BREEDING SITES OF *CULICOIDES PARAENSIS* AND OPTIONS FOR CONTROL BY ENVIRONMENTAL MANAGEMENT[1]

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INTRODUCTION

Culicoides paraensis (Diptera: Ceratopogonidae) is the primary vector for many urban outbreaks of Oropouche virus disease in the Amazon Basin *(1-4)*. Outbreaks of this acute febrile illness commonly occur with high attack rates, up to 44% of the population being affected *(1)*. Surveillance of man-biting arthropods during outbreaks of the disease have shown *C. paraensis* to be the most common diurnal anthropophilic insect in the affected urban areas *(3)*. In addition, this biting midge is a major pest in urban areas because its bite produces frequent and significant physical discomfort and dermatologic reactions *(5, 6)*. Documentation of the strong association of *C. paraensis* with domestic environments and its anthropophilic behavior has been presented elsewhere *(1-6)*. The purpose of this article is to present the results of studies that characterize *C. paraensis* breeding habitats in field locations having dense populations of these medically important midges.

MATERIALS AND METHODS

The Study Site

An agricultural research station located on the grounds of IPEAN (Instituto de Pesquisas e Experimentação Agropecuária do Norte) in Belém, Pará, Brazil served as our study site. Belém,

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the capital of the state of Pará, is located at the mouth of the Amazon River and has been the site of several major Oropouche virus disease epidemics *(1)*. The agricultural research station had been established, in part, to conduct research on the cacao tree, a fruit-bearing tree that produces the cocoa seed from which chocolate is derived. Our specific study site, encompassing an area of 10–15 hectares, was located in an area where cacao was being cultivated and that supported dense populations of *C. paraensis*.

Four general types of habitat were found in the study area, these being (1) mixed plots of mature cacao and banana trees, (2) marsh, (3) grassy areas, and (4) a monoculture of maturing deciduous trees. Banana plants are commonly planted with or before cacao as a sun-screen for the maturing cacao plants. Marsh areas with dense, low-growing vegetation and mixed primary and secondary forest stands bordered two portions of the study area.

The fruit pods of the cacao tree are normally picked by hand and taken to a centralized location where the pods are split in half to remove the cocoa seeds and meat. The hulls are then routinely discarded in piles that gradually decay. While they are decaying, however, the discarded hulls serve as reservoirs of organic matter and water that offer ideal breeding sites for a wide variety of invertebrates.

Banana plants are pruned periodically to keep them growing and bearing fruit. A common practice in Brazil is to leave the pruned parts on the ground to decay, and sometimes to cut them into smaller sections to facilitate the degradation process. Banana stumps, short basal portions of the plants that remain after the main stalks have been cut, will also decay. However, both the stalks and stumps require several weeks to decay; and during this time the vegetative matter is high in water content.

Breeding Site Surveillance

The potential breeding habitats available at the study site were monitored with the emergence traps described below. Habitats evaluated as breeding sites were cacao leaf litter, banana stumps, decomposing banana stalks, leaf axils of banana plants, piles of discarded and decomposing cacao hulls, and stagnant water within the marsh area. Breeding site surveillance was conducted from June 1977 to June 1978.

Trap locations were changed at two to three week intervals to avoid depleting the populations of immature *C. paraensis*. Each type of potential breeding habitat was monitored continuously with no less than two emergence traps. All collecting containers were examined periodically, and the *Culicoides* within were identified, counted, and recorded. Fresh containers were installed at the time of each collection. This sampling program was designed to quantify gross differences in breeding patterns at different sites over a one-year period.

Emergence Traps

Emergence traps used in this study, designed for sampling habitats associated with banana cultivation, are shown in the accompanying photographs. All were constructed with one or more removable transparent adult collecting containers affixed atop a larger, opaque emergence chamber covering the breeding site or sites. Although the structure of the emergence chambers varied with the type of breeding site being sampled, the collecting containers were always identical. Each of these collecting containers consisted of a funnel inverted so that the narrow end led into a 250 ml specimen cup. *Culicoides* midges were trapped when they emerged into the emergence chamber and subsequently entered the collecting container via the inverted funnel. A 70% alcohol solution was added to each container to kill and preserve the specimens. The trap was designed to take advantage of the positive phototaxis of *C. paraensis*.

One type of trap (designated Trap A) was made by attaching a black 2–3 mil plastic sheet to a pyramidal wooden frame. The trap (shown in Photo 1) was 1.2 m high, covered 1 m^2 of surface area, and could cover three to five sections of decaying banana stalks. Identical or similar traps were used to sample piles of decaying cacao hulls (Photo 2) and marshland habitats.

Trap B (shown in Photo 3) was designed to collect emerging adults from individual upright banana stumps. The emergence chamber of this trap consisted of a one-gallon paperboard "ice-cream carton" that was open at one end. The carton was made water-resistant by impregnating it with melted wax. A 10–12 inch surgical stockinette was attached to the open end, and this served as a sleeve that fit over the banana stump. A collecting container was attached over a small opening at the top of the chamber. The whole trap was covered by a small plastic trash sack to protect it from the weather.

Trap C was used to sample the large leaf axils of banana plants. The trap was made by encircling the upper two-thirds of the banana plant with heavy black plastic and placing two adult collecting containers near the top of the plastic cylinder. Wire spacers were placed between the tree and the plastic sheeting to provide adequate space for fly movement into the adult collecting containers.

Trap D (shown in Photo 4) was employed to sample the decomposing cacao leaf litter. This trap was constructed of modified disposable plastic mouse cages 10.5 × 8 × 4.5 inches. A small circular hole about 5 cm in diameter was cut out of the top and fitted with a half-pint container for collecting the adult midges. The disposable cage was turned upside down over the leaf litter and covered with heavy black plastic to exclude light and promote movement of adults into the collecting chamber.

RESULTS

Specimens of *C. paraensis* were collected at three of the six habitats sampled (Table 1). The banana stalks yielded the largest number of specimens, followed by the cacao hulls and then the banana stumps. No *C. paraensis* were collected from banana leaf axils, or from the cacao leaf litter or marshland habitats. Consequently, sampling of the cacao leaf litter and marshland habitats was discontinued in February and March 1978, respectively. Leaf axil sampling was only conducted for three months.

Culicoides paraensis was the principal species of *Culicoides* found breeding in decaying banana stalks. During some months cacao hulls yielded smaller numbers of *C. paraensis* than did the banana stalks. Both habitats, as well as the marshland habitat, produced other species of *Culicoides* biting midges (Table 2).

Considerable variation was observed in the *C. paraensis* emergence patterns at the two primary breeding habitats providing banana stalks and cacao hulls. As Figure 1 shows, the emer-

Photo I (above): A typical emergence trap (type A) used for sampling adult *Culicoides* as they emerged from decaying banana stalks. Three to five sections of banana stalks are covered by the trap. Photo 2 (below): Another type A emergence trap used to sample *Culicoides* midges emerging from discarded cacao hulls.

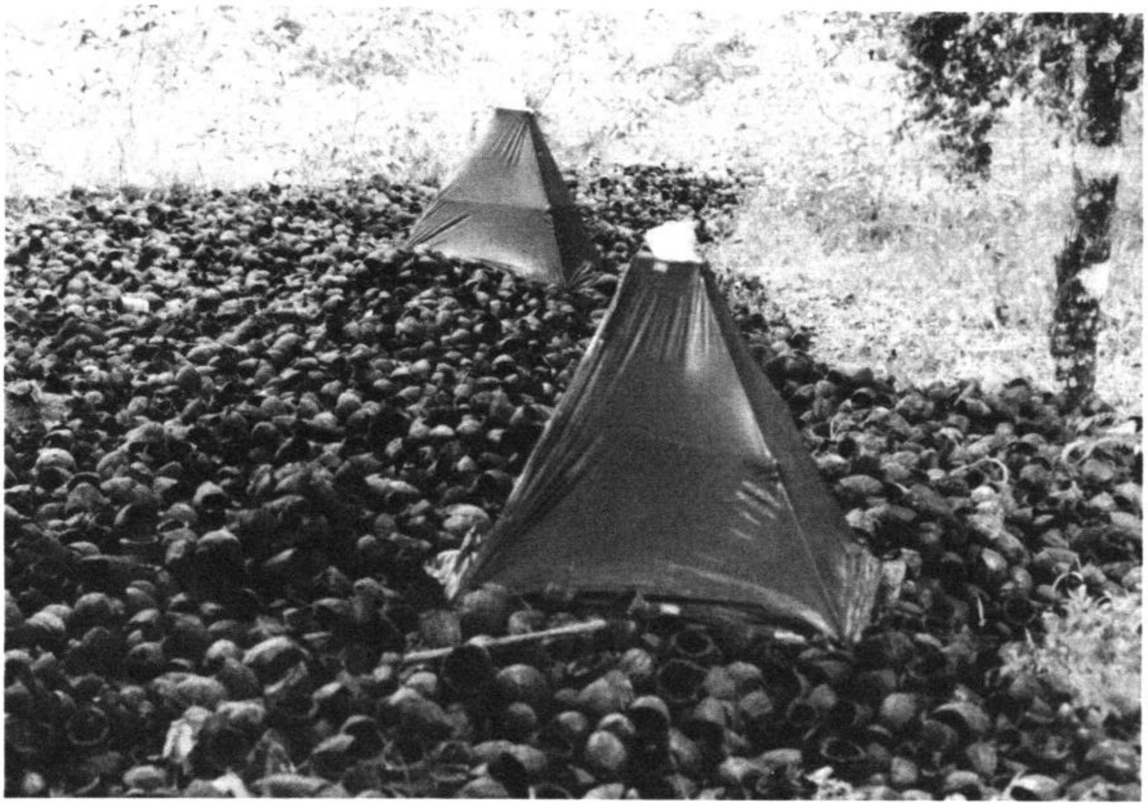

Photo 3 (above): A type B emergence trap used to sample banana stumps. Photo 4 (below): A type D emergence trap used to sample decaying leaf litter.

TABLE 1. The numbers of *Culicoides* midges collected from different habitats with emergence traps at an agricultural research station in Belém, Pará, Brazil, in 1977 and 1978.

	Habitat					
	Decaying banana stalks		Decaying cacao hulls		Decaying banana stumps	
Month and year	No. of trap-days	No. of *C. paraensis* captured per trap-day	No. of trap-days	No. of *C. paraensis* captured per trap-day	No. of trap-days	No. of *C. paraensis* captured per trap-day
June '77	—	—	54	2.18	782	.01
July '77	—	—	62	0.87	850	.01
August '77	—	—	78	0.29	290	.01
September '77	89	16.03	84	7.38	300	.10
October '77	110	8.44	90	7.75	280	.06
November '77	114	11.66	87	3.82	280	.04
December '77	96	4.47	54	6.96	280	.08
January '78	168	27.75	96	7.80	310	.44
February '78	186	2.28	102	19.40	280	.00
March '78	168	6.66	91	17.80	350	.17
April '78	112	3.12	56	11.00	310	.00
May '78	128	2.28	62	1.60	210	.07
June '78	112	.05	66	1.20	320	.02
July '78	124	.83	62	.05	280	.02

TABLE 2. Composition of the biting midge fauna[a] and the percentage represented by *Culicoides paraensis* in emergence trap samples from principal breeding habitats at an agricultural research station in Belém, Pará, Brazil, 1977 and 1978.

	Habitat					
	Decaying banana stalks			Decaying cocoa hulls		
		C. paraensis collected			*C. paraensis* collected	
Month and year	No. of *Culicoides* collected	No.	(%)	No. of *Culicoides* collected	No.	(%)
June '77	—	—	—	7,156	118	(1.6)
July '77	—	—	—	5,158	54	(1.0)
August '77	—	—	—	3,449	23	(0.7)
September '77	1,473	1,427	(96.9)	8,541	620	(7.3)
October '77	933	928	(99.5)	9,351	698	(7.5)
November '77	1,788	1,769	(98.9)	11,079	332	(3.0)
December '77	474	333	(70.2)	4,027	376	(9.3)
January '78	7,121	4,663	(65.5)	11,524	746	(6.5)
February '78	880	424	(48.2)	18,103	1,977	(10.9)
March '78	2,410	1,120	(46.5)	16,674	1,625	(9.7)
April '78	1,479	349	(23.6)	4,967	618	(12.4)
May '78	829	292	(35.2)	2,213	99	(4.5)
June '78	266	6	(2.3)	3,838	79	(2.1)
July '78	1,606	103	(6.4)	2,567	3	(0.1)

[a] The biting midges collected included *Forcipomyia* spp. and the following *Culicoides* species. *C. paraensis*, *C. debilipalpis*, *C. foxi*, *C. fusipalpis*, *C. hylas*, *C. insinuatus*, and *C. tetrahynia*.

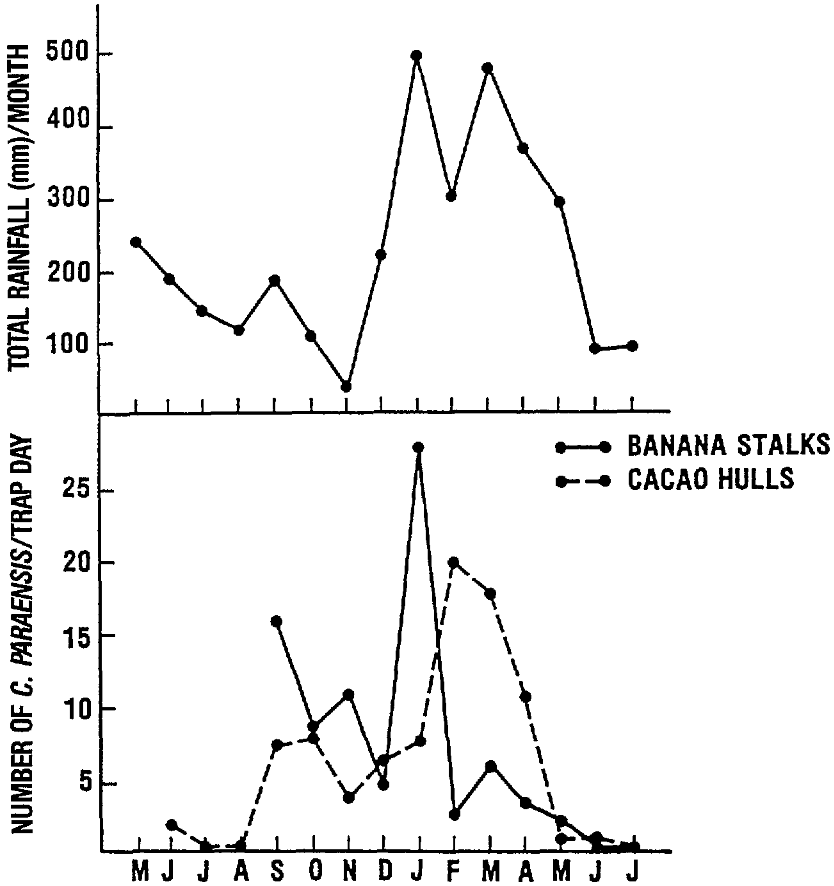

FIGURE 1. Rainfall patterns at the study site and the average numbers of *C. paraensis* captured per trap-day from decaying banana stalks and cacao hulls during each month of the study period in 1977 and 1978.

gence rates of *C. paraensis* from cacao hulls, but not from banana stalks, appeared to correlate with rainfall patterns.

DISCUSSION AND CONCLUSIONS

Decaying banana plant materials and decomposing cacao hulls were found to be the principal breeding sites of *C. paraensis* in the study area. This midge has been collected from tree holes in other parts of its geographic range. The scarcity of tree holes and negative results from the few that were sampled during our studies indicate, however, that tree holes were not an important factor in the proliferation of *C. paraensis* at our study site.

In the sampling program, we distinguished between banana stalks and banana stumps because of the amount of water associated with each. A decaying banana stump functions as a basin for rainwater and creates an aquatic environment, while the decomposing banana stalk creates a semiaquatic environment due to its more limited rainwater collecting capacity. Our emergence trap data (see Table 1) indicate that banana stumps yielded relatively few specimens of *C. paraensis,* and it seems that decaying banana stalks are preferred over banana stumps as breeding sites.

Banana plants are frequently planted in close proximity to houses in both urban and rural areas of Amazonia to provide a source of fruit for supplementing the family diet, to give shade, and to prevent soil erosion. The banana cluster is commonly harvested by cutting the entire trunk on which the fruit is borne, since this portion of the plant will not bear fruit again. Decayed banana stalks are thought to be useful as fertilizer, and so the trunk is usually cut into several small stalks that are left at the base of the plant to decompose. The length of time required for decomposition of the stalks depends on environmental conditions. Based on our observations, however, the stalks will serve as a breeding site for two to four months. Since oviposition occurs mainly on the exposed ends of the banana stalks, sectioning the trunk probably increases the availability of breeding sites.

Like the banana stalks, cacao hulls located in shaded areas can provide favorable breeding sites for *C. paraensis* during periods of little rainfall. In addition, we found the hulls to be an important breeding site for several other midge species. (Similar studies in Trinidad had indicated that *C.paraensis* was one of the predominant *Culicoides* species reared on rotting cacao hulls—*7*.)

Cacao is normally harvested once a year during the months of January through March. After the cacao pods are removed from the trees, they are taken to a central area, usually near the owner's residence, and processed manually for the seed. Since cacao hulls have no commercial value, they are generally piled in large mounds and left to decompose. A fresh cacao hull contains considerable organic matter, and some decomposition must occur before it provides an acceptable habitat for *C. paraensis (8)*. As it decomposes, however, it does provide a suitable breeding habitat for both *C. paraensis* and other midge species. Depending upon the quantity of hulls present, several thousand biting midges may be produced.

Although cacao plantations are not common in large urban areas, plantations are sometimes associated with smaller, agriculturally oriented towns and villages. One such village that typifies this situation is Tome Acu, a settlement in northern Brazil that was the site of an outbreak of Oropouche virus disease in 1978 *(9)*. This village is bordered by large cacao plantations and is burdened with dense populations of *C. paraensis*. In this area, the breeding of *C. paraensis* occurred almost exclusively among the large quantities of discarded cacao hulls.

Such linkages as those described between the cultural practices of human populations and dense populations of *C. paraensis* present various options for controlling this medically important biting midge. For example, significant reduction in *C. paraensis* population densities should result if banana refuse is eliminated from residential areas.

Destruction of the breeding substrate by burning is not feasible due to its high water content. A more effective direct approach would be to bury banana stalks and stumps or to dispose of the debris in a sanitary landfill. Either method would eliminate the breeding sites this material provides, so long as most of the residents participate. However, it should be noted that while such measures would be useful in preventing pest problems and disease outbreaks, they would not be useful in stopping an Oropouche virus disease epidemic. To contain an epidemic, it would be necessary to treat the area with insecticides so as to control the adult *C. paraensis* populations.

Large cacao plantations present similar, but perhaps simpler, control options involving removal or burial of both cacao refuse (discarded hulls) and banana refuse. Emphasis on these measures by the plantation management would facilitate the control effort. A similar program for villages would be more difficult, since voluntary participation of the residents would be required.

In sum, the early elimination of banana plant refuse and discarded cacao hulls should greatly reduce *C. paraensis* abundance and the likelihood of Oropouche virus disease epidemics occurring in urban areas within the Amazon Basin. The benefits of reducing the numbers of this pest species and disease vector through simple modifications in basic agricultural practices are sufficient to warrant a field trial of such a control effort.

SUMMARY

The biting midge *Culicoides paraensis* (Diptera: Ceratopogonidae) is a major pest in urban parts of the Amazon Basin, not only because its bite produces physical discomfort and skin reactions, but also because it is the primary vector for many urban outbreaks of Oropouche virus disease.

Studies on the breeding sites of *Culicoides paraensis* were conducted at an agricultural research station in Belém, Brazil, during 1977 and 1978. A variety of emergence traps were employed to quantify numbers of adult *C. paraensis* produced in decaying banana-plant stalks, stumps, and leaf axils; discarded cacao hulls; leaf litter; and marsh habitats. Banana stalks were found to yield large numbers of *C. paraensis,* while cacao hulls turned out to be the second most productive habitat.

Decaying banana stalks and cacao hulls are common refuse materials resulting from the cultivation of cacao and banana plants in urban and semiurban areas and on cacao plantations in the Amazon Basin. This article includes suggestions for the control of *C. paraensis* through elimination of these materials.

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Reports of Dengue-1 and Dengue-2 Outbreaks

As of May 1986 Brazil's Ministry of Health had reported a large dengue-1 epidemic estimated to have caused more that 300,000 cases. No cases of dengue hemorrhagic fever had been reported.

Also, dengue-2 activity was reported in several countries north of Brazil around this time. Specifically, the laboratory of the Caribbean Epidemiology Center (CAREC) isolated dengue-2 virus from one disease case in Trinidad and one in Suriname; the Pasteur Institute in Cayenne, French Guiana, reported increased dengue-2 activity in that country beginning in January 1986; and the institute isolated dengue-2 virus from two Cayenne residents in April. CAREC has advised health officials in its member countries to increase dengue surveillance activities and to step up efforts to control the *Aedes aegypti* vector.

Source: Caribbean Epidemiology Center, Notes, *CSR: CAREC Surveillance Report* 12(5):5, 1986.