once prodigious *Ae. aegypti* populations from Louisiana, and *L. culicis* might have figured in an adjunctive role.

The special study in Monroe, in which *Ae. aegypti* larvae developed normally after being introduced into sites from which they had spontaneously disappeared, suggests that an agent (agents) which may have figured in the demise of the mosquito was obligatory, and had, in turn, disappeared. *L. culicis* would fit this picture since it is apparently specific for *Ae. aegypti.*

SUMMARY. A survey was conducted during 1968 on the distribution, density and effects upon *Ae. aegypti* of *L. culicis* in an area extending from Temple, Texas, to Pensacola, Florida. The heaviest and most widespread distribution of *L. culicis* was coincident with flourishing populations of *Ae. aegypti.* There was no indication that the parasite presently exerts a serious limiting effect upon *Ae. aegypti* populations observed. However, *L. culicis* might act to potentiate the deleterious effects of other parasites, or of insecticides, or to render the infected individual less able to cope with adverse environmental factors.

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WET FILTER PAPER AS AN OVIPOSITION SUBSTRATE FOR MOSQUITOES THAT LAY EGG-RAFTS

CHARLES E. OSGOOD

Research Institute, Canada Department of Agriculture, Belleville, Ontario, Canada

INTRODUCTION. It is general practice, when rearing many mosquito species that lay their eggs singly, to provide moist paper towels or filter paper as oviposition substrata (Gerberg, 1970). This technique probably arose from observations that in nature these species usually oviposit on moist debris near the edges of their breeding pools.

In contrast, mosquitoes that lay their eggs in groups to form "egg-rafts" are generally considered to select free water surfaces for oviposition (Wallis, 1954). This assumption had been widely held for mosquitoes of the genus *Culex* (e.g. Carpenter and La Casse, 1955; King *et al.*, 1960) until Mattingly (1970) recognized this belief as incorrect and listed the following exceptions: *C. abominator* Dyar and Knab on the upper surface of *Lemna* fronds (Coad, 1913); *C. chrysonotum* Dyar and Knab on grass or sedge about one inch above the water surface (Arnett, 1948); *C. territans* Walker from above the water line to as much as 6–8 inches above it (Knab, 1904); *C. fergusoni* Taylor and *C. douglasi* Dobrotworsky on moist filter paper 2–5 and 1–3 inches respectively above the water line (Dobrotworsky, 1956); and *C. hayashii* Yamoda and *C. infantulus* Edwards on wet filter paper in the laboratory (Bohart and Ingram, 1946). In addition to Mattingly's citations, Hair (1968) found that *C. pilosus* (Dyar and Knab) was "attracted" to soft, moist mud for oviposition, and *C. peccator* Dyar and Knab was reported (Chapman and Barr, 1969) to lay most of its egg-rafts on moist paper toweling "well above the water line." Kennedy (1942) observed that an autogenous member of the *C. pipiens* complex laid 66 percent of its egg-rafts on open water when given a choice between open water and a water-soaked pad of white lint under "normal" room lighting. When he repeated this experiment in complete darkness the egg-rafts were distributed equally between the two media.

In addition to the *Culex* oviposition records, *Culiseta morsitans* (Theobald) lays its eggs 1.5 to 2 inches above the water line on moist substrate (Wallis and Whitman, 1968); and females of *Mansonia titillans* (Wlk.) attach their egg-rafts to the undersurface of the leaves of water lettuce (King *et al.*, 1960).

It is obvious from these numerous examples that many egg-raft-forming mosquitoes do not necessarily oviposit on open water. In this paper, oviposition by three additional raft-forming species on wet filter paper is reported and the advantages that can be derived from this behavior for experimental and colony maintenance procedures are discussed.

MATERIALS AND METHODS. Individual blood-fed stock colonies of *Culex pipiens* L., *Culex tarsalis* Coquillett and *Culiseta inornata* (Will.) that were ready to lay were given a choice between ovipositing in a 100 x 50 mm crystallizing dish containing two sheets of 9-cm, Whatman® #3 quantitative filter paper wetted with 10 ml of distilled water and in a similar dish containing approximately 100 ml of distilled water. Each replicate test was conducted during a single 9-hour dark period.

RESULTS AND DISCUSSION. It is apparent from Table 1 that females of each of the three species lay as readily on wet filter paper as on open water.

The use of filter paper for egg-laying proved useful in oviposition experiments with *Culex tarsalis* in which it was found that some of the materials being tested lowered the surface tension to such an extent that gravid females were unable to rest on the surface of the water and drowned while attempting to lay their eggs (Osgood, 1970). The use of wet filter paper in subsequent experiments provided a substrate upon which females could oviposit without being affected by surface tension.

This filter-paper technique may prove useful for testing oviposition repellents that are insoluble in water. The substances could be placed on one area of a piece of wet filter paper to present a side by side choice between the test material and the wet paper surrounding it. Promising compounds of this type could be used in conjunction with water emulsifiers or surface spreaders for application in mosquito control.

Most mosquitoes will not lay unless minimum substrate moisture levels are exceeded. Knight and Baker (1962) reported that *Aedes sollicitans* (Walk.) and

TABLE 1.—Oviposition responses of gravid mosquitoes to wet filter paper versus distilled water.

Species	Number of egg-rafts on distilled water	Number of egg-rafts on filter paper
	(Mean $\pm S_{\bar{x}}$ of rafts laid/replicate)[a, b]	
Culex pipiens	117.0 ± 14.4	98.0 ± 2.3
Culex tarsalis	105.0 ± 7.5	87.3 ± 20.8
Culiseta inornata	21	30

[a] Number of replicates/species = *C. pipiens* (3), *C. tarsalis* (4), *C. inornata* (1).
[b] Paired t-test indicates no significant differences between treatments ($P > 0.05$).

A. taeniorhynchus (Wied.) would not oviposit on gauze wicks when the moisture content was less than 45 percent by wet weight. Although minimum moisture levels were not established for the three species tested in the present paper, it was determined that 10 ml of distilled water on 2 thicknesses of filter paper permitted oviposition by *Culex tarsalis* when the dishes were placed in the cage one hour before commencement of the 9-hour oviposition period at 75° F and 45 percent RH. Under the same conditions *C. tarsalis* did not oviposit when provided with one sheet of filter paper wetted with 3 ml of distilled water.

For mosquito rearing, egg-rafts laid on filter paper are easily handled since by sectioning the paper the desired number of rafts can be transferred to each rearing pan, thus eliminating individual handling of large numbers of rafts.

Although *Culex pilosus* (King *et al.*, 1960) and *Culiseta inornata* (Buxton and Breland, 1952) have been shown by experiment to lay eggs possessing some degree of resistance to desiccation, the other raft-forming species mentioned in this paper have not been reported to possess this characteristic. This would suggest that the substrate retains sufficient moisture to maintain the eggs until they hatch. Indeed, raft-forming mosquitoes that lay above the water surface usually oviposit within a few inches of the water. Egg-placement above the water surface may be influenced by fluctuations in water level; or, because the eggs are relatively defenseless and vulnerable to attack by aquatic predators when floating on the water surface, may have selective value by permitting the eggs to hatch unmolested. Although terrestrial predators do feed on mosquito eggs under some circumstances (e.g. ants, Hinton, 1968), most of the mosquito species cited in this paper oviposit very close to the water margin where, under normal conditions, high moisture and wave action may tend to discourage foraging by predators.

Summary. *Culex pipiens, Culex tarsalis* and *Culiseta inornata* laid their egg-rafts as readily on wet filter paper as on free water when given a choice between the two media. Wet filter paper is useful when testing ovipositing mosquitoes' responses to materials with high surfactancy because the filter paper serves as a substrate upon which laying females can support themselves. Furthermore, large numbers of egg-rafts laid on filter paper can be quickly and easily transferred from oviposition dishes into rearing pans.

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EVALUATION OF SMOKE FROM INSECTICIDAL COILS CONTAINING SYNTHETIC PYRETHROIDS AS MOSQUITO REPELLENTS[1]

J. H. FALES, C. G. DURBIN, JR., AND G. D. MILLS, JR.
Entomology Research Division, Agr. Res. Serv., U.S.D.A., Beltsville, Maryland 20705

Fales *et al.* (1968) used a method of evaluating the repellency to mosquitoes of smoke from coils treated with insecticides to compare the repellency of pyrethrins or allethrin against *Culex pipiens pipiens* L. The same method was used to compare the repellency of the following pyrethroids with 0.5 percent pyrethrins:

trans-(+)-allethrin (concentration of 0.5 percent)

tetramethrin (concentration of 0.5 percent)

S. B. Penick SBP-1382 (NRDC-104) (5-benzyl-3-furyl)methyl *cistrans*-(±)-2,2-dimethyl-3-(2-methylpropenyl)cyclopropanecarboxylate (concentrations of 0.5, 0.25, and 0.125 percent)

S. B. Penick SBP-1390 (NRDC-107) (5-benzyl-3-furyl)methyl *trans*-(+)-2,2-dimethyl-3-(2-methylpropenyl)cyclopropanecarboxylate (concentrations of 0.5, 0.25, and 0.125 percent)

The coils were prepared by dipping them in benzene solutions containing the insecticide.

As in the earlier test, two wire cages of the same size (50.8 x 50.8 x 25.4 centimeters) were used. One cage containing about 50 mosquitoes (*C. p. pipiens* reared from egg rafts collected in nature) was placed inside a 28.3-m^3 chamber; the other just outside the chamber was connected to the first cage by a large (20.3-centimeter diameter) glass tube. When the coils were burned on the floor of the chamber, the test insects could move from the cage exposed to the smoke to the outside cage. Repellency was measured by the percentage of mosquitoes that left the exposed cage during a 20-minute exposure to the smoke. The doses of coil were measured in weight (grams=g) of coil burned. Thus, *trans*-(+)-allethrin and tetramethrin were both tested with 0.25, 0.5, and 1 g of coil; SBP-1382 and SBP-1390 were tested with 0.25 g of coil; and the pyrethrins standard was tested at 0.25 g of coil. Blank coils were tested with each lot of mosquitoes.

The results are given in Table 1. The repellency of the pyrethrins standard was only slightly less than in the earlier test (42 percent). Also, the untreated blanks again had little repellency.

Trans-(+)-allethrin was one-half as effective as pyrethrins at a dose of 0.25 g and only approximated the repellency of the standard when the dose of coil was

[1] Mention of a pesticide in this paper does not constitute a recommendation of this product by the U.S.D.A.