and heavy galvanized screening will last easily 2-3 years. Screens which are protected by curtains even though the curtain is on the leeward side of the screen will last much longer. This point is also taken advantage of in placing the screen on the frame. It has been felt by some that the screen often breaks around the edge because of the working back and forth of the screen in the wind, since the screen is held as in a vice by the frame and strip of molding.

This portion of the screen can be maintained practically new by placing the molding about ½ inch back from the edge of the frame; for the screen with the frame immediately back of it will not desintegrate even though it is directly exposed to the wind. The part of the wire affected by the to-and-fro movement of the screen is thus preserved and should not be broken if the screen is maintained reasonably taut.

Those screens which collect considerable dust from the house also rust out much more quickly. The screens can easily be cleaned with a fine wire brush or with a stiff bristled hand brush.

There is possibly a field for applying paint or other preservatives to screens but this has not been investigated.

It would seem, therefore, that, in the tropics where screens are exposed to the ocean breeze 12 months in the year, there really is no field for the lighter weight wires for screening. For all-around work I would use the .015 inch bronze wire which is only made at present in the 16 mesh but 14 mesh wire would certainly be fine enough or even a 12 mesh. For an especially efficient job where funds were available I would use the .015 inch Monel wire in the 12 mesh.

If one is back from the ocean several miles and wishes a cheaper wire he will get good service out of the .015 inch galvanized wire.

The most recent quotations I have on these wires bought in small quantities are F. O. B. New York, and per 100 square feet,

12 mesh galvanized screening .015 inch wire	$3.30*
16 mesh bronze–.015 inch wire	6.50
12 mesh Monel metal–.015 inch wire	17.00
16 mesh Monel metal–.009 inch wire	8.60

There is no doubt that in most cases in Puerto Rico screening is made much more difficult because of the type of house in common use with innumerable doors and lattice windows which open outward. One who is perfectly familiar with the habits of mosquitoes and who is desirous of avoiding their bites can of course protect himself with screens in almost any type of house in which all openings can be screened or stopped up. Where one is desirous of protecting a population not too well informed in the habits of mosquitoes and

* These prices were estimated at the time of the experiments.

who really are not concerned about the bites of the mosquitoes unless they are very numerous, it is necessary to make the screened house even more comfortable than the unscreened, so that people will want to stay in it at all hours that the mosquitoes are active; and at the same time the necessity for opening screened windows or doors must be reduced to a minimum. The average house in Puerto Rico is not very cool at best and it is essential to provide some kind of screened porch where people can be as comfortable as the weather will permit and still be protected from the bites of mosquitoes. The entire porch is best screened wherever possible so that there is not the possibility of sitting out in the unscreened portion. The number of entrance doors should be reduced to a minimum and in the case of the one on the porch there is much to be gained by making the door of boards instead of screening. It is much stronger and when mosquitoes are abundant they will be found trying to get in through the screens and will not be resting on the door so that there is not much danger of many entering when the door is opened.

To screen windows which are provided with lattice or wood shutters which open outward, the screen is usually nailed on to the inner side of the window frame leaving a space at the bottom where a narrow door the width of the window and about 6 inches high is hinged on. The latch of the window is worked through this door.

Even with a house well screened a certain amount of interest must be instilled into one or more of the inhabitants to see that children especially are inside at sundown and that no one keeps the doors open any longer than is absolutely necessary for entering or leaving the house. It usually takes a week or two after screening to get most of the mosquitoes out of the house and to become accustomed to the screens. A few mosquitoes will usually find entrance, but it now takes only a small amount of any of the numerous insecticides on the market to get rid of these. I personally have screened some of the most difficult houses to screen and in regions where *Aedes teniorrhynchus* was thick enough to make the screen appear black, and have been able to get along without mosquito nets and to live in comfort. Others who have become interested have been able to do the same thing. Finally an experiment was tried in screening a mayordomo's

house where either he or some member of his family was repeatedly down with malaria. They were sceptical about it at first but within 2–3 weeks they had removed the mosquito nets from the beds and after all those with parasites in the blood were cured, there was no reinfection during the year following the screening. There was no trouble whatever with mechanical injury to screens. It is planned now to try an experiment with the laborers' houses as well.

SUMMARY AND CONCLUSIONS

(1) The amount of obstruction to the movement of the air caused by various types of screens was studied. The least obstruction was caused by 12 mesh wire screen with .01 inch wire. The most was caused by cotton cloth screen.

(2) For Puerto Rico a 12 mesh screen with .015 inch wire will keep out all insects that screens are usually used for.

(3) Under the severe atmospheric conditions it is advisable to use the heavier grades of wire, i: e: .015 inch diameter. For all around use, bronze screen with this sized wire is probably the best, Monel metal in the same wire for special work, and galvanized screen in the same wire for screening back from the ocean or where conditions are not so severe.

(4) A screened house must be made as comfortable as possible and this usually means some form of screened porch. The number of screen doors and windows which open must be reduced to a minimum.

(5) The success of screening will depend to a large extent on intelligent cooperation of the inhabitants or such supervision and inspection as may be necessary to insure mechanical perfection of the screening at all times and the presence of the inhabitants in the house during the time that mosquitoes are active.