which are obviously weak or partially digested can be pre-recorded as such prior to testing so that they can be distinguished from full blood-meals which do not react. A separate category for weak samples not expected to react can thus be constructed.

SUMMARY AND CONCLUSIONS. Agar gel diffusion is a suitable method for the identification of mosquito blood-meals. The system has several advantages over other techniques particularly for screening large numbers of specimens. In many circumstances, a combination of agar gel for broad screening and capillary tube identification of specific hosts is advisable.

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EFFECT OF FELLING MANGROVES ON EMERGENCE OF *CULICOIDES* SPP. IN JAMAICA

JOHN B. DAVIES [1]

INTRODUCTION. In Jamaica, three species of biting sand flies (Diptera:Ceratopogonidae) are commonly associated with tidal mangrove swamp. *Culicoides furens* Poey and *C. barbosai* Wirth and Blanton are the main nuisance species, while a third, *C. insignis* Lutz is present in low numbers and only very rarely bites man.

An investigation into the breeding distribution of these species in which 16 emergence traps were placed in a transect across a 70-yard width of tidal swamp for 46 days showed that *furens* was associated with the drier white or black mangrove belts. *C. barbosai* tended to be confined to the seaward red mangrove belt and *insignis* was generally distributed across the swamp (Davies 1967).

When the original data from the above survey were grouped according to the shadiness of each trap site the results indicated that there was an association between shade and the numbers of each species caught, as shown in Table 1.

In the table, "shade" indicates traps that were shaded for more than three-quarters of the day; "half shade," for between a quarter and three-quarters of the day; and "open," for less than a quarter of the day. Because the distribution of *furens* was limited to the drier part of the swamp it was taken in only 12 of the 16 traps. The data in the table have been adjusted to allow for this.

The results show that while all species preferred some degree of shade there were great differences in the degree of preference. Compared with the "open" sites, *barbosai* was 22.8 times more abundant in the shade, while *furens* was less sensitive, with only 2.87 times as many. On the other hand *insignis* was more abundant in the "half shaded" habitat.

Whether this preference was determined by the presence or absence of shade alone or whether another factor was involved was not known. There was an obviously greater humus content in the

[1] Mosquito-Sandfly Research Unit, Jamaica. Present Address: Trinidad Regional Virus Laboratory, P.O. Box 164, Port-of-Spain, Trinidad.

TABLE 1.—Average numbers of *Culicoides* recovered over a period of 46 days from 16 emergence traps grouped according to shadiness of site. [Numbers of traps averaged in each group given in brackets].

Site	Average number per trap		
	furens	*barbosai*	*insignis*
Open	20.7 [3]	4.8 [4]	2.8 [4]
Half Shade	37.5 [4]	35.6 [5]	11.6 [5]
Shade	59.6 [5]	108.3 [7]	7.7 [7]
Mean for all sites	42.5 [12]	39.7 [16]	7.2 [16]

mud in shaded areas beneath mangroves. Bidlingmayer (1957) had found that the *furens* population in ditches in Florida was not increased by artificial shading, and suggested that humus content might be the deciding factor. In Jamaica *furens* may often be found breeding in open mud 50 feet or more from the nearest shade.

AIMS AND METHODS. To examine whether distribution was determined by shade or humus content a study area was chosen in the Bogue Swamps, west of Montego Bay, Jamaica. The site consisted of a tidal mangrove swamp some 110 yards in width, supporting an almost pure stand of white mangrove (*Langun-*

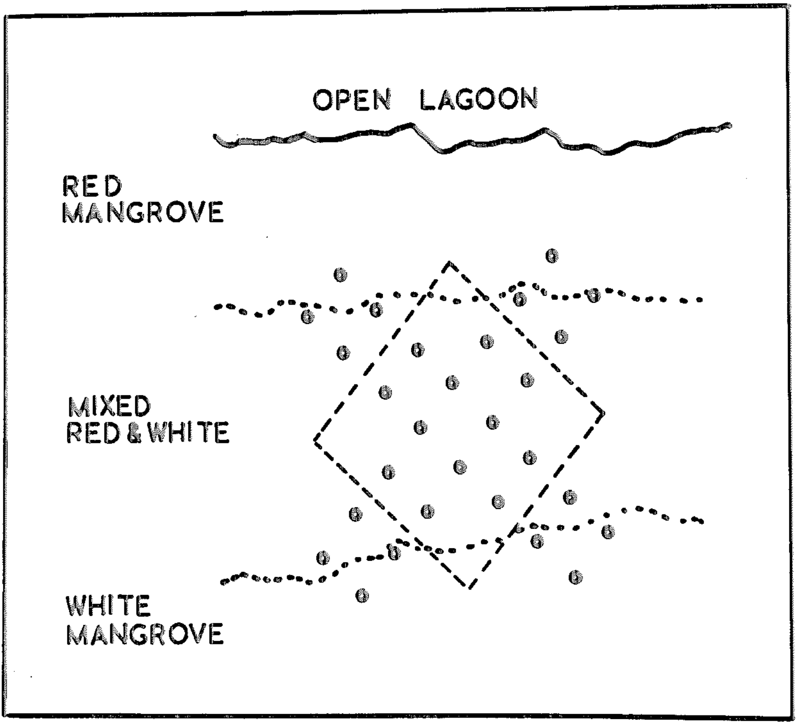

FIG. 1.—Sketch showing the arrangement of the emergence traps (circles) in relation to the rectangular cleared area and the vegetation zones in the swamp. The distance between the traps is three yards.

cularia racemosa) saplings 1 to 2 inches in diameter, and bearing a continuous canopy at about 12 feet. Towards the sea the white mangrove was replaced by a narrow belt of red mangroves (*Rhizophora mangle*). The black mud beneath the saplings was moderately firm and was covered by a mat of roots and pneumatophores, some of which were covered by a green algal felt. The area was flooded to a depth of about 6 inches by average high tides.

In the transition zone between the white and red mangroves 14 pairs of emergence traps were placed along two intersecting lines in the form of a cross (Fig. 1). Each trap was made of roofing felt shaped into a cone with a basal area of 2 square feet. Insects emerging from the mud beneath the traps were caught in greased glass jars inverted over a hole in the apex of each trap. It was intended that once the overall distribution and density had been determined an area of 12 yards square at the intersection of the two lines of traps would be completely cleared of vegetation. Observations would then be continued to determine whether any change in density occurred between the now unshaded central area and the surrounding natural swamp. Any change that did take place could then be attributed to the absence of shade alone, since it was unlikely that the humus content of the mud would change appreciably during the course of the experiment.

The traps were set out on 9 January 1964 and visited twice a week in order to change the catching jars. At the same time each trap was moved about one yard sideways to a predetermined position to avoid the accumulation of *Culicoides* larvae that may take place beneath a stationary emergence trap (Davies 1966). After 3 weeks of trapping the distribution of sand flies was considered to have been adequately estimated, and all vegetation in the central area was felled and the trash removed. Thereafter catching continued for a further 6 weeks after which the experiment was discontinued. At that time it was thought that the duration of the larval stage of all three species was of the order of 3 weeks. This has recently been confirmed for *furens* by Linley (1968) who also determined that the complete life cycle occupied 34–36 days for that species. Hence any change in population should have been apparent by the 6th week after removing the vegetation.

Almost one year later the area was revisited and it was noticed that the vegetation had shown very little regrowth. A number of stumps had put out shoots which had grown to a height of 3 or 4 feet, but many had died, leaving the area still very open. To determine whether there had been any long term effect, the traps were replaced and operated for an additional 4 weeks.

RESULTS. For the purpose of this analysis, the total number of sand flies (both sexes) of each species taken by each trap each week was taken as the unit of population estimate. From these data the average catch for the 12 center and 16 outer traps was obtained, to give the average weekly emergence rate for each area. Since the emergence rate of sand flies from a tidal swamp, and particularly *barbosai*, may vary considerably from week to week depending on the state of the tides, the estimates obtained were again averaged over the whole 3-week period before clearing, two 3-week periods after clearing, and the 4-week observation period 1 year later. These results are given in Fig. 2. As a further comparison the ratio of the catches between the outer and inner areas is also given.

In the 3 weeks before clearing, the outer traps caught slightly more *barbosai* than the inner area, 51.0 per trap-week compared with 44.0 per trap-week, with an overall ratio of 0.86 (weekly ratios; 0.91, 0.62, & 0.92). In the 3 weeks following, the ratio dropped to 0.59 (0.34, 0.64, & 0.70) rising to 0.68 (0.72, 0.62, & 0.84) in the next 3-week period, showing a general but slight reduction in emergence rate in the cleared area. However, it is unlikely that this reduction was enough to have any practical significance.

Almost one year later, *barbosai* was

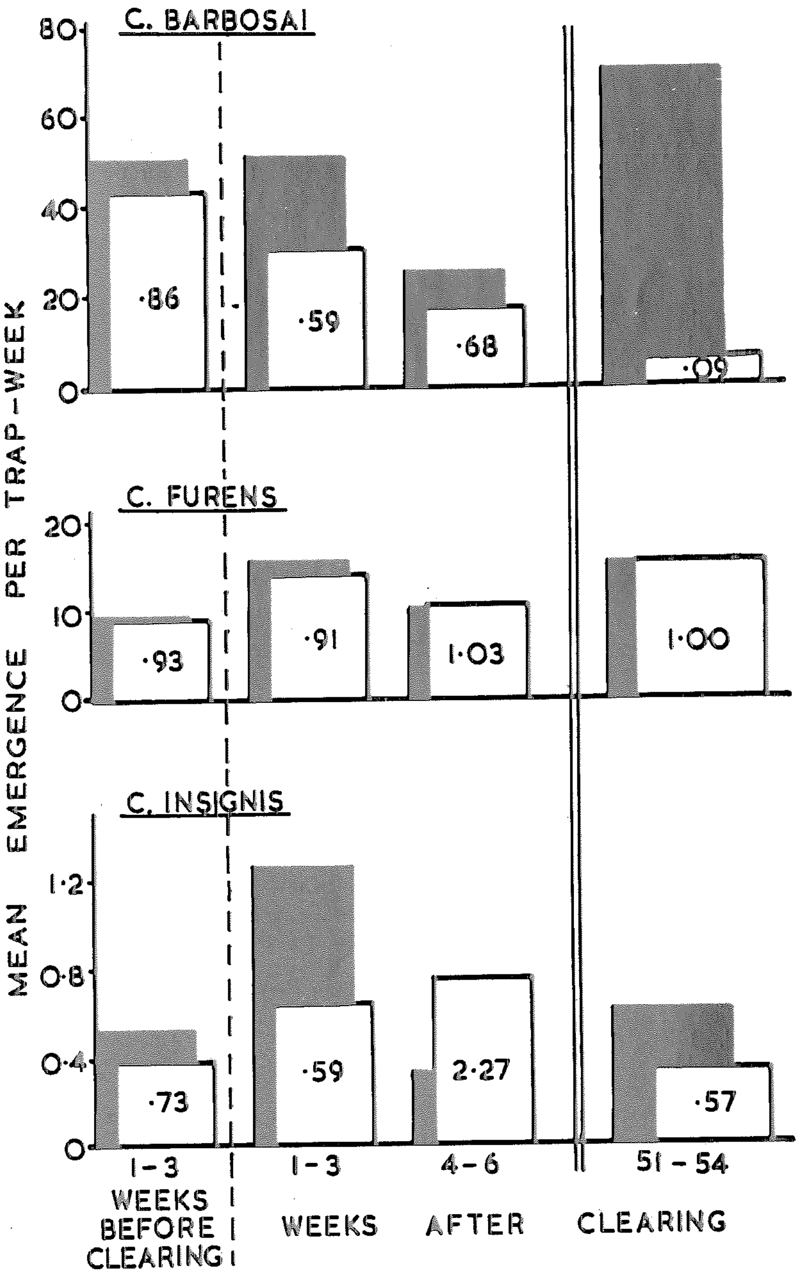

FIG. 2.—Mean catches of three species of sand flies from 16 emergence traps in undisturbed swamp (solid columns) and 12 traps in the cleared area (open columns) before and after the vegetation was removed. The ratio of the catches between the two areas is also given.

very much reduced in the central cleared area where the mean catch was 6.75 per trap-week compared with 71.5 per trap-week in the outer area, giving an overall ratio of 0.09 between the areas. This was consistent over the 4-week sampling period, the weekly ratios being; 0.03, 0.09, 0.13, & 0.19. The density of this species had been reduced to the order of one-tenth of its natural level by the vegetation removal.

C. furens appears to have been unaffected by the clearing. At the beginning, the ratio between the areas was 0.93 (weekly ratios; 0.98, 0.79, & 0.94) and over the six following weeks it was 0.95 (weekly ratios; 0.94, 1.22, & 0.86, and 1.80, 0.84, & 1.49). One year later, densities in the two areas were almost the same with an overall ratio of 1.0 (weekly ratios: 0.73, 0.91, 1.37, and 0.12).

The low numbers and erratic appearance of *insignis* make comparison difficult. However, there was no evidence to suggest that clearing the vegetation had any long term or immediate effect on its density.

DISCUSSION. Felling the mangroves appeared to have no immediate effect on the emerging populations of any of the three species of sand fly concerned in this study. When this experiment was planned it was assumed that the main selection between shaded and unshaded habitats would be made by the ovipositing female sand fly. This stage in the life cycle seemed to be the most likely to be able to distinguish between the two and by this selection the greatest influence on the distribution of the larvae would be achieved. It was thought unlikely that larvae would be able to migrate far enough to affect the population distribution to any great extent. The 6 weeks post-clearing observation period was based on the assumption that the immature stages of the life cycle occupied some 3 to 4 weeks. Hence adults emerging under the traps after the fourth week could be expected to be the progeny of eggs laid by females which had exercised their choice between the two areas.

The lack of change in population in the fifth and sixth weeks after clearing suggests that either the larval stage took longer than 3 weeks, or the ovipositing females did not make any distinction between the two areas. Other laboratory studies have since shown that *barbosai* may take 7 weeks or longer to develop through the immature stages (Davies 1965). This period is variable and depends on the habitat and food supply. Clearly the post-clearing observation time was not long enough.

One year later, when the population must have become stabilized it was obvious that *barbosai* showed a preference for the undisturbed swamp while both *furens* and *insignis* were unaffected. This is in keeping with field experience since *barbosai* has never been recovered from open mud whereas both *furens* and *insignis* have. It is possible that *barbosai* is attracted by obstructed ground cover since its distribution is usually confined to the red mangrove belt where stilt roots form a dense thicket up to three feet above the mud. Even where tidal conditions in the more open black mangrove areas are identical and shade conditions are similar, *barbosai* is absent. The continued presence of *furens* and *insignis* suggests that the nature of the mud showed little change. It is concluded that *barbosai* is primarily governed by shade in its distribution whereas *furens* and *insignis* are more influenced by other factors of which the nature of the mud is probably the most important.

POSSIBILITIES FOR CONTROL. In some areas of Jamaica, *barbosai* is the main nuisance species of sand fly. These areas are usually limited in extent so that it would be feasible to fell the red mangroves along the seaward edge of the swamps. Great care would have to be taken to leave sufficient length of stump so that the trees are not killed and regeneration can take place, otherwise the stabilizing effect of the trees on the swamp might be lost. There is no indication that this technique would be effective against *furens* or *insignis*.

ACKNOWLEDGMENTS. I am grateful to T. A. Castle, K. Chin, J. HoFatt and E. Foster for their assistance in collecting and sorting the trap material.

SUMMARY. To test the association between the breeding density of the sand flies *Culicoides furens, C. barbosai* and *C. insignis* and the shadiness of the habitat, the overall density of breeding in a mangrove swamp was estimated by means of 28 emergence traps. A 12-yard-square area in the centre was then cleared of vegetation and observations continued for a further 6 weeks. No appreciable change in density was observed over this period. One year later, however, the density of *barbosai* had been reduced to about one tenth of that in an untouched control area, but the densities of *furens* and *insignis* were still unchanged. It is suggested that felling the mangroves might be a feasible abatement method for *barbosai* in areas where this species is dominant and the breeding area limited in extent.

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WHITE EYE, A FEMALE-STERILE AND SEX-LINKED MUTANT OF *CULEX TRITAENIORHYNCHUS*

RICHARD H. BAKER

Pakistan Medical Research Center, 6, Birdwood Rd., Lahore, West Pakistan and the Institute of International Medicine, University of Maryland School of Medicine
Baltimore, Maryland 21201

A number of interesting mutants have been found in *Culex tritaeniorhynchus*, an important vector of Japanese encephalitis virus and West Nile virus, from various colonies collected in East and West Pakistan (Baker and Aslamkhan, 1968). This paper describes one of these mutants, white eye (*w*). White eye appears to be a fairly common eye color mutant in most species of mosquitoes where genetic studies have been carried out. It has been found in *Anopheles pharoensis, Anopheles gambiae,* and *Anopheles quadrimaculatus* (Kitzmiller and Mason, 1967), the *Culex pipiens* complex (Gilchrist and Haldane, 1947 and Laven, 1967), *Culex tarsalis* (Barr and Myers, 1966), and in *Aedes aegypti* (Bhalla 1968). Thus far, white eye appears generally to be sex linked for all species except in *C. tarsalis* where it appears to be autosomal. The white-eye mutant in *C. tritaeniorhynchus* is also sex linked, but differs from these mutants in that homozygous white-eye females are generally sterile.

In *Culex tritaeniorhynchus*, another sex-linked mutant, golden (*go*), was previously reported (Baker 1968). In that case, sex appeared to be determined by a single pair of alleles *M* and *m*, or a segment of