

## THE MOSQUITOES OF COSTA RICA<sup>1</sup>

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In Costa Rica sharp contrasts in climate occur within quite short distances. The Atlantic railway ascends from sea level to an altitude of 5,000 feet in a journey of less than 95 miles, while several of the nearby volcanoes are more than 10,000 feet high. The linear distance from the Atlantic to the Pacific Oceans varies from 160 miles in the north to only 75 miles near the Panaman border. Undoubtedly the great variations in climate account for the diversity of the mosquito fauna.

The backbone of the American continent, which stretches from the Canadian Rockies to the Chilean Andes, is not so lofty in Costa Rica as at its northern and southern extremities. Nevertheless this ridge of high mountains divides quite effectively the Atlantic and Pacific Zones. It also encloses a large upland plateau known as the "Meseta Central," most of which is 2,000 to 4,000 feet above sea level.

The climatic differences between the Atlantic and Pacific sides of this Republic are well illustrated by the figures for the average monthly rainfall. Through the courtesy of the United Fruit Company and certain other interested persons we were permitted to copy rainfall data from four representative localities on the Atlantic slope, which covered a total of 47 years of observations. We also obtained monthly rainfall tabulations for the city of San José extending over a 65-year period, and for the past 11 years from Puerto Jimenez on the Golfo Dulce. Both

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of the latter are on the Pacific slope. Table 1 shows the average monthly rainfall on the Atlantic and Pacific sides of Costa Rica.

The total annual rainfall is decidedly greater on the Atlantic coast than on the Pacific. The peak months on the Caribbean littoral are November and December, whereas the maximum rainfall on the Pacific side occurs in September and October. The figures in table 1 are shown in graph 1. The curve for the Pacific slope brings out clearly the long dry season lasting for four or five months in the beginning of each year, followed by

TABLE 1

*Average monthly rainfall on the Atlantic and Pacific sides of Costa Rica*

MONTHS	AVERAGE RAINFALL PER MONTH	
	Atlantic side	Pacific side
	inches	inches
January.....	10.4	0.9
February.....	5.2	0.4
March.....	6.1	1.0
April.....	7.5	2.6
May.....	10.2	9.6
June.....	11.6	11.0
July.....	13.6	9.4
August.....	11.2	10.1
September.....	10.3	13.2
October.....	11.6	14.8
November.....	15.5	8.3
December.....	18.2	2.5
Totals.....	131.4	83.8

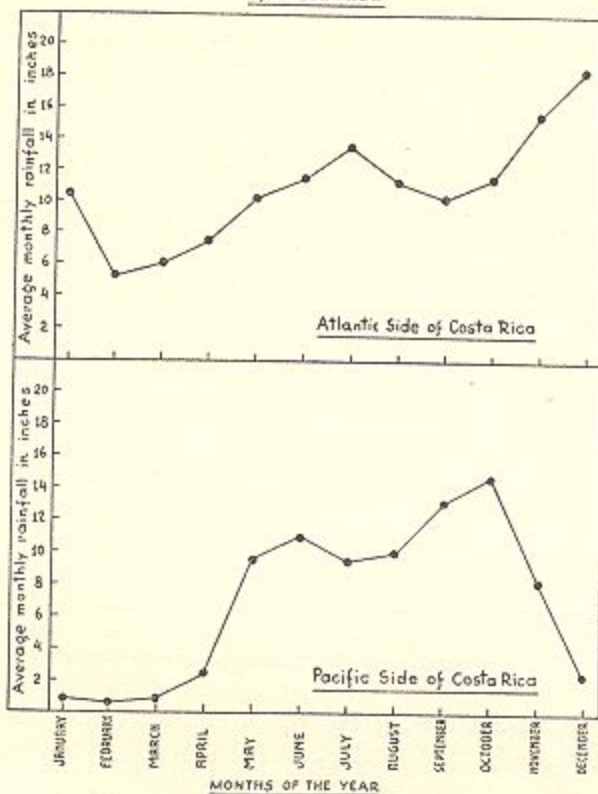
rain in May and June, and then a short dry season in July, before the heaviest rains in September and October.

Some of the earliest studies of the mosquito fauna of Costa Rica were made by Knab (1) in 1905, followed 16 years later by Alfaro (2) and Serre (3). Alfaro (4) reported no less than 73 different species from this country. Some of these later proved to be synonyms of one another, but the majority were valid.

The mosquito survey of Costa Rica on which the present report is based was conducted as a part of a malaria survey of the Republic. Accordingly more attention was paid to the *Anopheles* than to any of the other genera. Indeed, most of the

collections of non-anophelines were made merely incidentally to the main study. It is likely, therefore, that our knowledge of the anophelines is fairly complete, while undoubtedly many more culicine and sabethine species exist in this country than

Average monthly rainfall on the Atlantic and Pacific sides  
of Costa Rica



GRAPH 1

those we have encountered. Dyar (5) mentions the following 14 species, which we have not found as yet.

*Sabethes tarsopus*  
*Wyeomyia bromeliarum*  
*Wyeomyia hemisagnosa*  
*Wyeomyia pseudopecten*  
*Psorophora cilipes*  
*Haemagogus equinus*  
*Uranotaenia orthodoza*

*Culex derivator*  
*Culex educator*  
*Culex elevator*  
*Culex infictus*  
*Culex latisquama*  
*Culex metempsychus*  
*Culex restrictor*

From the first 1,000 collections which were made between December 1937 and July 1939, 24,704 mosquitoes were examined. Of these, 14,961 had been taken as adults and 9,743 as larvae or pupae. Among them we found 93 different species, of which 16 were *Anopheles*, 12 were *Aedes*, and at least 20 belonged to the genus *Culex*.

TABLE 2

*9,000 anophelines collected as adults classified by species and mode of capture*

SPECIES OF ANOPHELES	CAUGHT INSIDE HOUSES	CAUGHT IN STABLE-TYPE MOSQUITO TRAPS	CAUGHT WITH A HORSE AS BAIT AT SUNSET	OTHER MODES OF CAPTURE*	TOTALS	PER CENT OF ALL ANOPHELES CAUGHT
<i>Anopheles albimanus</i> .....	2,848	4,673	514	34	8,069	89.7
<i>Anopheles apicimacula</i> .....	1	57	79	43	180	2.0
<i>Anopheles argyritarsis</i> .....	1	9	25		35	0.4
<i>Anopheles eiseni</i> .....			1	21	22	0.2
<i>Anopheles neivai</i> .....			2		2	
<i>Anopheles neomaculipalpus</i> .....	3	31	6		40	0.4
<i>Anopheles pseudopunctipennis</i> ....	31	132	95	20	278	3.1
<i>Anopheles punctimacula</i> .....	4	53	52	14	123	1.4
<i>Anopheles strodei</i> .....	4	52	47		103	1.1
<i>Anopheles tarsimaculatus</i> .....	1		71		72	0.8
<i>Anopheles vestitipennis</i> .....	62		7		69	0.8
<i>Chagasia bathanus</i> .....			7		7	0.1
Totals.....	2,955	5,007	906	132	9,000	100.0

\* Other modes of capture include catches in hollow trees, outhouses, under bridges, in holes in the ground, and with human bait in the forests in the daytime.

#### RELATIVE PREVALENCE OF THE DIFFERENT ANOPHELINES

*Anopheles albimanus* accounted for 89.7 per cent of the first 9,000 *Anopheles* captured as adults, and *A. pseudopunctipennis* for only 3.1 per cent. We feel that this result has considerable significance in any consideration of the relative importance of those two species as vectors of malaria in Costa Rica. From an examination of table 2 it is evident that 96.4 per cent of the anophelines caught in houses and 93.3 per cent of those taken in stable-type mosquito traps were *A. albimanus*. But of the 906 mosquitoes of this genus caught with a horse or mule as bait at sunset, only slightly more than half were *A. albimanus*.

Adult catches with animal bait at nightfall yielded a greater diversity of anopheline species than did any of the other methods used.

In table 3 we have arranged the 7,548 anophelines which were taken in their immature stages, by species and by type of breed-

TABLE 3

7,548 anophelines collected as larvae or pupae, classified by species and type of breeding place

SPECIES OF ANOPHELES	TYPE OF BREEDING PLACE							TOTALS	PER CENT OF ALL ANOPHELINE LARVAE COLLECTED	
	Running streams	Pooled streams and ponds	Ground pools, ditches and borrow pits	Swamps, seepage areas and hoof prints	Bromeliads and other plants	Tree holes	Rock holes and artificial containers			Brackish water swamps or pools
<i>Anopheles albimanus</i> .....	5	160	2,174	436			39	125	2,939	38.9
<i>Anopheles albitarsis</i> .....		23							23	0.3
<i>Anopheles anomalophyllus</i> ....		1							1	
<i>Anopheles apicimacula</i> .....	18	44	75	132			2		271	3.6
<i>Anopheles argyritarsis</i> .....	27	227	745	595			12		1,606	21.2
<i>Anopheles bachmanni</i> .....		29							29	0.4
<i>Anopheles chiriquiensis</i> .....		7							7	0.1
<i>Anopheles eiseni</i> .....		20	2	35	7	4			68	0.9
<i>Anopheles neivai</i> .....					5				5	0.1
<i>Anopheles neomaculipalpus</i> ...		7	220	120					347	4.6
<i>Anopheles pseudopunctipennis</i> .....	38	934	688	417				7	2,084	27.6
<i>Anopheles punctimacula</i> .....	6	17	28						51	0.7
<i>Anopheles strodei</i> .....	2	1	10	1					14	0.2
<i>Anopheles tarsimaculatus</i> ....		3						9	12	0.2
<i>Anopheles vestitipennis</i> .....		5	3						8	0.1
<i>Chagasia bathanus</i> .....	64	18	1						83	1.1
Totals.....	160	1,496	3,946	1,736	12	4	53	141	7,548	100.0

ing place. Striking differences are shown in tables 2 and 3 between the percentages of anophelines taken as adults and as larvae. This difference is particularly notable in the case of *A. argyritarsis*. Table 3 shows that 21.2 per cent of the anopheline larvae captured were *A. argyritarsis*, whereas only 0.4 per cent of the adults listed in table 2 belong to that species.

Evidently *A. argyritarsis* feeds but rarely on either animals or humans, though it breeds freely in many places and under diverse conditions. It is hard to conceive how *A. argyritarsis* could ever be of much importance as a vector of any human disease in Costa Rica. (See table 3.)

The three commoner anophelines taken as larvae or pupae were *A. albimanus*, *A. argyritarsis* and *A. pseudopunctipennis*.

TABLE 4

*Larval collections of Anopheles albimanus, A. argyritarsis and A. pseudopunctipennis classified by the number of occasions on which each species was found in the various types of breeding places*

TYPE OF BREEDING PLACE	A. ALBIMANUS		A. ARGYRITARSIS		A. PSEUDOPUNCTIPENNIS	
	Number of times found	Per cent of total	Number of times found	Per cent of total	Number of times found	Per cent of total
Running streams.....	2	0.9	4	1.7	2	1.3
Pooled streams.....	20	9.1	31	13.4	45	28.7
Lakes and ponds.....	6	2.7	9	3.8	5	3.2
Ground pools, ditches or borrow pits.....	147	66.5	123	53.0	67	42.7
Wells, springs or small seepage areas.....	2	0.9	15	6.5	8	5.1
Hoof prints of cattle.....	21	9.5	28	12.1	15	9.5
Fresh water swamps.....	12	5.4	20	8.6	12	7.6
Brackish water swamps.....	10	4.5			3	1.9
Rock holes.....			2	0.9		
Artificial containers.....	1	0.5				
Totals.....	221	100.0	232	100.0	157	100.0

These accounted for 87.8 per cent of the 7548 anophelines caught in their immature stages. An analysis of the type of breeding place preferred by the three commoner anophelines was made by tabulating the number of occasions on which each species was found in each type of breeding place. Table 4 shows that *A. albimanus* usually selected ground pools. At least two-thirds of the collections were obtained in breeding places included in that category. The ten occasions on which *A. albimanus* were secured in partly brackish water are of interest, as well as the

one time that species was discovered in an iron drum full of rain water.

While half of the collections of *A. argyritarsis* were made in ground pools, certain other classes of breeding places also were frequently utilized by this species. *A. argyritarsis* was found in wells, springs and small seepage areas much more often than *A. albimanus*. The same statement applies to pooled and running streams. But the commonest of the three species to

TABLE 5

*Effect of sunlight on the occurrence of various species of Anopheles taken as larvae in Costa Rica*

SPECIES OF ANOPHELES	NUMBER OF TIMES FOUND IN SUN-LIGHT	NUMBER OF TIMES FOUND IN SHADE	TOTAL NUMBER OF LARVAL COLLECTIONS MADE	PER CENT OF OCCURRENCES IN SUN-LIGHT	COLLECTIONS WITHOUT DATA AS TO SUN-LIGHT
<i>Anopheles albimanus</i> .....	199	5	204	97.5	17
<i>Anopheles albiparvus</i> .....	1		1		
<i>Anopheles anomalophyllus</i> .....	1		1		
<i>Anopheles apicimacula</i> .....	31	16	47	66.0	3
<i>Anopheles argyritarsis</i> .....	194	16	210	92.4	22
<i>Anopheles bachmanni</i> .....		1	1		
<i>Anopheles chiriquiensis</i> .....	1	1	2		
<i>Anopheles eiseni</i> .....	6	8	14	42.9	1
<i>Anopheles neivai</i> .....		4	4	0.0	
<i>Anopheles neomaculipalpus</i> .....	36	3	39	92.3	8
<i>Anopheles pseudopunctipennis</i> .....	143	4	147	97.3	10
<i>Anopheles punctimacula</i> .....	9	5	14	64.3	
<i>Anopheles strodei</i> .....	6		6	100.0	2
<i>Anopheles tarsimaculatus</i> .....	3		3	100.0	
<i>Anopheles vestitipennis</i> .....	1	1	2		
<i>Chagasia bathanus</i> .....	5	11	16	31.3	

be met with in pooled streams was *A. pseudopunctipennis*. This type of breeding place accounted for three times as many of the *A. pseudopunctipennis* larvae as it did for *A. albimanus*—28.7 as compared to 9.1 per cent.

A factor of considerable importance in anopheline ecology is sunlight. Of the 16 species which we have found in Costa Rica, some have shown a marked preference for light, while others have appeared to select shade and the remainder have failed to exhibit a well-marked tropism either way. *Anopheles albimanus*,

*A. argyritarsis*, *A. neomaculipalpus* and *A. pseudopunctipennis* constitute the group which has consistently chosen breeding places well exposed to the sunshine. On the other hand *Chagasia bathanus* has seemed definitely to prefer shade, while *A. apicimacula*, *A. punctimacula* and *A. eiseni* have been met with in sunny as well as shady places. In a few collections we omitted

TABLE 6

Relative prevalence of 5,338 culicine mosquitoes captured as adults inside houses, in traps, or with a horse as bait at sunset

SPECIES OF MOSQUITO	CAUGHT INSIDE HOUSES	CAUGHT IN STABLE-TYPE MOSQUITO TRAPS	CAUGHT WITH A HORSE AS BAIT AT SUNSET	TOTALS	PER CENT OF ALL MOSQUITOES CAUGHT
<i>Psorophora cingulata</i> .....			4	4	0.1
<i>Psorophora ferox</i> .....		6	14	20	0.4
<i>Psorophora howardii</i> .....		13		13	0.2
<i>Psorophora lutzii</i> .....	1		37	38	0.7
<i>Psorophora tolteca</i> .....		8	44	52	1.0
<i>Psorophora varipes</i> .....			16	16	0.3
<i>Aedes aegypti</i> .....	44	1		45	0.8
<i>Aedes angustivittatus</i> .....	1	67	491	559	10.5
<i>Aedes euplocamus</i> .....		2	3	5	0.1
<i>Aedes taeniorhynchus</i> .....		62	335	397	7.4
Other <i>Aedes</i> and <i>Haemagogus</i> .....	1	2	5	8	0.2
<i>Mansonia fasciolata</i> .....	7	221	171	399	7.5
<i>Mansonia titillans</i> .....	56	837	524	1,417	26.5
<i>Deinocerites epitedens</i> .....			11	11	0.2
<i>Deinocerites pseudus</i> .....	11		17	28	0.5
<i>Culex chrysonotum</i> .....		32	50	82	1.5
<i>Culex corniger</i> .....		21		21	0.4
<i>Culex declarator</i> .....	16	267	106	389	7.3
<i>Culex fatigans</i> .....	1,340	219	211	1,770	33.2
<i>Culex</i> sp. ?.....	2	13	27	42	0.8
Sabethines, <i>Megarhinus</i> , etc.....	6	2	14	22	0.4
Totals.....	1,485	1,773	2,080	5,338	100.0

to record data as to light or shade, so the percentages in table 5 have been calculated from collections with complete data only.

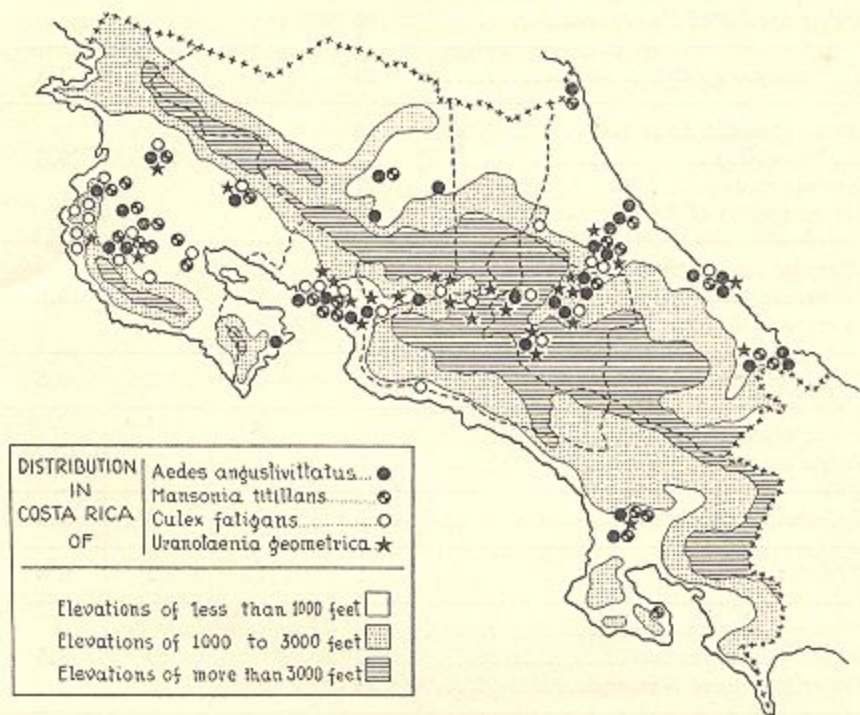
#### RELATIVE PREVALENCE OF THE VARIOUS CULICINES AND SABETHINES

The culicine mosquitoes most frequently taken as adults inside houses, in stable-type mosquito traps, with or without a horse as



bait at sunset, were *Culex fatigans*, *Mansonia titillans* and *Aedes angustivittatus*. Table 6 analyses the relative prevalence of 32 species among 5338 culicine mosquitoes caught as adults. Only the commoner species are mentioned in Table 6 by name, while the rarer ones have been grouped.

2,195 non-anophelines representing some 60 species were collected as larvae or pupae and were later bred out and identified.



MAP 1

Of these, the most numerous were *Culex stigmatosoma* and *Uranotaenia geometrica*. The latter were found in three times as many localities as the former. The geographical distribution of the various anophelines obtained in Costa Rica has been discussed in a paper by Kumm and Ruiz (6). Similarly, the distribution of four of the commoner non-anophelines, namely *Culex fatigans*, *Mansonia titillans*, *Aedes angustivittatus* and *Uranotaenia geometrica* is shown in the following map. It is evident that *Mansonia titillans* is confined in its distribution to

TABLE 7

Relative prevalence of 623 non-anopheline mosquitoes captured as adults in the forests in the daytime or in other ways

SPECIES OF MOSQUITOES	CAUGHT IN DAYTIME CAPTURES IN FOREST	OTHER MODES OF CAPTURE*	TOTALS	PER CENT OF ALL MOSQUITOES CAUGHT
<i>Psorophora ferox</i> .....	64	3	106	17.0
<i>Psorophora lutzii</i> .....	33			
Other species of <i>Psorophora</i> .....	6			
<i>Haemagogus</i> species.....	10	1	11	1.8
<i>Aedes angustivittatus</i> .....	42	2	248	39.8
<i>Aedes nubilus</i> .....	67	6		
<i>Aedes serratus</i> .....	127			
Other species of <i>Aedes</i> .....	4			
<i>Mansonia arribalzagae</i> .....	16	1	95	15.2
<i>Mansonia fasciolata</i> .....	5	1		
<i>Mansonia titillans</i> .....		72		
<i>Lutzia allostigma</i> .....		3	3	0.5
<i>Culex nigripalpus</i> .....	5		56	9.0
Other species of <i>Culex</i> .....	7	44		
<i>Sabethoides chloropterus</i> .....	5	3	8	1.3
<i>Limatus</i> species.....	1	1	2	0.3
<i>Wyeomyia melanocephala</i> .....	19		59	9.5
<i>Wyeomyia scotinomus</i> .....	7			
Other species of <i>Wyeomyia</i> .....	24	9		
<i>Goeldia</i> species.....	11		11	1.8
<i>Trichoprosopon digitatus</i> .....	19		19	3.0
<i>Orthopodomyia fasciipes</i> .....		3	3	0.5
<i>Megarhinus moctezuma</i> .....		2	2	0.3
Totals.....	472	151	623	100.0

\* Other modes of capture include catches in hollow trees, outhouses, under bridges and in holes in the ground.

localities at or near sea level, whereas the other three species have been found in the highlands as well as the lowlands.

In addition to the 5338 culicine mosquitoes caught as adults inside houses, in stable-type mosquito traps or with a horse as bait at sunset, 623 other non-anophelines were taken in the forests in the daytime, or in various other ways. Because of the proximity of Costa Rica to some of the endemic regions of jungle yellow fever, it seemed worthwhile to study the day-biting mosquitoes of the Costa Rican forests. Accordingly, we occasionally made daytime catches of adult mosquitoes in the dense forest, when time permitted and conditions were suitable. Such catches have been made with human bait in the manner often employed in Brazil. The 472 mosquitoes thus obtained are listed in the second column of table 7. This shows that the most prevalent mosquitoes in the Costa Rican forests included certain wild species of *Psorophora*, *Aedes* and *Mansonia*.

During the course of the mosquito survey of Costa Rica we discovered new species of *Haemagogus*, *Orthopodomyia* and *Aedes*. A new species of *Haemagogus*, *H. mesodentatus*, was described by Komp and Kumm (7), and the new species of *Orthopodomyia* from Orosi will be named by Dr. F. W. Edwards. A new *Aedes* belonging to the subgenus *Howardina* was found breeding in arboreal bromeliads on the slopes of the Irazú and Poás volcanoes and will be described at a later date.

GEOGRAPHICAL DISTRIBUTION RECORDS WITH NOTES ON  
PREFERRED TYPES OF BREEDING PLACES FOR  
EACH SPECIES

<i>Name of species</i>	<i>Province</i>	<i>Localities</i>
<i>Sabethoides chloropterus</i> Humboldt	Alajuela	Coyolar
	Guanacaste	Santa Cruz
	Puntarenas	Esparta, Puntarenas

Adults of this species were captured during the daytime with human bait in the forests.

<i>Limatus asulleptus</i> Theobald	Alajuela	Orotina
	Limón	Beverley

In Orotina this species was found breeding in some ornamental sea shells which had been employed to decorate an open air altar in the garden of the local church.

<i>Limatus durhamii</i> Theobald	Alajuela	Orotina
	Guanacaste	Cañas
	Puntarenas	Esparta, Golfito

*L. durhamii* was obtained from the same ornamental sea shells in the church at Orotina as *L. asulleptus*. It was also found in holes in bamboos which were full of rain water.

<i>Wyeomyia aporonoma</i> Dyar and Knab	Cartago	Orosi
	Guanacaste	Santa Cruz
	Limón	Barra del Parismina, Liverpool, Margarita, Siquiness
	Puntarenas	Golfito, Pozo

Larvae of this species were usually encountered in rain water in tree holes and coconut shells, but on one occasion they were also found in the holy-water font of the church in Santa Cruz.

<i>Wyeomyia complosa</i> Dyar	Limón	Barra del Parismina
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Larvae of *W. complosa* were aspirated from the interstices of the pink flowers of certain large *Heliconias* which were found in the forest behind the cemetery at Parra del Parismina.

? <i>Wyeomyia guatemala</i> Dyar and Knab	Cartago	Orosi
	Limón	Bananito, Barra del Parismina, Cairo, Liv- erpool
	Guanacaste	Cañas

The larvae live in the water which collects in the leaf bases of arboreal bromeliads.

<i>Wyeomyia intonca</i> Dyar and Knab	Cartago	Turrialba
	Limón	Bananito, Beverley, Liv- erpool and Siguirres

Larvae were aspirated from rain water in the leaf bases of certain arboreal bromeliads.

<i>Wyeomyia melanocephala</i> Dyar and Knab	Limón	Barra del Parismina, Liverpool
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Adults of *W. melanocephala* were captured with human bait in the forests in the daytime.

? <i>Wyeomyia melanopus</i> Dyar	Cartago	Orosi
	Limón	Liverpool

Larvae of this species were secured by sucking up water from the leaf bases of certain arboreal and terrestrial bromeliads and on one occasion from a tree hole.

<i>Wyeomyia scotinomus</i> Dyar and Knab	Cartago Limón	Orosi Laguna de Jaloba, Liverpool
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Larvae were encountered in the rain water which collects in the leaf bases of certain arboreal bromeliads.

<i>Goeldia leucopus</i> Dyar and Knab	Limón	Liverpool
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Adults were taken in daytime captures in the forests.

<i>Goeldia longipes</i> Fabricius	Limón	Barra del Parismina, Siquirres
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A day-biting sylvan species.

<i>Goeldia magna</i> Theobald	Limón	Laguna de Jaloba.
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A single adult specimen of *G. magna* was obtained in the dense forest shortly after midday.

<i>Trichoprosopon digitatus</i> Rondani	Limón	Bananito, Beverley, Liverpool, Margarita, Siquirres
	Puntarenas	Esparta

This is the cocoa-pod mosquito. Dyar (5) says that the adults do not bite, but we have been bitten by this species in the States of Bahia and Para, Brazil, as well as in Costa Rica.

? <i>Psorophora champerico</i> Dyar and Knab	Limón	Siquirres
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This species was caught in the daytime in the forest.

<i>Psorophora cingulata</i> Fabricius	Alajuela Cartago Limón	Pital Canada Barra del Parismina, Siquirres
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Adults only were obtained, and they were secured either with a horse as bait at sunset, or else in the dense forests in the daytime.

<i>Psorophora ferox</i> Humboldt	Cartago Guanacaste	Chitarría Filadelfia, Liberia, Las Cañas, Santa Cruz
	Limón	Barra del Parismina, Beverley Chase, Cahuita, Laguna de Jaloba, Liverpool, Margarita, Siquirres
	Puntarenas	Pozo, Puntarenas

We encountered larvae of this species in ground pools exposed to the sun, and on two occasions in semistagnant pools at the edge of slowly running streams.

<i>Psorophora howardii</i> Coquillett	Guanacaste	Belen, Liberia, Santa Cruz
	Puntarenas	Puntarenas

*P. howardii* breeds in ground pools and in the water which has collected in the hoof prints of cattle, in the sunshine.

<i>?Psorophora jamaicensis</i> Theobald	Cartago	Turrialba
	Guanacaste	Belen, Cañas, Las Juntas, Pozo de Agua, Santa Barbára, Santa Cruz
	Limón	Barra del Colorado, Cairo, Cieneguita, Puerto Viejo
	Puntarenas	Barranca, Jicaral, Paquera

This species was found breeding in sunny pools and depressions on the ground.

<i>Psorophora lutzii</i> Theobald	Limón	Bananito, Barra del Colorado, Beverley, Field, Liverpool, Margarita, Siquirres, Suerre
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No larvae were taken, but adults were caught with a horse as bait at sunset, and in the forests in the daytime.

<i>Psorophora varipes</i> Coquillett	Limón	Chase, Field, Margarita
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Adults only were obtained and they were captured with a horse as bait at sunset, or else with human bait in the forests in the daytime.

<i>Haemagogus anastasionis</i> Dyar	Guanacaste	Santa Cruz
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Larvae of this species were collected in a holy-water font in the church at Santa Cruz, and were described by Komp and Kumm (7).

<i>Haemagogus chalcospilans</i> Dyar	Puntarenas	Golfito, Puerto Jimenez, Puntarenas
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*H. chalcospilans* was found breeding in tree holes and coconut shells full of clean rain water.

<i>Haemagogus iridicolor</i> Dyar	Limón	Barra del Parismina
	Puntarenas	Pozo

Adults were caught with human bait in the dense forests in the daytime, while larvae were aspirated from rain water in tree holes.

*Haemagogus lucifer* Howard,      Limón      Guapiles  
Dyar and Knab

This species breeds in tree holes.

*Haemagogus mesodentatus* Komp      San José      San José  
and Kumm

A tree-hole breeder found in the Parque Bolivar, San José, and described by Komp and Kumm (7).

*Aedes aegypti* Linnaeus      Alajuela      Orotina  
Limón      Cieneguita, Liverpool,  
Siquirres, Zent, Puerto  
Viejo  
Puntarenas      Esparta, Puntarenas

*Stegomyia* larvae were encountered in artificial containers, and also in some ornamental sea shells that were being utilized to decorate an open air altar in the garden of the church at Orotina.

*Aedes angustivittatus* Dyar and      Alajuela      Cerrillos, Coyolar, Mue-  
Knab      lle, Pital, Santa Clara,  
Cascajal  
Cartago      Canada, Chitaria, Orosi,  
Peralta, Sanatorio Du-  
ran, Turrialba  
Guanacaste      Bolsón, Cañas, Filadel-  
fia, Liberia, Santa  
Barbára, Santa Cruz,  
Sardinal  
Limón      Bananito, Barra del Col-  
orado, Barra del Paris-  
mina, Cairo, Castilla,  
Chase, Cieneguita,  
Liverpool, Margarita,  
Puerto Viejo, Siqui-  
rres, Suerre  
Puntarenas      Barranca, Paquera,  
Pozo, Puntarenas,  
Sierpe, Volcan

This is the commonest of the *Aedes* which we have taken in Costa Rica, both as regards the actual number of adults and larvae obtained and in the number of different localities where this species has been met with. It breeds in ground pools, hoof prints of animals, pooled streams and sometimes in fresh water swamps.

<i>Aedes euplocamus</i> Dyar and Knab	Guanacaste	Liberia
	Heredia	Heredia
	Limón	Bananito, Puerto Viejo, Siquirres
	Puntarenas	Barranca, Paquera

This species breeds in ground pools in the sun.

<i>Aedes hastatus</i> Dyar	Puntarenas	Pozo
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Larvae of *A. hastatus* were found in ground pools beside a slowly running stream in the sunlight.

<i>Aedes lithoecetor</i> Dyar and Knab	Cartago	Peralta, Turrialba
	Guanacaste	Las Juntas

A rock-hole breeder by preference, which occasionally appears in ground pools as well.

<i>Aedes nubilus</i> Theobald	Limón	Barra del Parismina, Beverley, Field, La- guna de Jaloba, Liver- pool, Margarita, Siqui- rres
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No larvae were secured, but adult *A. nubilus* were captured in the forests with human bait.

<i>Aedes atropalpus</i> Coquillett	Guanacaste	Liberia
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Larvae of this species were observed in urns and flower vases half full of rain water in the cemetery at Liberia.

<i>Aedes terreus</i> Walker	Alajuela	Orotina, Rio Segundo, San Mateo
	Cartago	Orosi
	Guanacaste	Liberia, Santa Cruz
	Limón	Chase
	San José	San José, Santa Ana

This is a tree-hole breeder and has been obtained nowhere else.

<i>Aedes quadrivittatus</i> Coquillett	Alajuela	Poás Volcano
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This species breeds in the leaf bases of arboreal bromeliads on the slopes of Poás Volcano.

<i>Aedes</i> n. sp.	Alajuela	Poás Volcano
	Cartago	Cipreses

A bromeliad breeder which was taken on the slopes of the Irazú and Poás volcanos.



<i>Aedes serratus</i> Theobald	Guanacaste	Filadelfia
	Limón	Bananito, Barra del Parismina, Field, Laguna de Jaloba, Liverpool, Siquirres
	Puntarenas	Pozo

A day-biting sylvan species. No larvae were seen.

<i>Aedes taeniorhynchus</i> Wiedemann	Guanacaste	Bolsón, Cañas, Filadelfia, Huacas, Pozo de Agua, Santa Barbára, Santa Cruz, Sardinal
	Limón	Cieneguita, Puerto Viejo
	Puntarenas	Barranca, Bonilla, Caldera, Jicaral, Puntarenas, San Lucas Island

Usually a brackish water breeder, but occasionally found in pools of fresh water also, near the sea.

<i>Theobaldia maccrackena</i> Dyar and Knab	Cartago	Sanatorio Duran
	San José	San Isidro de Coronado

The larvae of this species were found in ground pools in the high mountains. It is also known from the Chiriqui Volcano region in Panamá.

<i>Mansonia arribálagas</i> Theobald	Limón	Barra del Parismina, Laguna de Jaloba, Liverpool
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A day-biting sylvan species of which we obtained no larvae.

<i>Mansonia fasciolata</i> Lynch— Arribálagas	Alajuela	Muelle, Pital
	Cartago	Canada, Chitaría, Orosi, Peralta
	Limón	Barra del Colorado, Barra del Parismina, Cairo, Chase, Cieneguita, Liverpool, Margarita, Siquirres, Suerre
	Puntarenas	Barranca, Bonilla, Pozo

No larvae were seen, but numerous adults were captured inside houses, in traps, with a horse as bait at sunset, and even in the dense forests in the daytime.

<i>Mansonia titillans</i> Walker	Alajuela	Muelle
	Cartago	Chitaría

Guanacaste	Bolsón, Cañas, San Lazaro, Filadelfia, Liberia, Paso Tempisque, Pozo de Agua, Quebrada Honda, Santa Bárbara, Santa Cruz, Sardinal
Limón	Barra del Colorado, Cairo, Chase, Cienequita, Margarita, Siquirres, Suerre
Puntarenas	Barranca, Bonilla, Caldera, Palmar, Pozo, Puerto Jimenez, Puntarenas, Sierpe

This species breeds in ground pools and ponds, especially in the presence of *Pistia stratiotes*. It is very abundant in the coastal lowlands.

*Deinocerites epitedeus* Knab      Limón      Puerto Viejo

In Costa Rica this species has been caught on the Atlantic coast only.

*Deinocerites pseudus* Dyar and Knab      Puntarenas      Bonilla, Jicaral, Puntarenas, Tarcoles, San Lucas Island

A crab-hole breeder which has been found, so far, on the Pacific coast only.

*Culex (Lutzia) allostigma* Howard, Dyar and Knab      Limón      Siquirres

No larvae have been seen, but adults were captured resting inside a water tank.

*Culex aikenii* Aiken      Puntarenas      Bonilla

This species was secured in a pond, whose surface was largely overgrown with floating *Pistia stratiotes*.

*Culex bastagarius* Dyar and Knab      Cartago      Canada

Larvae were obtained in a stagnant pool in a slowly running stream among plenty of horizontal and vertical vegetation.

*Culex chrysonotum* Dyar and Knab      Alajuela  
Limón      Pital  
Puntarenas      Barra del Colorado,  
Chase, Estrada, Puerto Viejo, Siquirres  
Pozo

*C. chrysonotum*<sup>1</sup> breeds in ground pools and ponds in the sunshine and was found on one occasion in partly brackish water with *Anopheles tarsimaculatus* and *Aedes taeniorhynchus*.

*Culex conservator* Dyar and Knab      Puntarenas      Golfito

An adult of this species was taken in a hollow tree in the forest at Golfito.

*Culex conspirator* Dyar and Knab      Guanacaste      Cañas, Santa Cruz  
Limón      Liverpool

Larvae were encountered in pot holes and rocky pools at the edge of streams and rivers among floating leaves and other debris.

*Culex corniger* Theobald      Alajuela      Mastate, San Rafael Sur,  
Alajuela  
Cartago      Orosi  
Limón      Liverpool  
San José      Santa Ana

Larvae of this species were found in ground pools, tree holes, and even coconut shells full of rain water.

*Culex coronator* Dyar and Knab      Cartago      Peralta  
Limón      Estrada

Specimens of this species were taken in ground pools and depressions along the edges of streams as well as in seepage areas in the sunshine.

*Culex daumastocampa* Dyar and Knab      Limón      Cairo

The larvae live in the water that collects in the leaf bases of arboreal bromeliads.

*Culex declarator* Dyar and Knab      Alajuela      Caseajal, Mastate  
Cartago      Orosi  
Guanacaste      Cañas, Liberia, Santa Cruz  
Limón      Cieneguita, Siquirres  
Puntarenas      Barranca, Pozo

This is generally a ground-pool breeder though it has been found in pot holes among rocks in the beds of intermittent streams, but always in the sunlight.

*Culex fatigans* Wiedemann      Alajuela      Orotina, Rio Segundo,  
San Antonio de Tejar  
Cartago      Canada, Capellades,  
Orosi  
Guanacaste      Arenal, Cañas, Huacas,  
Liberia, Nicoya, Que-

	brada Honda, Rio Seco, Santa Bárbara, Santa Cruz, Santa Rosa, Sardinal, Tem- pate
Limón	Cairo, Cieneguita, Guapiles, Siquirres
Puntarenas	Barranca, Esparta, Pun- tarenas
San José	Parrita, San José

Breeds in abundance in artificial containers, ground pools, seepage areas, and indeed in any place with dirty water. It is the commonest *Culex* in Costa Rica.

*Culex hesitator* Dyar and Knab      Cartago      Orosi, Peralta

Larvae were found in hoof prints, neglected ditches and pools in the ground exposed to the sun.

*Culex inhibitor* Dyar and Knab      Puntarenas      Bonilla

This species breeds in sunny ponds which are covered with floating lilies' *Pistia stratiotes*, water hyacinth and other horizontal vegetation.

*Culex jenningsi* Dyar and Knab      Cartago      Orosi, Turrialba.

*C. jenningsi* breeds in the water that collects between the leaf bases of arboreal bromeliads.

*Culex mollis* Dyar and Knab      Limón      Cairo  
San José      Santa Ana

In Costa Rica this is a tree-hole breeder.

*Culex mutator* Dyar and Knab      Cartago      Peralta

Larvae were found in holes in rocks exposed to the sun beside the Reventazón River.

*Culex nigripalpus* Theobald      Guanacaste      Santa Cruz

Adults of this species were caught resting on leaves in the shade in a banana plantation, but no larvae were found.

*Culex pilosus* Dyar and Knab      Limón      Estrada

Larvae were secured in stagnant collections of water in the hoof prints of cattle in the sunshine.

*Culex stenolepis* Dyar and Knab      Cartago      Cipreses, Orosi

This is a bromeliad breeder and has been seen nowhere else.

<i>Culex stigmatosoma</i> Dyar	Alajuela	Alajuela
	Cartago	Cartago, Orosi, Palomo, Paso Ancho, Paraiso, Sanatorio Duran, Tapanti
	San José	Santa Ana

This is a common species on the central plateau where it breeds in pools beside streams, ponds, ditches, seepage areas, swamps and the hoof prints of animals, but always in the sunshine.

<i>Culex trifidus</i> Dyar	San José	Santa Ana
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Larvae were found in sunny pools along the edge of a stream among *Spirogyra* and considerable debris.

? <i>Culex</i> sp. ?	Cartago	Cipreses
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This highland species breeds in the leaf bases of arboreal bromeliads.

<i>Aedomyia squamipennis</i> Lynch— Arribáizaga	Puntarenas	Barranca
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*Aedomyia* larvae were obtained in a sunny swamp whose surface was largely covered with *Pistia stratiotes*.

<i>Orthopodomyia fascipes</i> Coquillett	Limón	Bananito, Cairo
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No larvae of this species were seen, but adults were occasionally encountered in hollow trees in the forest or other well-shaded places.

<i>Orthopodomyia phyllozoa</i> Dyar and Knab	Cartago	Orosi
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The larvae live in the water which collects in the leaf bases of arboreal bromeliads.

<i>Orthopodomyia</i> n. sp.	Cartago	Orosi
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On one occasion larvae of this species were secured in large numbers from an abandoned tank or cesspool full of clear rain water in the village of Orosi.

<i>Megarhinus moctezuma</i> Dyar and Knab	Alajuela	Orotina
	Puntarenas	Barranca, Esparta, Jesus Maria, San Lucas Is- land
	San José	San José

A tree-hole breeder. Adults were occasionally caught in houses, in hollow trees, or in well-shaded places, such as under bridges.

<i>Megarhinus superbus</i> Dyar and Knab	Cartago	Orosi
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This species breeds only in epiphytic bromeliads.

<i>Uranotaenia coatzacoalcos</i> Dyar and Knab	Alajuela	Ceiba, Turrucares
	Cartago	Orosi
	Guanacaste	Cañas
	San José	San Isidro de Coronado

Larvae have been found in running as well as pooled streams, in ditches, ground pools and fresh water swamps, in both light and shade.

<i>Uranotaenia geometrica</i> Theobald	Alajuela	Alajuela, Atenas, Cascajal, Higuito, San Antonio de Tejar
	Cartago	Canada, Chitaría, El Alto, Orosi, Palomo, Peralta, Turrialba
	Guanacaste	Caja, Cañas, Liberia, Veintiseiete de Abril
	Limón	Cairo, Chase, Limón, Siquirres
	Puntarenas	Arancibia, Barranca, Miramar, Pozo
	San José	Aserri, San Isidro de Coronado, Santa Ana

A very common species which has been observed in pooled streams, ponds, seepage areas, ditches, swamps, the hoof prints of animals and indeed ground pools of all kinds. It shows a decided tropism for breeding among green *Spirogyra*; at least three quarters of all our collections of this species having been found in the presence of green algae in the sunlight.

<i>Uranotaenia lowii</i> Theobald	Guanacaste	Liberia
	Puntarenas	Arancibia, Kilometro 99
	San José	Parrita

Rather a rare species, it breeds in rocky pools beside rivers, borrow pits, the hoof prints of animals, and other types of ground pools in the sunshine.

<i>Uranotaenia pulcherrima</i> Lynch	Puntarenas	Bonilla
—Arribálzaga		

A single larva of this species was taken in a pond full of water lettuce.

<i>Uranotaenia sapphirina</i> Osten—	Cartago	Canada, Orosi
Sacken		

A rare highland species which has been encountered in semistagnant pools in slowly running streams, with plenty of vegetation and exposed to the sun.

<i>Anopheles albimanus</i> Wiedemann	Alajuela	Cascajal, Ceiba, Ciruelas, Hidalgo, Muelle,
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	Pital, Santa Clara, Coyolar
Cartago	Canada, Chitaría, Pe- ralta, Turrialba, Uja- rras
Guanacaste	Arenal, Bebedero, Belen, Bolsón, Buena Vista, Caballito, Cañas, Co- pal, Corralillo, Fila- delfia, Huacas, Lagu- nilla, Liberia, Mata- palo, Montano, Mora- cia, Nandayure, Ni- coya, Ortega, Paso Tempisque, Pozo Azul, Pozo de Agua, Que- brada Honda, Rio Seco, Roblar, San Juan (Abangares), San Juan (Santa Cruz), San Lazaro, Santa Barbára, Santa Cruz, Santa Rosa, Sardinal, Tem- pate, Vigía, Veintei- siete de Abril, Zapote
Limón	Barra del Colorado, Barra del Parismina, Bonifacio, Cahuita, Cairo, Chase, Ciene- guita, Estrada, Guaci- mo, Guapiles, Jimenez, Limón, Liverpool, Margarita, Matina, Pacuarito, Penshurst, Pocora, Puerto Viejo, Siquirres, Suerre, Westfalia, Zent
Puntarenas	Arancibia, Barranca, Bonilla, Caldera, Cho- mes, Corozal, Esparta, Golfito, Jesus Maria, Jicaral, Kilometro 99, Lepanto, Palmar, Pa- quera, Pozo, Puerto Jimenez, Puntarenas, Salinas, Tarcoles, San Lucas Island

The commonest anopheline in Costa Rica. It breeds principally in sunny ground pools about half of the collections having been obtained in the presence of *Spirogyra*.

*Anopheles albitarsis* Lynch— Puntarenas Buenos Aires, Volcán  
Arribáizaga

Larvae of *A. albitarsis* were obtained in a sunny pond among algae, vertical and horizontal vegetation.

*Anopheles anomalophyllus* Komp Cartago Canada

A very rare species which has been taken only once in a pool in a slowly running stream.

<i>Anopheles apicimacula</i> Dyar and Knab	Alajuela	Alajuela, Atenas, Ciruelas, Coyolar, Escobal, Palmares, Pital, Quebrada Azul, San Antonio de Tejar, San Ramón, Santa Clara
	Cartago	Canada, Chitaria, Orosi
	Guanacaste	Arado, Cañas, Higueron, La Sierra, Las Juntas, Liberia, Nambi, Nicoya, Pozo Azul, Santa Cruz, Santa Rosa, Sardinal, Tilaran
	Limón	Barra del Colorado, Cairo, Cimarrones, Guacimo, Guapiles, Jimenez, Laguna de Jaloba, Liverpool, Siquirres
	Puntarenas	Barranca, Esparta, Jicaral, Palmar, Paquera, Pavones, Pozo, Puerto Jimenez, Puntarenas, Volcan
	San José	Escasu, Villa Colon

The breeding places selected by *A. apicimacula* were similar to those chosen by *A. argyritarsis* except that at least one third of the former were in the shade. In only 28.6 per cent was *Spirogyra* noted.

<i>Anopheles argyritarsis</i> Robineau—Desvoidy	Alajuela	Aguas Zarcas, Alajuela, Atenas, Balsa, Carrillo, Cascajal, Cerrillos, Ciruelas, Concepción, Coyolar, Escobal, Flo-
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	rencia, Grecia, Hacienda Vieja, Higuito, La Guacima, Mastate, Muelle, Naranjo, Ojo de Agua, Orotina, Palmares, Quebrada Azul, Rio Segundo, San Antonio de Tejar, San Mateo, San Rafael Norte, San Rafael Sur, San Ramón, Santa Clara, Turrucares, Villa Quesada
Cartago	Atirro, Cachi, Capellades, Cartago, Chitaria, El Alto, El Hoyo, Florencia, Las Mesas, Orosi, Palomo, Paraiso Pejivalle, Platanillo, Tapanti, Tres Rios, Tucurrique, Turrialba, Tuis, Ujarraz
Guanacaste	Cañas, La Cruz, Las Juntas, Los Angeles, Liberia, Pozo Azul, Sabana Grande, San Antonio, San Juan (Abangares), San Juan (Santa Cruz), Santa Cruz, Tempate, Tilaran, Veinteisiete de Abril
Heredia	Barreal, Heredia, San Antonio de Belen, Santo Domingo
Limón	Cairo, Guapiles, Limón, Pacuarito, Siguirres, Waldeck
Puntarenas	Arancibia, Baron, Barranca, Boruca, Buenos Aires, Esparta, Jesus Maria, Miramar, Rio Seco, San Isidro, San Rafael, Volcan
San José	Alajuelita, Aserri, Coronado, Curridabat, Desamparados, Escasu, San Juan de Tibas,

San José, San Marcos  
de Tarazu, Santa Ana,  
Villa Colon

A very abundant species which was encountered somewhat more often in running streams, pooled streams and seepage areas than *A. albimanus*. In only 31.5 per cent of the collections which yielded this species, did we note the presence of green algae. Larvae of *A. argyritarsis* have been identified from collections made in rock pools in the dry bed of a stream more than a mile away from the nearest human habitation.

<i>Anopheles bachmanni</i> Petrocchi	Puntarenas	Barranca
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Larvae of this species were obtained in a pooled stream between the floating leaves of water lettuce.

<i>Anopheles chiriquiensis</i> Komp	Alajuela	Zarcero
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The larvae of this rare highland species were found in pools in a slowly running stream, some in the shade and some in the sunlight.

<i>Anopheles eiseni</i> Coquillett	Alajuela	Zarcero
	Cartago	El Hoyo, Orosi
	Guanacaste	Hatillo, Liberia, Nambi, San Antonio, Tilaran
	Heredia	Barreal
	Limón	Cairo, Guapiles, Liver- pool, Margarita
	Puntarenas	Golfito
	San José	San José, San Juan de Tibas

While not a particularly common species in Costa Rica *A. eiseni* has been obtained in its larval stages under a great variety of conditions, including pools in stream beds, ditches, seepage areas, hoof prints of cattle, tree holes, coconut shells full of rain water, and even bromeliads. More than half of these were in the shade, and in only 14.3 per cent of the collections did we observe *Spirogyra*.

<i>Anopheles neivai</i> Howard, Dyar and Knab	Cartago	Canada, Orosi
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This species breeds in the rain water which collects between the leaf bases of arboreal bromeliads.

<i>Anopheles neomaculipalpus</i> Curry	Guanacaste	Cañas, Higuaron, Lagu- nilla Liberia, Mata- palo, Santa Cruz
	Limón	Chase, Guacimo, Si- quirres
	Puntarenas	Barranca, Pozo

A relatively abundant species during the rainy season, the larvae of which were observed in ground pools, ditches, hoof prints of cattle and small ponds, almost always in the sunshine. In about a quarter of the breeding places we noticed green algae.

<i>Anopheles pseudopunctipennis</i> Theobald	Alajuela	Atenas, Cascajal, Ceiba, Cerrillos, Ciruelas, Coyolar, Escobal, Higuito, La Guacima, Muñoz, Ojo de Agua, San Antonio de Tejar, San Rafael Sur, Santa Clara
	Cartago	Canada, Orosi, Tapanti Tucurrique, Turrialba
	Guanacaste	Arenal, Belen, Caballito, Caja, Cañas, Copal, Corralillo, Huacas, La Sierra, Liberia, Matapalo, Montano, Quebrada Honda, Rio Seco, Sabana Grande, San Blas, San Juan (Santa Cruz), San Vicente, Santa Bárbara, Santa Cruz, Santa Rosa, Sardinal, Veintecisiete de Abril
	Heredia	Heredia
	Limón	Cairo, Guacimo, Guapiques, Limón, Pocora, Siquirres, Waldeck
	Puntarenas	Arancibia, Barranca, Caldera, Canjel, Corozal, Esparta, Jesus Maria, Kilometro 99, Pavones, Pozo, Salinas Tarcoles, Volcan
	San José	Coronado, Santa Ana

Numerous larvae of this species were taken in ground pools, ditches, hoof prints of cattle and seepage areas. It was also frequently found in pooled streams and sometimes at the very edge of slowly running rivers, particularly in the sunlight and where green algae was flourishing. Among 31 collections in which a record was made as to the presence or absence of *Spirogyra*, algae were noted as present in 22 or 70.1 per cent.

<i>Anopheles punctimacula</i> and Knab	Dyar	Guanacaste	Cañas, Huacas, Rio Seco, Santa Cruz
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Limón	Barra del Colorado, Beverley, Cieneguita, Liverpool, Puerto Viejo, Siquirres, Suerre
Puntarenas	Barranca, Paquera, Pozo

*A. punctimacula* breeds in semistagnant pools and at the edges of slowly running streams, in ditches, borrow pits, hoof prints of animals, and small ponds. More than a third of the collections of this species were obtained in the shade and *Spirogyra* was noted in only 25 per cent.

<i>Anopheles strodei</i> Root	Alajuela	Cascajal, Muelle
	Guanacaste	Cañas, Liberia, Quebrada Honda
	Limón	Cairo, Chase, Margarita, Pocora, Siquirres, Suerre
	Puntarenas	Barranca, Bonilla, Jicaral, Kilometro 99, Pozo Volcan

A ground pool breeder which has also been observed in small ponds, the hoof prints of cattle, and in slowly running streams in the sunshine.

<i>Anopheles tarsimaculatus</i> Goeldi	Limón	Barra del Colorado, Cahuita, Cieneguita, Puerto Viejo
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This is the brackish water *Anopheles*. It was obtained in addition on one occasion in a fresh-water stream about fifty yards from the sea.

<i>Anopheles vestitipennis</i> Dyar and Knab	Limón	Barra del Colorado, Cahuita, Suerre
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Larvae of *A. vestitipennis* were found in a slowly running stream with much vegetation and algae, as well as in an overgrown shaded pool.

<i>Chagasia bathanus</i> Dyar	Alajuela	Pital, Quebrada Azul, Santa Clara
	Guanacaste	Arado, Cañas, Higuaron, La Sierra, Lagunilla, Las Juntas, Rio Seco, Santa Bárbara, Santa Cruz, Santa Rosa
	Limón	Barra del Colorado, Cairo, Guapiles, Puerto Viejo
	Puntarenas	Jicaral, Paquera, Pozo, Puerto Jimenez

*Chagasia bathanus* shows a marked tropism for shady pools in running streams. If there are trees along the bank the *Chagasia* larvae will be found wherever any exposed tree roots enter the water of the stream. At other times they may be secreted among grass growing at the edge of the water, but hardly ever if *Spirogyra* is present.

KEYS TO THE CULICIDAE OF COSTA RICA, ENCOUNTERED IN THE PRESENT SURVEY

Species representing all of the five tribes recognized by Dyar were encountered. A brief key to these five tribes is given below as well as generic keys for the tribes *Anophelini* and *Culicini*. In addition species keys for the identification of adult females of the genera *Psorophora*, *Aedes*, *Orthopodomyia*, *Mansonia*, *Uranotaenia* and *Anopheles* have been prepared. In the genera *Haemagogus* and *Culex* identification is based on the characters of the male terminalia, the female adults being indistinguishable in many cases; keys to the male terminalia of those genera are beyond the scope of this paper.

KEYS TO TRIBES OF COSTA RICAN MOSQUITOES (DYAR, NEC EDWARDS)

- Tribes. 1. Sabethini  
 2. Culicini  
 3. Megarhinini  
 4. Uranotaeniini  
 5. Anophelini
1. Base of hind coxa in line with upper margin of meron. No mesonotal setae. Postnotal setae always present. Apex of 7th segment of female abdomen surrounded by a fringe of stiff bristles. Hind margin of abdominal tergites without setae.....*Sabethini*
  - Base of hind coxa below upper margin of meron (except in *Megarhinus*); mesonotal setae always present. Postnotal setae usually absent (present in some *Haemagogus*, *Deinocerites*, and *Carrollia*). Hind margin of abdominal tergites with setae.....2
  2. Palpi of female nearly as long as proboscis, which is straight. First abdominal tergite without scales. Scutellum crescent-shaped, without lobes (except in genus *Chagasia*). Coloration never metallic....*Anophelini*
  - Not as above.....3
  3. Large species, covered with metallic scales. Proboscis thinner and curved downwards on apical half. Posterior margin of scutellum straight. Clypeus much broader than long.....*Megarhinini*
  - Smaller species, usually without metallic scaling (see *Haemagogus*). Proboscis straight, uniform, or slightly swollen at tip. Posterior margin of scutellum trilobed.....4
  4. Small species, with spots or lines of metallic blue scales on thorax, base of wing, and/or pleura. Proboscis long, straight, directed backwards, the tip swollen. Anal vein ending at or slightly before, the fork in the fifth vein.....*Uranotaeniini*
  - Small to large species, usually without metallic blue spots. Proboscis straight, not directed backwards, tip not usually enlarged. Anal vein ending beyond the fork in the fifth vein.....*Culicini*

KEY TO THE GENERA AND SUBGENERA OF TRIBE ANOPHELINI OF COSTA RICA  
(AFTER EDWARDS)

Generic characterization; Palpi straight, as long as the proboscis; scutellum without lobes, crescent-shaped (except in genus *Chagasia*); first abdominal tergite without scales..... Tribe *Anopheleini*

In a recent personal communication, Dr. F. W. Edwards of the British Museum accepts the suggestion of the second author (W. H. W. K.) that *Kerteszia* be raised to the rank of a subgenus co-equal with *Nyssorhynchus*, instead of being considered a "group" under the subgenus *Nyssorhynchus*. With the exception of this emendation, the classification is that of Edwards (Genera Insectorum, Diptera, Fam. Culicidae, Fasc. 194, 1932).

1. Scutellum trilobed; sides of mesonotum with erect scales; first hind tarsal segment twice as long as hind tibia; resting-attitude *Mansonia*-like (one species, *bathanus*)..... *Chagasia*  
Scutellum not trilobed; sides of mesonotum without erect scales; first hind tarsal segment slightly longer than hind tibia; resting-attitude with proboscis, thorax, and abdomen in straight line at angle to resting surface (genus *Anopheles*)..... 2
2. A small slender black species, with unmarked wings; mesonotum with a narrow white longitudinal line in integument; body without scales; legs very long and slender (one species, *kompi*, not yet found in Costa Rica but probably present)..... subgenus *Stethomyia*  
Larger species, with spotted wings; mesonotum without narrow central white line; body with scales..... 3
3. Hind tarsi with last three segments all white, or with a narrow black basal ring on fifth segment..... subgenus *Nyssorhynchus*  
Hind tarsi otherwise marked..... 4
4. Hind tarsi all dark, unmarked (3 species, *chiriquiensis*, *pseudopunctipennis* and *eiseni*)..... series *Anopheles* of subgenus *Anopheles*  
Hind tarsi otherwise marked..... 5
5. Hind tarsi speckled and banded with white and black; wings with broad black, white, or yellow scales; mesonotum without parallel black lines; costa of wing marked with spots irregular in size..... 6  
Hind tarsi with all segments white apically, black basally; mesonotum with 4 bare black longitudinal lines; wings with 4 subequal costal white spots (one species, *neivai*)..... subgenus *Kerteszia*
6. Hind tarsi mostly dark; narrow light bands encircling both ends of second, third and fourth segments (one species, *vestitipennis*)  
series *Cyclolepteron* of group *Anopheles*  
Hind tarsi speckled with black and white, not disposed in bands surrounding the articulations... (three species, *apicimacula*, *punctimacula* and *neomaculipalpus*)..... group *Arribalzagia* of subgenus *Anopheles*

## KEY TO GENERA OF TRIBE CULICINI (DYAR, NEC EDWARDS)

1. Base of hind coxa *in line* with upper margin of meron; setae absent on dorsum of mesonotum; postnotum with setae in several species; spiracular setae

- absent; postspiracular setae present in several species, but usually absent; dorsum of thorax and abdomen clothed with purple, blue, or green metallic scales, sides with silvery white scales. . . . . *Haemagogus*
- Base of hind coxa below upper margin of meron; setae present on dorsum of mesonotum; postnotum without setae (except in 1 *Deinocerites* and some *Carrollia*); spiracular setae present or absent; postspiracular setae present or absent; mesonotal scales not purple metallic. . . . . 2
2. Abdomen pointed. . . . . 3
- Abdomen rounded and blunt at tip. . . . . 4
3. Eighth segment of abdomen completely retractile; cerci usually long; spiracular setae present; postspiracular setae present. . . . . *Psorophora*
- Eighth segment of abdomen somewhat retracted; cerci long, exerted (see subgenus *Howardina*, in which abdomen is not notably pointed, with terminal segments projecting ventrally); spiracular setae absent; postspiracular setae present. . . . . *Aedes*
4. Large species, with spotted wings; lower side of base of first vein pilose; spiracular setae present, postspiracular setae absent (one Costa Rican species, found at high altitudes). . . . . *Theobaldia*
- Smaller species, usually with unspotted wings; lower side of base of first vein bare, or with scales only; spiracular setae absent; postspiracular setae usually absent (present only in *Mansonia*). . . . . 5
5. Wing-scales broad, especially on sixth vein; wings usually spotted and legs speckled; tarsal claws without pulvilli. . . . . 6
- Wing-scales narrow, especially on sixth vein; wings not spotted (except in *Lutzia*), legs not speckled; tarsal claws with pulvilli. . . . . 8
6. Clypeus with white scales; tufts of outstanding scales on apices of middle and hind femora; wings nearly completely covered with broad brown and yellow scales; small species with banded legs. . . . . *Aedomyia*
- Clypeus bare; no outstanding tufts on middle and hind femora; wings and legs variously spotted. . . . . 7
7. Postspiracular setae absent; fourth and fifth fore tarsal segments shorter than third; thorax marked with lines of silver or golden scales. . . . *Orthopodomyia*
- Postspiracular setae present; fourth and fifth fore tarsal segments longer than third; thorax with irregular scale pattern. . . . . *Mansonia*
8. Large yellowish species with banded legs; costa of wing with black and yellow areas; many lower mesepimeral setae. . . . . *Lutzia*
- Smaller species, with wing-scales all dark; lower mesepimeral setae but few. . . . 9
9. Antennae normal, not longer than proboscis; postnotum bare (except in some *Carrollia*); abdomen rounded, cerci not prominent. . . . . *Culex*
- Antennae slender, much longer than proboscis; first flagellar segment always very long; postnotum usually bare (with setae in *epitedeus*); abdomen rather pointed, cerci prominent. . . . . *Deinocerites*

## KEY TO THE SPECIES OF PSOROPHORA IN COSTA RICA

Seven species of the genus *Psorophora* occur in Costa Rica. One of them, *howardii*, belongs to the subgenus *Psorophora*; four species, *ferox*, *champerico*, *lutzi* and *varipes* are included in the subgenus *Janthinosoma*; and the remaining two namely *cingulata* and *jamaicensis* fall in the subgenus *Grabhamia*. The

classification of the species in the two subgenera *Janthinosoma* and *Grabhamia* is in an unsatisfactory condition, which will not be improved until further studies are made with fresh material. Dyar separated the *Grabhamia* species on the number of filaments on the claspette, but Martini showed that these characters are variable.

1. Mesonotum with smooth nude longitudinal areas; claws toothed; a large bluish-black species with raised scales on hind legs; tarsi with white rings at bases of 1st and 2nd segments.....*Howardii*  
Mesonotum uniformly scaled, sometimes sparsely; claws toothed (*Janthinosoma*) or simple (*Grabhamia*)..... 2
2. Dark species with dark-scaled wings; tarsal segments all dark, except the fifth hind tarsal segment (and sometimes the fourth), which is white; tarsal claws toothed (*Janthinosoma*)..... 3  
Grayish or brownish species; wings usually with bicolored scales; tarsal segments white-ringed basally; tarsal claws simple (*Grabhamia*)..... 6
3. Hind tarsi with last segment dark; fourth segment black basally, white apically; mesonotum with dark scales centrally, sides with whitish scales; hind femur with apical white mark.....*Varipes*  
Hind tarsi with last segment all white..... 4
4. Mesonotum with sparse golden scales only, on black integument; hind legs with erect scales.....*Ferox*  
Mesonotum dark-scaled centrally, white-scaled on sides..... 5
5. Scutellum dark-scaled.....*Lutzi*  
Scutellum with yellowish scales.....*Champerico*
6. Large brownish species, with wing-scales all dark; no mesial white ring on first tarsal segment; abdominal segments with silvery white apical bands, broadening on sides.....*Cingulata*  
Smaller grayish species, with wing-scales black and white; a mesial white ring on first tarsal segment; abdominal segments with white posterior bands, broadening centrally.....*Jamaicensis*

#### KEY TO THE SPECIES OF Aedes IN COSTA RICA

Twelve species of the genus *Aedes* occur in Costa Rica, representing five of the eight subgenera of this genus.

In naming the species we have made two necessary changes in the usual nomenclature. What has been formerly called *perichares* we call *atropalpus*, following Edwards, and in accordance with our own comparison of adults and larvae of this species from the United States, Costa Rica, and Panama; we agree with Shannon and Edwards that *thorntoni*, *podographicus* and *terrens* are but one polymorphic species, which shows variation in numbers of larval head-hairs and in mesonotal scaling, but no correlation between these larval characters and the adults.

1. Proboscis white-ringed.....*Taeniorhynchus*  
Proboscis without a white ring..... 2
2. Clypeus with white scales; a lyre-shaped silvery white mark on mesonotum; legs black, with silvery white tarsal bands.....*Aegypti*



- Clypeus bare; mesonotum otherwise marked; legs either black or with tarsi variously marked..... 3
3. Tarsal segments all black..... 4  
 All or some of the tarsal segments white-banded..... 8
4. Mesonotum dark brown, uniform, without white scales (male with central white line on mesonotum)..... *Nubilus*  
 Mesonotum with white or yellow scales, either in a central line, or in an anterior patch..... 5
5. Mesonotum dark, with two narrow parallel lines of white or yellowish scales dorsally (markings variable, sometimes broad, sometimes narrow, sometimes fused across)..... *Angustivittatus*  
 Mesonotum otherwise marked..... 6
6. Mesonotum with a single median line of white scales..... 7  
 Mesonotum with anterior half (except extreme sides) covered with silvery scales..... *Euplocamus*
7. Small species, with narrow median line of white scales on mesonotum. *Hastatus*  
 Large, robust species, with broad median line of silvery white scales on mesonotum..... *Serratus*
8. Claws toothed on tarsi of front and middle legs; mesonotum with silvery or yellowish silvery scales in patches, not in distinct lines..... 9  
 Claws simple; mesonotum with distinct lines of golden scales..... 11
9. Mid and hind tarsi with broad white band, formed by white rings at apex of second segment and base of third; mesonotum either entirely silvered across anteriorly, or with narrow black median band (markings variable; trec-hole breeding species)..... *Terrens*  
 Mid and hind tarsi not so marked; the second and third tarsal segments on these legs ringed basally only, or only very narrowly white on preceding segments..... 10
10. Mesonotum variable, usually with dark median band, the sides silvery, sometimes forming a curved lateral silvery mark, sometimes almost entirely silvered across; abdomen without median white line..... *Atropalpus*  
 Mesonotum variable, usually with anterior area of pale golden or silvery scales, sometimes with 2 darker longitudinal lines; sides dark; abdomen with median white line..... *Lithocetor*
11. Mesonotum brown, with six parallel narrow golden lines, four on dorsum, two on lateral margins; these lateral lines straight, not curving dorsally and not merging with subdorsal lines before reaching anterior margin of mesonotum..... *Quairivittatus*  
 Mesonotum brown, six narrow golden lines, the four dorsal lines parallel, the two on lateral margins curving inward and joining the subdorsal lines before reaching anterior margin of mesonotum..... *Allotecnon* n.sp.

## KEY TO THE SPECIES OF ORTHOPODOMYIA IN COSTA RICA

Only three species of the genus *Orthopodomyia* are known to occur in Costa Rica. Two of them, *phyllozoa* and a new species to be described, have narrow silvery markings on the mesonotum; *fascipes* lacks these silvery lines. The wing-scales are all broad, and no mid-mesepimeral setae are present; the fourth fore tarsal segment is very short.

1. Mesonotum without narrow silvery lines..... *Fascipes*  
 Mesonotum with narrow silvery lines..... 2  
 2. Wings with yellow spots involving costa..... *Phyllozoa*  
 Wings without yellow spots; wing-scales all dark except for a long white  
 streak at base of first vein..... n.sp.

## KEY TO THE SPECIES OF MANSONIA

1. Wing-scales distinctly inflated, broad, black and yellow; femur without  
 subapical white ring; tarsi dark with white rings at bases of segments,  
 broadest on hind legs..... *Titilians*  
 Wing-scales narrow, elliptical, all black; femur with narrow white subapical  
 ring..... 2  
 2. Tibiae all dark; mesonotum reddish, with two white spots on shoulders  
*Arribalzagae*  
 Tibiae with yellowish speckles; mesonotum without white spots, but with  
 brown and yellow scales in lines..... *Fasciolata*

## KEY TO THE SPECIES OF URANOETAENIA

1. Tarsi all dark, without white markings; mesonotum with median blue line  
*Sapphirina*  
 Tarsi with white markings, especially on the hind legs..... 2  
 2. All tarsal segments marked with white at base and apex; mesonotum with  
 median blue marks..... 3  
 Terminal hind tarsal segments white; apices of hind tarsal segments white;  
 mesonotum without median blue marks..... 4  
 3. Fourth and fifth segments of hind tarsi all white; abdomen with apical tri-  
 angular spots on tergites; a large species..... *Geometrica*  
 Fifth segment of hind tarsi all white; fourth segment white apically, dark  
 basally; abdomen with apical white bands on two segments; a much smaller  
 species..... *Pulcherrima*  
 4. Mesonotum with a metallic blue line from base of wing half way to anterior  
 margin of mesonotum..... *Coatzacoalcos*  
 Mesonotum without such a line, but with a black spot at wing-base, with a  
 central area of metallic blue scales; a very small mosquito..... *Lowii*

## KEY TO ADULT ANOPHELES OF COSTA RICA

Extreme caution should be exercised in using the following key for the separation of the females of species of the subgenus *Nyssorhynchus*. This subgenus contains many exceedingly variable species, in which all criteria for separation, based on wing markings, the amount of black and white on the second hind tarsal segment and on the palpi, have been found to be of little value. This is particularly true of the species which have a black ring on the fifth hind tarsal segment. The only sure way of knowing whether a species of this subgenus occurs in any given territory is to obtain larvae and males, which have excellent characters for the separation of the species.

1. Scutellum trilobed; a medium-sized shaggy brown species, with dark shaggy palpi; mesonotum with erect black scales before wing-bases; wings heavily

clothed with broad ovate scales, mixed dark and light, not forming definite spots; second to fifth hind tarsal segments broadly white basally, black apically, with a narrow black ring near base of each segment (*Chagasia*)

*Bathanus*

Scutellum not trilobed; mesonotum without erect scales before wing-bases; legs not marked as above..... 2

2. Slender black species, without scales on body; mesonotum dark brown, with a narrow median white line in integument; wing-scales all black; legs very long and slender, all black (subgenus *Stethomyia* not yet found in Costa Rica)..... *Kompi*

Body with scales; mesonotum without median white line..... 3

3. Hind tarsi all dark; mesonotum with broad gray central stripe (*Anopheles*)... 4  
Hind tarsi with terminal segments white, or variously speckled or banded... 6

4. Hind tibia with broad white apical band; wing-scales dark except for a white spot at apex and another on base of first vein..... *Eiseni*

Hind tibia all dark; wing with black and white costal markings..... 5

5. Costa of wing dark, with two white spots, one at junction of subcosta, the other at tip; first vein with three white spots, first spot basal, third spot opposite first white spot on costa; fifth vein basally white, apically black. Thorax broadly gray centrally, clothed with sparse narrow white scales

*Pseudopunctipennis*

Costa of wing with five white spots, the first spot basal, second spot beyond humeral cross-vein, third spot between this and large spot at junction of subcosta, fourth spot at tip; base of first vein white; fifth vein white, with a black spot beyond middle and one at tip; thorax broadly gray centrally, clothed with long pale hairs only (specimens from Guatemala have darker wings, with base of first vein all dark, and a small black spot at extreme base of sixth vein)..... *Chiriquiensis*

6. Hind tarsi with apical portion of second segment white, all of third, fourth and fifth segments white, with or without a narrow basal black ring on fifth segment (*Nyssorhynchus*)..... 7

Hind tarsi not so marked..... 12

7. Hind tarsi with narrow black ring on fifth segment..... 8  
Hind tarsi with fifth segment all white..... 11

8. Last two segments of palpi white..... 9

Terminal segment of palpi white; preceding segment more black than white. 10

9. Second segment of hind tarsi half black, half white (salt-water)

*Tarsimaculatus*

Second segment of hind tarsi more white than black (fresh-water)

*Strodei anomalophyllus*

10. Large species, the white spots on costa of wing usually broad..... *Albimanus*

Smaller species, the white spots on costa of wing reduced; spot B 2 (the second costal white spot from base) usually smaller than the preceding dark spot..... *Bachmanni*

11. First abdominal sternite with two parallel lines of white scales; mid tarsal segments with white rings; second hind tarsal segment nearly half black, half white..... *Albitarsis*

- First abdominal sternite bare, without scales; mid tarsal segments without white rings; second hind tarsal segment about one-third black. *Argyritarsis*
12. Mesonotum gray, with four bare black lines; costa of wing with four or five alternating subequal black and white spots; hind tarsal segments narrowly black basally, broadly white apically; abdomen without scales (*Kerteszia*)  
*Neivai*
- Mesonotum, wings, and legs not as above.....13
13. Hind tarsi brownish black, with very narrow yellowish rings at both ends of segments 3 and 4; wings large, without a bend on costa at junction with subcosta, clothed with small narrow brown scales which form three or four small spots on costa..... *Vestitipennis*
- Hind tarsi irregularly speckled with black and white; wings with a prominent bend or "kink" on costa at junction with subcosta, with large broad black, white, or yellow scales, forming large black spots on costa (*Arribalzagia*) . . .14
14. Grayish species, with only two large dark spots on costa of wing; pale scales of wing all white; black spot at apex of wing usually large, distinct  
*Neomaculipalpus*
- Brownish or blackish species, with three large black spots on costa of wing; pale scales of wing either white or yellow.....15
15. Brownish species; wings with black, white and yellow scales; fifth vein speckled with dark and pale scales; black spot at apex of wing diffuse, about the same size as the dark spot between it and the third large costal spot  
*Punctimacula*
- Blackish species; wings with black and white scales only; fifth vein black at the base and on upper fork; black spot at apex of wing prominent, larger than the black spot between it and the third large black costal spot  
*Apicimacula*

## OTHER BLOOD SUCKING INSECTS IDENTIFIED INCIDENTALLY

Dr. F. W. Edwards of the British Museum (Natural History) identified *Simulium metallicum* Bellardi and *Simulium quadrivittatum* Say from Orosi. And Dr. J. W. S. Macfie of the same Museum named for us specimens of *Culicoides diabolicus* Hoffmann from Siquirres. A *Triatoma dimidiata* taken in the baptismal font of the Orosi Church was examined by Dr. H. S. Barbour of the United States National Museum.

Dr. C. B. Philip of the Rocky Mountain Laboratory identified the following eight species of *Tabanidae*:

*Chrysops tanyceras* O. S.  
*Chrysops variegatus* De G.  
*Dichelacera analis* Hine  
*Dichelacera coloptera* Hine

*Tabanus mexicanus* Linnaeus  
*Tabanus appendiculatus* Hine  
*Phaeotabanus magnificus* Kroker  
*Lepidoselaga crassipes* Fabricius

And Mr. R. A. Cooley, also of the Rocky Mountain Laboratory named for us specimens of two ticks and one species of flea namely *Amblyomma cajennense*, *Amblyomma ovale* and *Pulex irritans*.

#### SUMMARY

In a mosquito survey of the Republic of Costa Rica 14,961 adult mosquitoes and 9,743 larvae were examined, representing 93 different species. Greater attention was paid to the *Anopheles* than to any other group. Tables were drawn up to show the relative prevalence of the various anophelines and culicines, when caught as adults or when taken in their immature stages. In addition, we have listed the distribution records of all the species found during this survey, together with notes on the types of breeding places preferred by them. Keys for the adult females of many of the Costa Rican mosquitoes have been included, as well as the names of certain other biting insects which we have been able to identify from this country.

It is a pleasure to acknowledge the help received from Dr. F. W. Edwards of the British Museum, London, who verified our identifications of 70 of the species of mosquitoes taken in this Republic. We are also much indebted to a number of the sanitary inspectors attached to the Costa Rican Health Department who sent us collections of adults and larvae from a great many places. Among these we would like to mention by name Sr. Moises Cortes, Sr. Luis Villalobos, Sr. Abel Gutierrez, Sr. Manuel Martinez and Sr. Alejandro Perez Rivas. Finally we would like to express our sincere appreciation of the courtesies extended to us on repeated occasions by the officers and employees of the United Fruit Company.

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