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Wire mesh screening for the exclusion of houseflies

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INTRODUCTION

Since the introduction of the modern synthetic residual insecticides, with their efficiency and convenience, many older methods of controlling insects have been neglected. The steadily increasing problem of insecticide resistance, however, coupled with growing concern about the possible hazards of toxic residues, have forced us to realize that we may not be able to rely on chemical control measures indefinitely. This is especially true of that versatile insect, the housefly, which has shown itself capable of developing resistance to all the more potent modern insecticides.

Among the older fly control measures, suitable in particular circumstances, is screening, which may be desirable for excluding flies from hospitals, canteens and food manufacturing plants. Moreover, a screen capable of excluding houseflies would also keep out blowflies and wasps (the latter being especially troublesome in jam factories).

Examining the literature, one finds specifications of wire or cloth mesh for the exclusion of mosquitoes; and these are based on actual experiments, usually with anophelines (Davey & Gordon, 1938; Block, 1946). The textbook on the housefly by West (1951) notes that 'A mesh of 14 wires to the inch will exclude houseflies, blowflies and similar species, but it is better to use about an 18-mesh screening in order to exclude smaller insects at the same time'. This may be true in countries plagued with mosquitoes; but, indoors in Britain, these are seldom a problem and it seemed possible that a wider mesh might be adequate to exclude flies, blowflies and wasps. Such wider mesh would allow passage of more light and air and would be cheaper. Accordingly, some simple experiments were undertaken to determine the mesh size required.

WIRE MESH SPECIFICATIONS

The aperture size in wire mesh is dependent on the mesh number (i.e. number of wires per linear inch) and the thickness of the wire. The latter is graded by standard wire gauge (s.w.g.) numbers, which are a set of rather arbitrary figures, ranging from 7/0 (0·5 in.) to 1/0 (0·324 in.) and from 1 (0·3 in.) to 50 (0·001 in.), approximating to a geometrical series. Examples of diameters in the range likely to be used in insect screen gauze are as follows:

s.w.g.	16	18	20	22	24	26	28	30	32	34
d (in.)	0·064	0·048	0·036	0·028	0·022	0·018	0·015	0·012	0·011	0·009
(mm.)	1·63	1·22	0·914	0·711	0·559	0·457	0·376	0·315	0·274	0·234

As a result of the experiments on anopheline mosquitoes, the following recommendations have been made:

16 mesh, 31 s.w.g. (aperture 1·3 mm.). Excludes most mosquitoes.

18 mesh, 33 s.w.g. (aperture 1·15 mm.). Excludes all mosquitoes.

EXPERIMENTS WITH HOUSEFLIES

To determine the gauze dimensions necessary to exclude houseflies, some representative samples were obtained from Messrs N. Greening and Sons Ltd. (whose catalogue gives full details of all relevant dimensions). An extremely simple test method was employed. Batches of twenty to thirty flies were confined in glass jars (7 lb. jam jars) with the mouths covered with the gauze samples under test. Over each mesh, another jar was inverted to catch the flies which escaped. After 5 hr. the flies which escaped (and the remainder) were killed, counted and

Table 1. *Dimensions (mm.) of male flies which did not escape through 7/20 mesh and female flies which did escape. N.B. (a) With proboscis retracted. (b) Including wing base. (c) Pronotum to base of sternopleuron*

	Head		Thorax		Abdomen	
	Width	Depth[a]	Width[b]	Depth[c]	Width	Depth
Males	2·11	1·81	2·15	2·27	2·07	1·48
Females	2·12	1·84	2·35	2·35	2·37	1·91

Table 2. *Dimensions of gauze samples and numbers of flies which escaped through them. (Totals of 50 of each sex confined for 5 hr.)*

Gauze		Aperture length (mm.)		Flies escaped (x/50)	
Mesh	s.w.g.	Theoretical	Measured	Males	Females
7	20	2·71	$2{\cdot}75 \pm 0{\cdot}14$	8	23
8	22	2·46	$2{\cdot}49 \pm 0{\cdot}11$	4	6
9	24	2·26	$2{\cdot}25 \pm 0{\cdot}06$	2	3
10	32	2·26	$2{\cdot}17 \pm 0{\cdot}09$	0	0
10	24	1·98	$1{\cdot}77 \pm 0{\cdot}07$	0	0
12	31	1·82	$1{\cdot}79 \pm 0{\cdot}10$	0	0
14	32	1·54	$1{\cdot}53 \pm 0{\cdot}07$	0	0
18	32	1·16	$1{\cdot}16 \pm 0{\cdot}05$	—	—

sexed. The experiments were done at 25° C. in a lighted rearing room. The flies used were taken from a laboratory colony maintained at 25° C. The average weight of the males was about 17 mg. and of the females 24 mg. Some of their dimensions were measured by a low power microscope with a graduated eyepiece (Table 1). At the same time, the aperture dimensions of the gauzes were checked and found to depart slightly from their theoretical values (Table 2).

It will be noted that flies escaped from jars covered with gauze of 9 mesh and larger, but none got through 10 mesh or smaller. Curiously enough, more females escaped than males, presumably because their urge to escape was greater. A comparison of the mesh apertures with minimum fly dimensions shows that the flies had little room to manoeuvre, bearing in mind the necessity of getting through legs and wings. Unlike the mosquito, which has a narrow thorax, the fly cannot take advantage of the extra length of the diagonal, since its thoracic outline is nearly circular.

ADVANTAGES OF WIDER MESH FOR FLY EXCLUSION

It appears that 10 mesh, 32 s.w.g., can be used for fly exclusion with fair confidence; only occasional, undersized flies are likely to get through it. The larger fly mesh will exclude only 20% of the light as compared with 36% excluded by a standard mosquito gauze (18 mesh, 32 s.w.g.).

Wider gauze will allow better ventilation, though this is much more difficult to assess than might be expected. Three methods of measurement have been found in the literature. Eckert & Pflüger (1941) measured the pressure drop due to various wire gauze frames in a wind tunnel and thereby worked out various curves relating their characteristic resistance coefficients to wind speed. Lomax (1945) fitted mosquito gauze circles into a pendulum frame and recorded their effects in damping the oscillation of the pendulum. Croton & Crowden (1955) employed an electric fan and a kata-thermometer to determine the degree to which mosquito nets reduced air currents and their cooling effects. This last method seems to give the type of information desired; but it is rather vague and difficult to standardize. On the other hand, the technique of Eckert & Pflüger, though precise, demands rather elaborate equipment. Therefore, some tests with the simple pendulum method were undertaken.

For my tests, I used a stiff wire pendulum, 60 cm. long, suspended from two cotton threads. At the lower end, at right angles to the plane of oscillation, the wire was bent into a 12 cm. diameter circle. The various gauzes were fixed in this ring and the pendulum weight kept constant by addition of lead weights, when necessary. The pendulum was released at an angle of 45° to vertical and allowed to swing in still air. The numbers of oscillations were counted as the amplitude decreased to various angles. Results were based on the number of swings between 15° and 5° to the vertical. Over this range the gauze circle was moving at an average speed of 22 cm./sec. falling to 7·5 cm./sec. At this low speed, where no turbulence occurs, the air behaves as a viscous fluid and it may be assumed that the resistance of the grid is proportional to air velocity.* It can be shown that, under these conditions, the air resistance is proportional to the reciprocal of the number of swings to decrease from one given (small) angle to another. The actual equation (derived on the lines of the well known textbook of Ramsey, 1933) is

$$k = \frac{W \log \theta_1/\theta_2}{ag} \frac{1}{z},$$

where k = air resistance; z = number of swings between angles θ_1 and θ_2; W = weight and a = radius of the pendulum; g = gravity constant.

* This seems a satisfactory approximation for the lower air speeds relevant to ventilation. Eckert & Pflüger (1941) show that the curves relating the 'resistance coefficient' to air speed bend sharply at higher velocities, as turbulence behind the grid wires begins to introduce an additional factor. In the higher range, resistance is related to the square of the air velocity.

Using the data for 10 mesh, 32 s.w.g. gauze given in Table 3, the reciprocal of the number of swings can be plotted against the percentage obstruction of the pendulum (see Fig. 1). There is a good linear relationship, which can be fitted by the equation

$$y = 0{\cdot}001557(x+8{\cdot}07)$$

(where y = reciprocal of swings; x = % occlusion). When $y = 0$, corresponding to the infinite number of swings expected with no air resistance, $x = -8{\cdot}07$. This value is due to the air resistance of the pendulum frame (apparently equivalent to 8 % of the area of the circle).

On this basis, exclusion of air, like that of light, is linearly related to the area of

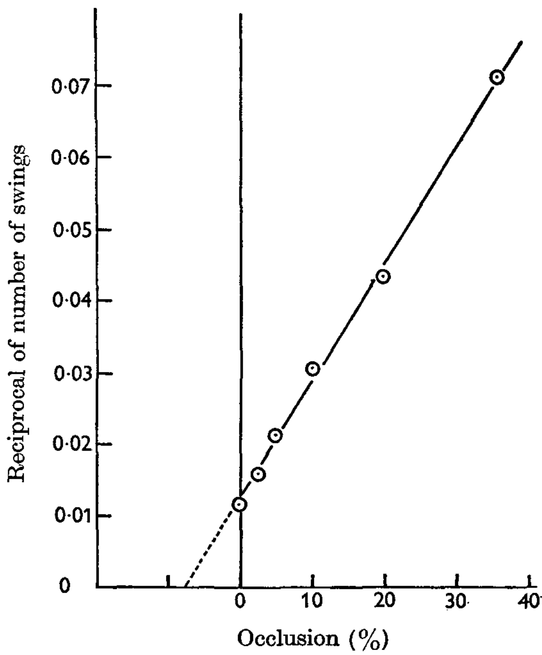

Fig. 1. Damping of a pendulum by air resistance of a circle of wire gauze. Relations between reciprocal of the number of swings between 15° and 5° and the occlusion of the circle by gauze.

Table 3. *Results of tests with the pendulum method of gauze assessment* (*Lomax*, 1945)

Pendulum circle			
Nature of obstruction	Obstruction (%)	No. swings 15° to 5°	$\frac{1}{\text{no. swings}}$
Empty	0	86	0·0116
Strip of 10/32 gauze filling $\frac{1}{8}$th circle	2·5	63	0·0159
Strip of 10/32 gauze filling $\frac{1}{4}$ circle	5·0	47	0·0213
Strip of 10/32 gauze filling $\frac{1}{2}$ circle	10·0	32·5	0·0308
Disc of 10/32 gauze filling whole circle	20·0	23	0·0435
Disc of 18/32 gauze filling whole circle	36·0	14	0·0714
Disc of 10/24 gauze filling whole circle	39·0	13·5	0·0741

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the obstructing wires. Such a relationship will tend to be distorted as the percentage obstruction increases to an extent that an appreciable proportion of air flows round the pendulum circle, instead of through it. Yet the linear relation appears to hold over the range covered, with wires of the same thickness. In short, exclusion of light and air by a fly gauze would be about half that caused by mosquito gauze.

A final advantage of the wider gauze is that, whatever metal is used, its cost will only be about half that of the finer mosquito gauze. This may be some consideration where a large building is to be proofed.

SUMMARY

Control of houseflies by modern insecticides is becoming unreliable owing to emergence of resistant strains, so that some older measures deserve reconsideration. Exclusion of mosquitoes by gauze has been studied experimentally but not, apparently, of houseflies.

Some simple tests show that a suitable gauze to exclude houseflies (and larger insects) would be 10 mesh 32 s.w.g. with an aperture 2·17 mm. square. This compares with a gauze recommended for excluding mosquitoes, 18 mesh and 32 s.w.g. with an aperture 1·16 mm. square.

The advantages of the wider gauze for flies are admission of more light and air and lower cost. Some simple experiments on the relative air resistance of mosquito and fly gauze were made by a method involving retardation of a pendulum by a gauze circle. The results suggest that the obstruction to ventilation is roughly proportional to the percentage obstruction (as with light) which was 20 % for the fly gauze and 36 % with the mosquito gauze.

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