Field Studies on the Feeding Habits and Diurnal Shelters of Some *Phlebotomus* Sandflies (Diptera: Psychodidae) in Panama[1]

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ABSTRACT

An investigation of the natural hosts of *Phlebotomus* sandflies was carried out as 1 phase of the search for the reservoir of cutaneous leishmaniasis. Various types of traps baited with live animals were tried, but direct collecting from caged animals gave far better results. The 8 species represented in the catch of more than 600 female *Phlebotomus* were all common, man-biting species. The range of hosts was wide and included sloths, opossums, kinkajous, and chickens. Although no clear-cut host preferences were demonstrated, the kinkajou (*Potos flavus*) was consistently the most attractive to sandflies. A study of natural cavities used as diurnal shelters and of some artificial cavities set out to test their attractiveness to sandflies, seemed to indicate that sandflies are attracted to cavities only when they can serve as feeding or breeding sites.

Some 65 described species of *Phlebotomus* sandflies are known to occur in Panama. Of these, 6 or 8 species may be regarded as common man biters. Several other species that are relatively rare in Panama also are known to bite man. One species, *P. trinidadensis* Newstead, has been found feeding on the gecko, *Thecadactylus rapicaudus* (Houttuyn), and 2 other species, *P. vespertilionis* Fairchild and Hertig and *P. isovespertilionis* Fairchild and Hertig, are associated with, and are presumed to feed on, bats (McConnell and Correa 1964). That the man-biting species of *Phlebotomus* will feed on horses, dogs, and other large mammals is well known, but their food in the absence of such hosts has been a matter of speculation. The hosts of the other sandflies in Panama are unknown.

At this laboratory, *P. sanguinarius* Fairchild and Hertig and *P. gomezi* Nitzulescu are routinely reared, and have been found to feed readily under laboratory conditions on the following: opossums (*Didelphis, Caluromys,* and *Marmosa*); rodents (*Proechimys, Tylomys, Sciurus,* and the guinea pig); the kinkajou (*Potos*); and on baby chicks. The four-eyed opossum (*Philander*) seems to be more acceptable to *P. sanguinarius* than to *P. gomezi*. Both species can sometimes be induced to feed on Syrian hamsters, but both reject white mice (Johnson et al. 1963).

The present study was undertaken in an attempt to find out something of the natural feeding habits, the range of hosts, and the host preferences among species of Panama sandflies. Any information with respect to the natural hosts of man-biting sandflies is likely to provide suggestive evidence in regard to reservoirs of human cutaneous leishmaniasis and other zoonoses. Some of these studies have been carried out in known areas of present or recent endemicity for cutaneous leishmaniasis.

STUDY AREAS

Madden Forest Preserve.—Madden Forest, a Government preserve in the Canal Zone, lies mostly on the Pacific side of the continental divide. The region consists of advanced secondary growth, with small areas of primary forest. It is traversed by Madden Highway, which has considerable vehicular traffic, but there are no habitations and no agriculture or cutting of the forest. Apart from picnickers at 2 points along the highway, the forest is penetrated only by occasional hikers or hunters, and is not known to be endemic for cutaneous leishmaniasis. The principal study areas are well off the highway at altitudes between 350 and 400 ft above sea level. Sandflies are found throughout the year, although in reduced numbers during the dry season from January to May. Since Madden Forest is easily accessible from the laboratory, we have used this area for several years to pretest field methods before applying them elsewhere.

Quebrada Bonita is a small valley crossed by the Transisthmian Highway near Buena Vista, on the Atlantic slope about 16 miles from Colon. This area, heavily forested and an intense focus of leishmaniasis when first visited by staff members of this laboratory in 1956, has been the scene of extensive and continuous field studies since that time. The incidence of the disease has followed the classic pattern and has declined with the progressive clearing of the forest and the decreasing proportion of nonimmunes. House spraying in connection with the malaria eradication campaign also has been carried out recently. A house-to-house census along a forest trail in 1958 yielded 39 active or very recent cases in the total population of 124 persons of all ages; in 1964 a census of the 190 persons in the same area revealed only 2 active cases locally contracted, 1 of them several years ago, with old, incompletely healed lesions. A certain patch of forest, in which regular collections had been made for several years, was used as the area for the operations herein reported. Although this patch was gradually reduced to a strip only about 50 yards wide, with an area of perhaps 2 or 3 acres running up the side of a ravine from the stream below, the sandflies remained abundant throughout the period of these observations. This slope was later cleared completely.

Almirante.—The Gorgas Memorial Laboratory has maintained a field station near the railroad about 2

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miles from Almirante for several years. This region is in the Province of Bocas del Toro, on the Caribbean not far from the Costa Rican border. There is no definite dry season at Almirante, and heavy rains may be expected during any month of the year. The region is devoted primarily to the commercial cultivation of bananas and cacao, but numerous small uncut forest areas remain between the plantations. Sandflies are abundant in the forests throughout the year. The hospital at Almirante has treated numerous cases of leishmaniasis through the years and foci of infection still exist in that district. Four of the laboratory's employees, who had been the only nonimmunes when they joined the regular crew, contracted leishmaniasis at the field station.

METHODS AND RESULTS

The methods used for catching, transporting, and handling sandflies were those that have been employed at this laboratory for some time (see Hertig and Johnson 1961). Bait animals used for attracting sandflies were live trapped in or near the study areas with collapsible wire-mesh box traps baited with corn, bananas, and oranges. Details of the construction and use of various sandfly traps are considered individually along with the results obtained.

Traps for Phlebotomus.

A trap for *Phlebotomus* which could be baited with live animals and left in the forest unattended would have obvious advantages for a study of natural hosts. Several types of traps were modified or devised for this purpose.

Double-Funnel Trap.—A mosquito trap described by Bellamy and Reeves (1952) consisted of a large metal can with a screen funnel in 1 end. A modification of this trap was constructed, consisting of a stainless-steel cylinder 10 inches in diameter and 36 in. long. Funnels made of fine-meshed brass screening, with ¾-in. central apertures, were fitted into each end of the cylinder.

When the trap was in use, 1 or 2 caged bait animals were inserted and the unit was set out in the forest on the ground, or suspended from trees horizontally at various heights below or within the canopy. The trap was usually placed in position in the late afternoon and checked for sandflies the following morning.

The results of trials with the double-funnel trap are shown in Table 1. These traps were put out an equivalent of 99 trap nights in 3 different study areas. A reptile, 2 genera of birds, and 7 genera of mammals were used as bait. Two ♂ and 41 ♀ sandflies were collected, of which 29 ♀ had taken a blood meal. The species of *Phlebotomus* represented in the catch were *panamensis* Shannon, *sanguinarius*, *trapidoi* Fairchild and Hertig, and a single male *shannoni* Dyar. Of the bait animals used, only the opossums (*Didelphis* and *Caluromys*), the sloths (*Bradypus* and *Choloepus*), and the kinkajou (*Potos*) produced results.

It is clear that our modification of the Bellamy-Reeves trap is not highly effective in the prevailing environmental conditions of Panama. There are 2 inherent disadvantages of this type of trap for *Phlebotomus*: the small size of the insects necessitates a fine-meshed screen which reduces airflow through the trap; and changes of temperature at high humidity tend to cause condensation within the metal cylinder. It is probable that a trap of this type would produce more satisfactory results in a drier region.

Cuboidal Nylon Trap.—Another type of sandfly trap was tested at Quebrada Bonita and Madden Forest. A cuboidal nylon tentlike structure, 44×44 in. × 36 in. high, with the bottom of the cube open, was suspended over bait animals, leaving a few inches between the sides of the trap and the ground. Barretto and Coutinho (1940) reported the successful use of such a trap in Brazil.

In theory, sandflies attracted to the bait animals would enter under the sides of the trap. After feeding they would be sluggish and would tend to remain in the trap where they could be collected later. In practice, however, the cuboidal trap produced poor results. A few sandflies were caught, but those species prevalent in the study areas seemed little inclined to enter the trap or to stay inside after feeding. When simultaneous direct collecting was used as a control, many more sandflies were attracted to the controls than to the same species of animals in the trap.

Oiled Paper Traps.—Sheets of paper smeared with castor oil were successfully used by Kirk and Lewis (1940) for trapping sandflies in the Sudan. The papers were suspended in cleft sticks at the mouth of animal burrows. The captured insects were harvested by cutting the paper into strips and agitating them in alcohol. Quate (1964) reported recent successful use of oiled paper and metal plates in the Sudan.

An adaptation of this method was found useful by Hertig (1949) in sandfly studies in Greece. He made a frame of thin strips of wood with their flat sides nailed together to form a 12-in. square. Typewriter-size paper was tacked to the frame so as to lie in its midplane, which permitted frames to be prepared in the laboratory and stacked for transport without the oiled papers' coming in contact with one another. Numbered frames were set out or hung in position, left over night, and picked up the following morning. Sandflies could be individually picked off; and the frames with the same paper, wiped clean with xylene if necessary, could be used repeatedly. Castor oil seems to be neither attractive nor repellent to most insects. It will hold only the smaller insects and thus is favorably selective in sandfly studies. The oiled-paper technique takes advantage of the common *Phlebotomus* flight habit of alighting on almost any object in its path.

A few trials of these frames had been made in Panama by one of us (M.H.). The frames were suspended beneath an aluminum roof as protection against rain. There was, nevertheless, considerable

Table 1.—Trials of double-funnel trap for the collection of *Phlebotomus*. September 1962–January 1963.

Bait animals	Locality[a]	Height (ft) above ground	No. of nights	*Phlebotomus* caught
Reptiles				
Boa constrictor L.	MF	0	4	None
(boa constrictor)	QB	25	11	None
Birds				
Baryphthengus martii (Spix) (rufous motmot)	QB	10	2	None
Gallus domesticus L. (chicken)	QB	3–10	7	None
Mammals				
Didelphis marsupialis L.	MF	0	11	*P. panamensis*, 3 fed ♀
(common opossum)	A	15	4	None
	QB	2–4	13	None
Philander opossum (L.)	MF	0	5	None
(four-eyed opossum)	QB	2	3	None
Caluromys derbianus Waterhouse	A	30	3	None
(woolly opossum)	QB	25	3	*P. trapidoi*, 1 fed ♀; undetermined, 2♀
Bradypus griseus Wagler (three-toed sloth)	QB	10	8	*P. sanguinarius*, 11♀ (7 fed); *P. trapidoi*, 4♀ (2 fed), 1♂
Choloepus hoffmanni Peters (two-toed sloth)	QB	10–20	9	*P. sanguinarius*, 1♀; undetermined, 2♀
Sciurus granatensis Humboldt (red squirrel)	MF	2	2	None
Potos flavus (Schreber)	A	25–50	6	*P. trapidoi*, 16 fed ♀; *P. shannoni*, 1♂
(kinkajou)	QB	10–20	8	*P. trapidoi*, 1♀
Totals			99	41♀ (29 fed), 2♂

[a] A = Almirante; MF = Madden Forest; QB = Quebrada Bonita.

splashing from surrounding vegetation, and even in the absence of rain the sandfly catch was slight and no further trials were made at that time.

In the present study, similar wooden frames with oiled paper were tested in Madden Forest and at Quebrada Bonita. In the attempt to determine the flight pattern of sandflies, particularly when approaching a bait animal such as a horse, the frames were hung singly or in groups at various distances, with disappointing results.

A trap baited with small animals and surrounded by oiled-paper frames was devised which it was hoped would catch sandflies that might be attracted. The caged animals were placed inside a larger, open-ended, cagelike device made of wire fencing, 12×12 in. × 24 in. long, and provided with a sheet-aluminum roof with suitable overhang to protect against rain. Six oiled-paper frames were hung around the sides and open ends, with 2 more on top under the aluminum roof. Sandflies would have access to the animal through the bottom and around the edges of the frames.

Although a few sandflies were caught in this series of tests, the results were inconsistent and inconclusive. It appears that castor oil, which had been effective in drier areas such as Greece, is not suitable for use in the humid forests of Panama. When exposed to high humidity the oil tends to run off, leaving the papers with insufficient adhesiveness. Castor oil with various additives, such as petrolatum, also was tried, but the results were only slightly improved. In comparison with the above, direct collecting gave such superior results that the oiled-paper method was abandoned.

Direct Collecting.

Because of the very limited results obtained in attempting to trap sandflies by the methods described, direct collecting from caged bait animals was initiated at Quebrada Bonita in February 1963. The study area was suitable for this method, since the forest was limited and the collectors could wait in the open away from the bait animals to minimize the effect of human attractiveness to the sandflies. Trials were made on 17 nights during the dry season of 1963. Two or more genera of bait animals were taken to the area before sunset. The animals in their cages were set up in 2 or more groups on pole racks about 4 ft above ground (Figs. 1, 2). The racks were placed about 50 ft apart, in a line at right angles to the prevailing winds. Sandflies had access to the animals through the bottoms of the cages as well as from all other directions. After the animals were in position, the collectors retired to an adjacent cleared area some 50–100 yards away. Beginning at 1900 hr, all bait animals were checked at half-hourly intervals, and sandflies found on the animals were collected in suction vials. The time spent near the animals amounted to about 5 min every half hour. Collecting was usually continued until 2200 hr, or until 3 successive inspections failed to reveal any sandflies. On each collecting night at least 2 genera of animals were used, to offer the sandflies a choice and thereby test the relative attractiveness of the various hosts.

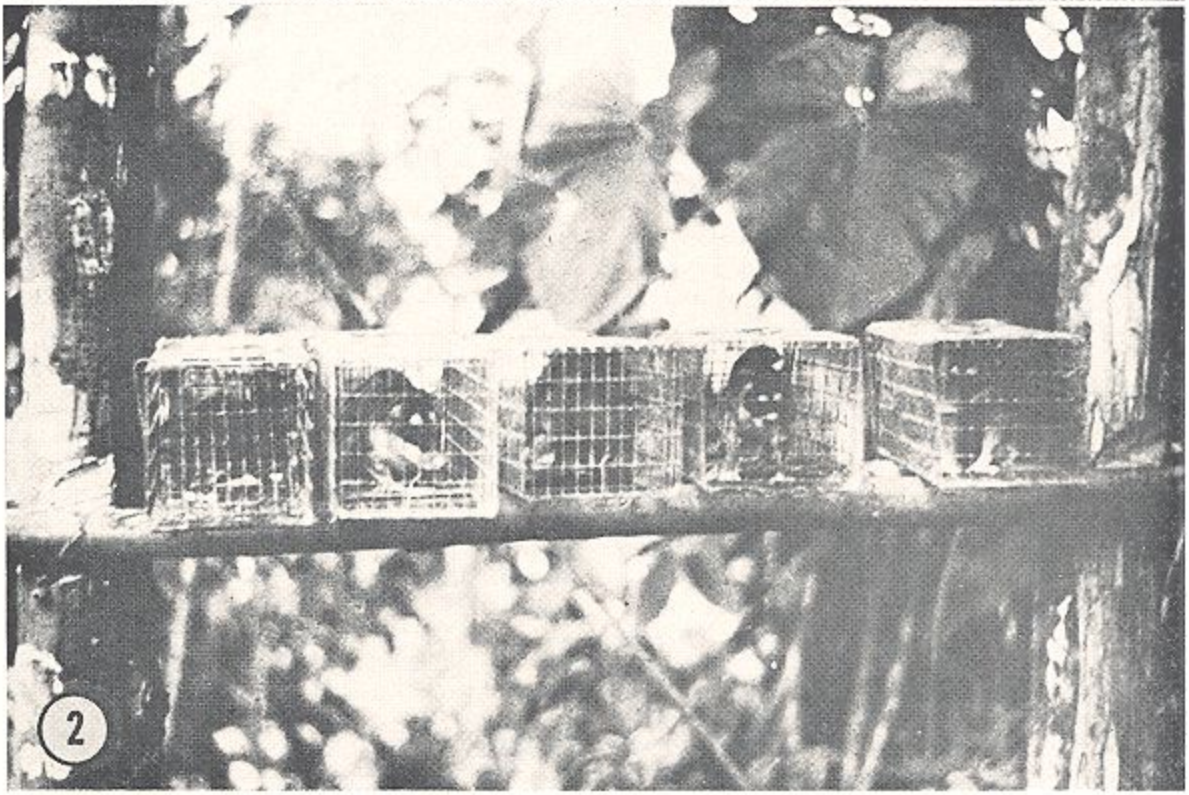

FIG. 1, 2.—Bait animals caged for direct collecting of *Phlebotomus* sandflies; cages supported on pole racks to permit free access from above and below. FIG. 1.—Two caged kinkajous, *Potos flavus*. FIG. 2.—Five opossums, *Philander opossum*.

Table 2.—Total numbers of *Phlebotomus* caught on each bait species by direct collection on 17 nights at Quebrada Bonita. February to May 1963. Numbers of females that had fed are given in parentheses.

Date	Animals used	Sandflies caught	
		Males	Females
20 Feb.	5 *Didelphis*	19	61 (33)
	4 *Potos*	33	95 (29)
4 Mar.	6 *Philander*	13	7 (0)
	2 *Potos*	1	26 (5)
6 Mar.	1 *Choloepus*		2 (0)
	2 *Potos*	1	79 (17)
11 Mar.	1 Chicken	15	8 (3)
	4 *Didelphis*	1	5 (0)
	2 *Choloepus*	2	2 (2)
13 Mar.	1 Chicken	16	29 (8)
	2 *Bradypus*	40	14 (3)
	2 *Didelphis*		3 (3)
	1 *Potos*		1 (1)
18 Mar.	2 *Didelphis*		0
	4 *Philander*		0
25 Mar.	1 Chicken	4	1 (1)
	4 *Didelphis*	2	71 (40)
	2 *Potos*	6	90 (8)
27 Mar.	1 Chicken	12	5 (0)
	2 *Didelphis*	11	23 (7)
	4 *Philander*	80	15 (0)
3 Apr.	2 *Didelphis*		5 (1)
10 Apr.	2 *Potos*		5 (0)
24 Apr.	2 *Didelphis*	1	3 (0)
6 May	3 *Didelphis*		2 (0)
8 May	3 *Didelphis*		10 (3)
13 May	4 *Potos*	6	18 (4)
15 May	4 *Potos*	1	25 (5)
20 May	6 *Didelphis*		0
22 May	6 *Didelphis*		0
Totals		264	605 (173)

Some attempt was always made to balance the attractant mass by using larger numbers of small animals (e.g., 6 opossums, *Philander*, to 2 kinkajous, *Potos*).

The results of the direct-collecting method are shown in Table 2. A total of 605 ♀ *Phlebotomus*, representing 8 species, was obtained; about 170 of these had secured a blood meal before capture and most of the others were attempting to feed when caught. The species represented by the fed females are shown in Table 3. It can be seen that the predominant species were *P. sanguinarius* and *P. gomezi*, which are the dominant man-biting species in the area. *P. trapidoi*, *P. ylephiletor* Fairchild and Hertig, and *P. shannoni* are all common man biters in Panama, but they are not numerous at Quebrada Bonita during the dry season. A single female *P. ovallesi* Ortiz was caught while taking a blood meal from a kinkajou. This species is not abundant in Panama, but has been taken biting man.

These collections demonstrate that the host range of the man-biting sandflies at Quebrada Bonita is wide. A bird (domestic chicken), 2 genera of edentates, 2 genera of marsupials, and a carnivore (kinkajou) all attracted sandflies under field conditions. The kinkajou, however, seemed to be the most attractive of the animals used. Table 2 shows that on most of the nights that kinkajous were used, more sandflies were caught from them than from the other bait animals (e.g., 6 March, 79 ♀ from *Potos* and only 1 ♀ from the two-toed sloth, *Choloepus*). The contradictory indication of 13 March (only 1 ♀ on kinkajou vs. 46 ♀ on 3 other genera) may be explained by the fact that the kinkajou was not healthy and remained asleep, curled up with feet hidden, throughout the evening.

During the course of the collecting, it was noticed that sandflies on the mammals nearly always attempted to feed on the feet or on the tail. It is therefore necessary in tests of this sort to leave the bottom of the cage unobstructed, with free access for sandflies from all directions. No sandflies were seen feeding on the nose or snout of the mammals, even in the case of the common opossum, *Didelphis*, which has bare areas on the snout. The sandflies collected from the chicken were feeding on areas of bare skin on the neck, head, and under the wings.

It can be noted also from Table 2 that on some nights few or no sandflies were encountered. This phenomenon seems to be primarily a matter of the well-known sensitivity of *Phlebotomus* to unfavorable weather. Maximum feeding is to be expected on

Table 3.—Host distribution of sandfly females caught on bait animals by direct collection on 17 nights at Quebrada Bonita. February 20 to May 22, 1963. Numbers of females that had fed are given in parentheses.

Phlebotomus species	Bait species and number of nights used						
	Gallus domesticus 4	*Choloepus hoffmanni* 2	*Bradypus griseus* 1	*Didelphis marsupialis* 12	*Philander opossum* 3	*Potos flavus* 8	Totals 30
sanguinarius	19 (4)	3 (2)	3 (0)	108 (20)	10 (0)	204 (14)	347 (40)
gomezi	13 (4)	0	9 (3)	63 (26)	1 (0)	91 (19)	177 (52)
sanguinarius + *gomezi*[a]	—	—	—	— (33)	—	— (29)	— (62)
trapidoi	10 (4)	1 (0)	2 (0)	9 (6)	0	38 (6)	60 (16)
shannoni	1 (0)	0	0	1 (1)	10 (0)	0	12 (1)
ylephiletor	0	0	0	1 (1)	0	0	1 (1)
vexillarius Fairchild and Hertig	0	0	0	1 (0)	0	1 (0)	2 (0)
panamensis	0	0	0	0	1 (0)	4 (0)	5 (0)
ovalesi	0	0	0	0	0	1 (1)	1 (1)
Totals	43 (12)	4 (2)	14 (3)	183 (87)	22 (0)	339 (69)	605 (173)

[a] In the collection made the first night (Feb. 20) from *Didelphis* and *Potos* the sandflies were kept separate as to hosts and the total fed females from each were counted, but when subsequently identified to species the females were not recorded as fed or unfed.

warm nights of high relative humidity with no wind or rain. A light shower does not necessarily terminate sandfly movement, but it is usually impossible to attract them during a moderate or heavy rain. Readings with a hand-held anemometer at Quebrada Bonita indicate that a breeze of as much as 8–10 mph inhibits sandfly activity. Biagi and Biagi (1953) reported that 3 species of *Phlebotomus* in southern Mexico suspend feeding when the relative humidity reaches 90%. Although humidity was not measured during the present study, it seems clear that feeding activity at Quebrada Bonita continues at humidities between 90% and 100% as long as the temperature does not drop below about 25°C.

Sandflies have usually been regarded as crepuscular or postcrepuscular in habits. The latter term best describes the sandflies at Quebrada Bonita. The graph (Fig. 3) is based on the average number of females of all species collected on kinkajous at each half-hour period. Nights with little or no sandfly activity are omitted from the calculations. It can be seen that the sandflies begin to feed at 1900 hr (i.e., immediately after dark), and that feeding increases rapidly for the first half-hour. Thereafter the increase is more gradual until peak activity is reached at 2030 hr. After that time, the drop in numbers is pronounced, and by 2200 hr there are seldom any sandflies to be seen.

Observations by various members of the laboratory staff have shown that Panama sandflies also have a predawn period of activity, but data on this behavior were not obtained during the present study.

The decrease in number of sandflies caught by direct collecting during April and May is the result

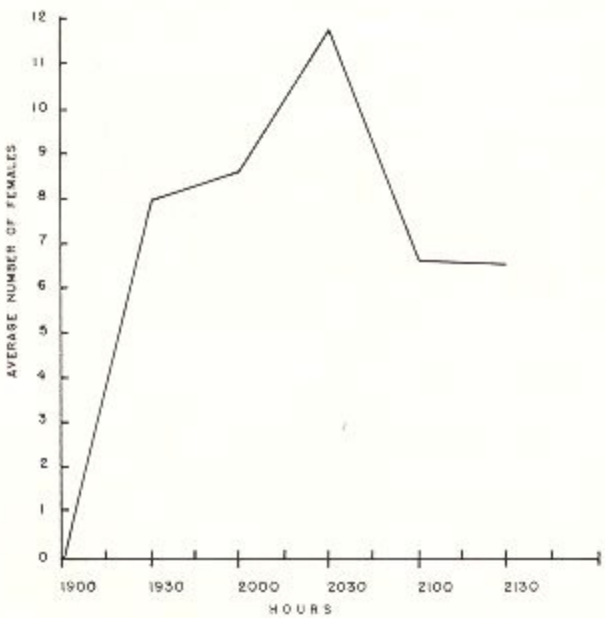

FIG. 3.—Feeding activity of *Phlebotomus* sandflies based on direct collections from caged kinkajous, *Potos flavus*, at Quebrada Bonita, February to May 1963. Average number of female sandflies caught during brief visits every half hour on 7 nights.

of 2 interrelated factors. As the dry season progresses, there is a gradual decline in the overall sandfly population. Also, toward the end of the dry season residents of the area do a considerable amount of burning of brush and cutover land, so the whole countryside becomes hazy with smoke. The smoke may kill some sandflies but in any case it seems to inhibit their activity.

Natural and Artificial Cavities.—A dozen or so species of Panama sandflies can often be found in the daytime in natural cavities such as hollow trees, spaces between tree buttresses, holes under rocks, and animal burrows. Most of the sandflies found in such situations are species that do not bite man, but *P. ylephiletor*, a man biter, is sometimes found in rock crevices and buttresses. From limited current information (see Hanson 1961), the daytime shelters of the commoner man biters are probably the leaves scattered over the forest floor, in close association with their breeding places in the rotting leaves and surface debris.

Starting in September 1962 and continuing through July 1963, studies were made of cavity-inhabiting sandflies in Madden Forest. A rectangular study plot, 60×75 yards, was laid out and all natural and artificial cavities were mapped. The 26 numbered cavities included 10 buttresses, 1 artificial and 2 natural burrows, and various items, probably of military origin and long abandoned, such as: concrete drain tile, 8 in. and 24 inches in diameter; hollow building tile, singly, in a small pile or part of a ruined wall; 2 hollow concrete structures, 5 or 6 ft long. Some of these objects, already well "seasoned," were relocated or arranged so as to provide hiding places which might be attractive to sandflies. If successful, they might furnish information not only on sandfly ecology, but could provide convenient sources of wild sandflies, fed or unfed, and serve as sites for various experimental procedures. All these various cavities were examined weekly from November 1962 through March 1963, and occasionally thereafter until July 1963. Periodic sample collections of sandflies were brought to the laboratory for determination.

Although 14 species of *Phlebotomus* were recorded from the study plot, only *P. vespertilionis* and *P. trinidadensis* were found to be abundant. *P. isovespertilionis* may occasionally be present in small numbers along with *P. vespertilionis*, but since only the males of these 2 species can be separated, the females were all recorded as *P. vespertilionis*. Many *P. vespertilionis* were encountered in a shallow hollow in a fig tree (*Ficus* sp.) and in a road culvert. Both of these sites were inhabited also by bats. Numbers of *P. trinidadensis* were regularly collected from a large hollow tree and in the larger buttress cavities.

The hollow in the fig tree was studied with special interest, since both the bats and the sandflies could be observed in situ with the aid of a flashlight. Although sandflies were not actually seen feeding on the bats, fed females were often seen on the walls of the hollow within a few inches of the bats. The colony con-

sisted of 6 or 8 large, frugivorous bats. They were first observed on 5 September 1962 and were seen regularly through 9 July 1963. On 24 July 1963 there were neither bats nor sandflies at the site.

The sandfly population in the *Ficus* tree varied from 50 to more than 200 individuals, and they could be found there at any time during daylight hours. After dark, when the bats had gone out, few if any sandflies could be found in the cavity. Since most of the female sandflies collected from the site were recently fed *P. vespertilionis*, it seems likely that this species was feeding on the bats in the daytime. It is also probable that the sandflies leave the hollow at night to seek sites for oviposition. This hypothesis is supported by the fact that Hanson (1961) found few sandfly larvae in hollow trees, presumably because of the high concentration of bat feces. One of the large concrete structures here mentioned, partially filled with leaves and detritus, situated about 10 yards from the *Ficus* tree, also yielded numbers of *P. vespertilionis* during both daylight and nighttime collecting.

Armadillo and rodent burrows on the study plot yielded sandflies in numbers of from 10 to 50 or more only while the burrows were occupied. After the mammalian inhabitants had abandoned the burrows, few sandflies could be found in them. *P. runoides* Fairchild and Hertig and *P. nordestinus* Mangabeira were species found in natural animal burrows.

In addition to the artificial cavities just mentioned, a wooden structure was made with the idea of simulating some features of a hollow tree. Unpainted 18×48-in. panels of plywood formed the sides of an A-shaped structure with a 24-in. base. Front and back were provided with panels extending to within 6 in. of the bottom, which was left open. A small hinged door in the front panel permitted inspection of the interior. This "A-frame" was set between buttresses of a tree.

Sandflies were rarely found in any of the artificial cavities. Occasional sandflies were caught in these sites, but such occurrences must be regarded as accidental. In one instance a sandfly, frightened from the forest floor by the approach of the observer, was seen to fly into one of the large concrete pipes, where it was collected.

The wooden A-frame proved to be unattractive to all animals while it was new. After about 3 weeks of aging, it began to take on a typical hollow-tree invertebrate fauna. Crickets, spiders, and tipulids were regularly seen in it, but only an occasional *Phlebotomus* was found.

Bait animals were left in the A-frame at various times, but few sandflies were caught as a result. None were found in the structure after it had been baited with a 5-ft boa constrictor for 1 week. Trials with the common opossum for 2 nights also proved negative. On the other hand, 11 sandflies were seen in the A-frame after a silky anteater, *Cyclopes didactylus* (L.), had been left there overnight. It was possible to capture only 5 of the sandflies; they turned out to be *P. trinidadensis*, 3 of which had fed. Whether they fed on the bait animal is unknown. Silky anteaters are difficult to obtain and to maintain in captivity, and unfortunately it was not possible to run a second trial with these animals.

From the observations made so far, it appears that artificial cavities are unattractive to the sandflies in Madden Forest. These negative results combined with observations on natural cavities seem to indicate that sandflies are attracted to cavities only when they can serve as feeding or breeding sites.

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