SOME EFFECTS OF SCREENS IN RETARDING ENTRY OF THE COMMON SALT-MARSH SAND FLY *CULICOIDES FURENS* (POEY) (DIPTERA: HELEIDAE)[1, 2]

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Culicoides furens (Poey) is widely distributed in the Americas. It is found as far south as Brazil and as far north as Massachusetts. It is prevalent in the West Indies and in the coastal areas of the Atlantic Ocean and the Gulf of Mexico in the United States. It is the most abundant species of *Culicoides* in Florida where it ranks high among the major pests of man.

The blood-sucking habits of these insects attract them to man. Their bite, in many people, produces a lesion more painful and of longer duration than that of some of the pestiferous mosquitoes from the same regions. They do not transmit disease organisms in the United States, but are known to be the intermediate hosts of *Mansonella ozzardi* (Manson) in the British West Indies (Buckley 1934).

The problem created by large numbers of them entering dwellings is one which taxes the resourcefulness of home owners and those people interested in furthering real estate and tourist developments. It is an important item in the budgets of the district mosquito control units which annually spend large sums of money in attempts to protect the populace from these pests. Sand fly control at drive-in theaters is a must to insure maximum attendance. Attendance at public parks is considerably reduced during the periods of peak sand fly abundance.

Prior to 1949 the principal measures directed at larval control consisted of the diking and pumping of salt marshes to prevent tide water overflow and rainwater retention. These measures are only partially successful because little was known then, or even now, of the biology of the species.

When these studies, concerning screens, were initiated in 1950 the outlook was not yet too promising for the use of the newer insecticides as sand fly larvicides, while space spraying or fogging for adult control was prohibitive in most areas because of excessive costs. No evaluation had been made of screening for the exclusion of *Culicoides*, although numerous implications had been drawn. There has been very little scientific information published on the effectiveness of screens or of the chemical treatment of screens to retard insects. It was the author's opinion at this time that an evaluation of insect screening effectiveness could well be made. The periodic peaks of great abundance and the regularity of high populations for several months of the year in the Miami, Florida, area, made the use of *C. furens* the most suitable of the Heleidae for use as a test insect. The following experiments were conducted from 1950–1955, in an attempt to shed light on the effectiveness of those screening materials most commonly in use around dwellings and offices.

MATERIALS AND METHODS. The relative numbers of sand flies trapped in live animal cages was the method used for ascertaining the effects of different types of screening in retarding sand fly entry. In these tests, cages containing rats were provided with 4 "windows" comprising a total of 72 square inches. These windows were screened with one of a series of seven different types of screening.[3]

[1] From the Division of Foreign Quarantine, Public Health Service, U.S. Department of Health, Education, and Welfare, Quarantine Station, Miami Beach, Florida.

[2] A portion of a dissertation presented in partial fulfillment of the degree of Doctor of Philosophy at the University of Illinois, 1955.

[3] The author expresses his gratitude to Mr. R. W. Bacon, Insect Wire Screening Bureau, N.Y.C. for supplying the wire screen materials tested, and to The Chicopee Manufacturing Corporation of Georgia, for the plastic screening used in tests.

The screen materials used were:

Galvanized insect wire screening, 14x14 mesh—0.011 inch diameter wire; Bronze insect wire screening, 14x18 mesh—0.011 inch diameter wire; Aluminum insect wire screening, 14x18 mesh—0.013 inch diameter wire; Bronze insect wire screening, 18x18 mesh—0.011 inch diameter wire; Aluminum insect wire screening, 20x20 mesh—0.013 inch diameter wire; Plastic insect screening, 14x18 mesh—0.015 inch filament diameter; Plastic insect screening, 20x20 mesh—0.015 inch filament diameter.

The word "mesh" is used in the above designation of the various screen materials, and elsewhere in the text, to mean the number of open spaces per linear inch in both warp and filler directions of the screen.

Three replicates of each test were run, with each replicate consisting of a check cage without screen and one cage each in which the "windows" were covered with one of the seven screen materials being evaluated.

Each replicated series of cages was placed in an area of the salt marsh with similar conditions of shading, light, wind currents and attractiveness to sand flies.

The cages used were modified live animal traps designed by Curran and Goulding (Figure 1) (Personal communication, 1951). Each contained one domesticated rat within an inner wire cage. Entering the cages through the screen barrier being

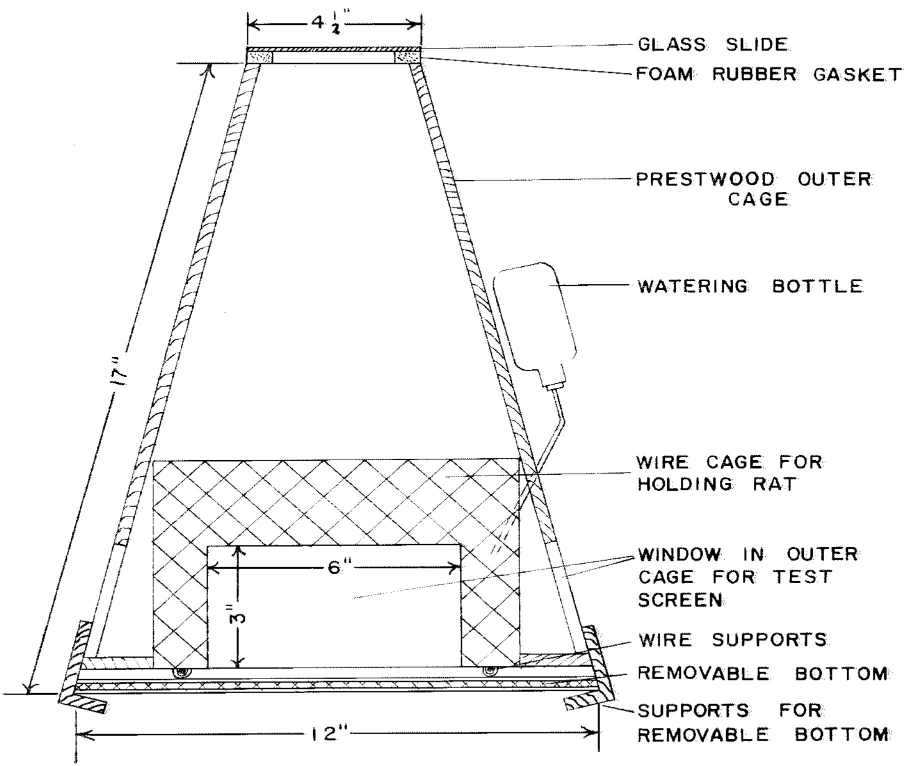

FIG. 1.—Sand fly trap showing construction details.

evaluated, the sand flies would feed upon the rat and seek to leave the trap. The top of the cage was covered by a glass plate coated on the underside with tanglefoot. Flying upward, the insects were caught in this plate. The comparative rate of sand fly entrance retardation for the trap was then determined by the relative numbers of sand flies trapped on these plates.

Daily counts were made of the numbers of sand flies caught on the glass plates. A binocular dissecting microscope was used in making the counts. A very thin layer of tanglefoot must be used in order to allow for proper identification of *C. furens* from some of the similar but less common *Culicoides* of the area, such as *C. inamollae* Fox and Hoffman, *C. canithorax* Hoffm. and *C. melleus* Coquillett.

Frequently extremely large numbers of sand flies occurred on a single glass plate. In these cases only a quadrant of the slide was checked and the total for the slide arrived at by multiplying by four the number found in the quadrant. It was convenient to have a quarter-inch grid paper beneath the slides as a guide in systematically determining the counts in all cases.

The light passage properties of the various screens were simply arrived at by using a darkened wooden box (Figure 2), open on one end and with a narrow slit at the other end. The open end was covered by the screen to be tested while the light receptive gauge of an exposure meter was placed in the slit at the opposite end. A centrally placed 60-watt light bulb was the standard source of illumination. Readings made without screening in the box and with screens in place, gave the data necessary to determine the light passing ability of the screen in question.

Airflow determination for the different screens was obtained by placing a sample of the screen in question over a 3 inch x 3 inch opening at the end of a pyramidal cone. At the large open end of this pyramid a fan was used to create a regular wind flow. An anemometer was placed two inches in front of the screen, so that the screen was between the wind source and the anemometer (Figure 3). Readings made with and without screening in place gave the comparative data necessary to determine the ability of the various screens to retard wind passage.

CALCULATION OF PERCENT ENTRANCE RETARDATION. It was recognized that the different traps would vary in their acceptability to sand flies for entrance and that this variance would, in large measure, be due to location, shading or shelter of the trap from wind. Another factor would be the density of larval breeding in the surrounding area. In the experiments, possible changes in entry acceptance capacity of

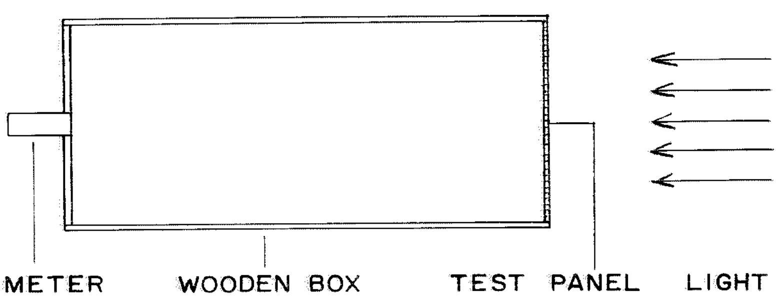

FIG. 2.—Device used to evaluate light penetration through screening.

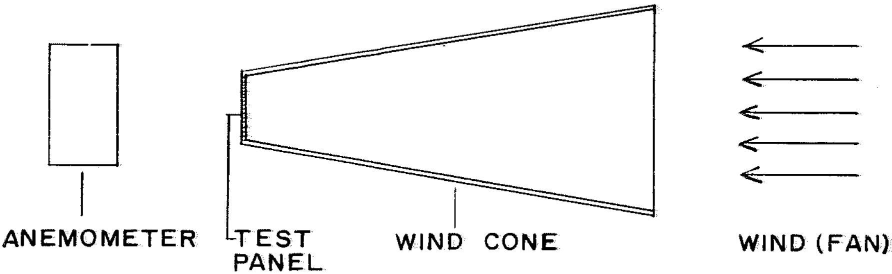

FIG. 3.—Device used to evaluate air flow through screening.

the traps were considered in utilizing the daily sand fly counts from all of the traps during a pre-treatment period when none were screened.

Entrance acceptability of the traps was determined by averaging 12 counts, replicated 3 times (12-day count) on each trap. If the pre-treatment counts on the unscreened cages vary from their counts during the tests, it is assumed that the same forces will be acting on the screened cages. Therefore, the entrance acceptance counts on the screened cages are corrected proportionately upward if more sand flies are found on the checks, or downward if fewer sand flies are observed. This is termed the "corrected normal count" and may be represented by the formula:

$$\text{Corrected normal count} = \frac{\text{—Avg. entrance count on checks during test period}}{\text{—Avg. entrance count on checks during pre-test period}} \times \text{Entrance acceptance counts of screened cage (or screen treatment)}$$

Percent sand fly entrance retardation is evaluated by comparing the corrected normal count with the treatment, thus:

$$\text{Percent entrance retardation} = \frac{\text{corrected normal count—treatment count}}{\text{corrected normal count}} \times 100$$

TEST RESULTS. In general, the results of the tests (Table 1) indicate that screening, even of the best available quality, is not satisfactory in itself for the complete exclusion of *C. furens.* The most satisfactory screening was 20x20 mesh plastic, excluding 96.3 percent of the sand flies; 20x20 mesh aluminum excluded 95.1 percent. The small apertures in these screens, however, also cut down on the airflow and light passage to a point where, in the semitropics, they are no longer satisfactory for use on buildings. These undesirable traits precluded the testing of screens of finer mesh, even though it can be assumed that screening of smaller aperture size probably would be sufficient to completely exclude these pests.

Of the remaining screen types tested, 18x14 plastic and 18x18 bronze were found to be the most practical. The number of sand flies excluded is reasonably close to that of the 20x20 mesh screening and yet the rate of airflow and light passage is materially greater.

However, it is entirely possible and indeed probable that either of these two screens would actually allow for sufficient sand fly entrance in dwellings to cause considerable annoyance and irritation, especially when the sand fly population is extremely high.

The larger numbers of sand flies penetrating 18x14 mesh aluminum, 18x14 bronze and 14x14 galvanized screening, eliminate them from further consideration.

Table 1 shows that in all of the screen

TABLE 1.—Exclusion factors of various mesh untreated screens used for sand fly retardation

Type screening and mesh in inches	Average size of screen openings (sq. inches)	Percent of light penetrating screening	Percent of air penetrating screening	Percent retardation of sand flies
Bronze 18x14	0.002694	65.3	75.4	83.4
Plastic 18x14	0.002288	55.7	70.3	94.6
Aluminum 18x14	0.002485	61.6	75.6	56.1
Galvanized 14x14	0.003648	67.3	80.2	45.5
Bronze 18x18	0.001895	63.8	71.5	90.0
Plastic 20x20	0.001444	50.0	65.2	96.3
Aluminum 20x20	0.001369	49.7	64.2	95.1

types tested there is a close correlation between the number of sand flies excluded and the amount of air and light passing through the screens, with the exception of aluminum 18x14 mesh screening. It can be surmised that the failure of this screening to exclude a larger number of sand flies than 18x14 mesh bronze screening which has larger apertures, is due to color differences of aluminum and bronze. The sand fly's reaction to these colors probably accounts for the greater degree of retardation by bronze over aluminum screening.

The literature reviewed and the results of the experiments herein reported indicate the necessity for fine mesh screening if 100 percent sand fly exclusion is to be obtained. Yet, the evidence seems pronounced that regardless of adoption of a screen with a specific aperture size, some few insects will penetrate. Witness the penetration of recommended screening by small sized *Aedes aegypti* (L.) (Block 1945, 1946), (Stearns and Gillespie, 1945), or the need to specify 16x16 mesh screening as a barrier to *Anopheles gambiae* Giles and *A. funestrus* Giles in West Africa (Davey and Gordon, 1938). The measurements of these mosquitoes are considerably greater (over 0.166 inch) than those of a specimen of *C. furens*, which measures only 0.0018 inch dorso-ventrally and 0.0018 inch from wing base to wing base. Theoretically, a screening of horizontal and vertical proportions slightly less than this would bar entry of all of these sand flies. This, however, would be prohibitive since the mesh would be too fine for practical purposes.

Summary. Seven different meshes of insect screens namely, 14x14 galvanized, 18x14 bronze, 18x14 aluminum, 18x14 plastic, 18x18 bronze, 20x20 plastic and 20x20 aluminum were evaluated as barriers to the entrance of the common salt-marsh sand fly, *Culicoides furens* (Poey). Four screens were found to exclude 90 percent or better of the sand flies, 20x20 aluminum, 20x20 plastic, 18x18 bronze and 18x14 plastic, but two of these, 20x20 aluminum and 20x20 plastic, excluded so much light and airflow that they are not ordinarily satisfactory for use in the tropics or semi-tropics.

The rate of airflow and light passage was determined for the seven screen materials tested. Its relationship is proportionate to the numbers of sand flies excluded.

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