

## THE OCCURRENCE OF ANOPHELES DARLINGI ROOT IN CENTRAL AMERICA<sup>1,2</sup>

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### INTRODUCTION

In 1930, R. C. Shannon (1) reported the discovery of the African Anopheles mosquito, *A. gambiae*, at Natal, Brazil. This very dangerous mosquito had been introduced from Africa, probably by means of the fast mail-packets which run between Dakar, Senegal, French West Africa, and Natal.

A parallel discovery is the finding of *Anopheles darlingi* Root in British Honduras, Guatemala, and Spanish Honduras. Hitherto this species had not been found further north than Venezuela.

In October and November 1939, Mr. Ivan Sanderson, collecting mammals for the British Museum, made incidental collections of mosquitoes at his camp on Dog Creek, in the jungle some few miles south of Stann Creek Village, in British Honduras. These mosquitoes were sent to the writer for identification by Dr. R. L. Cheverton, Senior Medical Officer, at Belize, British Honduras. Among the specimens submitted were eight females and one male of the *Nyssorhynchus* group of Anopheles, superficially resembling *Anopheles argyritarsis* R. D. The single male was found to be *A. darlingi*, upon dissection and examination of the male termi-

<sup>1</sup> From the Gorgas Memorial Laboratory, Apartado 1252, Panama, Rep. de Panama.

<sup>2</sup> The observations reported in this paper were made possible by the cooperation of the Gorgas Memorial Laboratory, Panama, Rep. de Panama; the Medical Department of the United Fruit Co., Boston, Mass.; The Medical Department of H. M. Colony of British Honduras; the Seccion de Lucha Antimalarica of the Depto. de Sanidad of Guatemala; and the International Health Division of the Rockefeller Foundation.

nalía. The occurrence of this dangerous species so far north of its known range was brought to the attention of the Director of the Gorgas Memorial Laboratory at Panama, Rep. de Panama; the Chief Health Officer of the Panama Canal; and the General Manager of the Medical Department of the United Fruit Co.



FIG. 1. MAP OF AREA IN WHICH *ANOPHELES DARLINGI* EXISTS IN CENTRAL AMERICA

An expedition to the site of Mr. Sanderson's camp in British Honduras was arranged through their cooperation. In company with Dr. Vernon F. Anderson, First Medical Officer of the Medical Department at Belize, who gave us all assistance, the site was visited, but a two-day search failed to reveal larvae, pupae, or adults. However, larvae and pupae of *A. darlingi* were found in a

stream-pool, partly open to the sun, along the course of Silk Grass Creek, some 200 yards from the camp of the Silk Grass Forest Preserve, on March 18, 1940. This site was about two miles west of the site of Sanderson's camp. A survey of Silk Grass Creek for half a mile downstream from the camp resulted in the collection of about 15 *darlingi* larvae from small stream-pools along the creek, and the impression was gained that these larvae were present in fair numbers, rather widely scattered. The region had been suffering from extreme drought, and probably the larvae were forced to breed in stream-pools, as no other water was then available.

On March 19th a search for adult females was made, and six females, filled with blood, were found in the partly screened sleeping-quarters of the party, and in the thatched huts of the employees of the Forest Reserve camp. Although attempts had been made nightly to capture mosquitoes, using horses for bait, not a single *A. darlingi* was taken in this way, although other mosquitoes, including *Anopheles*, were captured in numbers.

#### IDENTITY OF THE SPECIES

One of the first questions which comes to mind when a species is reported so far out of its normal range, is whether it is identical with the species as found elsewhere. Fortunately, the writer had collected *A. darlingi* in British Guiana and Venezuela (2), and was familiar with the species as found there. The larvae, pupae, and adult females taken by the writer, and the terminalia of the single male taken by Sanderson, agreed in almost every particular with the original description of the species by Root (3). The larvae showed the same type and spacing of the anterior clypeal head-hairs, the same sort of ramified inner prothoracic hairs, the same large spurs at the bases of the pleural hairs, and most characteristic, the "long hairs arising from prominent papillae about midway of the length of the posterior flaps of the spiracular mechanism." (3). The pupal trumpets likewise corresponded to Root's description. The adult females had the same wing-markings as described, spot B2 (the second white costal spot from base) being smaller than the preceding black area. The three terminal seg-

ments of the hind tarsi were pure white. However, the first hind tarsal segment lacked the apical white ring found in South American specimens, and the second hind tarsal segment was about 75 per cent black basally, instead of less than half black. Specimens collected near Stann Creek in August 1940 showed the normal amount of black on this segment. The male terminalia, upon which the original recognition of the species in British Honduras depended, were in all respects like those of *A. darlingi*



FIG. 2

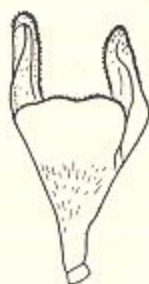


FIG. 3



FIG. 4

FIG. 2. PUPAL TRUMPET OF *A. DARLINGI* FROM ABOVE.

FIG. 3. PUPAL TRUMPET OF *A. DARLINGI*, FROM BELOW, DRAWN TO LARGER SCALE.

FIG. 4. SPIRACULAR APPARATUS OF LARVA OF *A. DARLINGI*, SHOWING LONG FILAMENTS ARISING FROM LATERAL PLATES.

males taken by the writer in British Guiana and Venezuela. Here it may be said that Root's description of the mesosomal leaflets is misleading. He states "The leaflets are not obviously serrate". The writer has examined Root's type material in the U. S. National Museum, and by turning over the slide of the male terminalia was able to see the deep serrations normally present in the leaflets.

Dr. H. W. Kumm, of the International Health Division of the

Rockefeller Foundation, on a visit to British Honduras in August 1940, obtained eggs from gravid females, and kindly sent them to the writer. These eggs agree with the figure of the egg of *A. darlingi* given by Galvão, Lane, and Correia (4), obtained from females in the State of São Paulo, Brazil.

So it appears that in every respect the species found in British Honduras conforms to the accepted concept of the species as found in South America.

As independent verification of the writer's identification was desirable, specimens of larvae, pupae, and adult females were sent to Dr. Henry W. Kumm. Dr. Kumm has had extensive experience with *A. darlingi* in Brazil, and kindly verified the writer's identification.

The species as found in Central America also showed the characteristic habit, noted by various observers in South America, of feeding by preference on man. As noted above, no specimens were taken by the writer on horse-bait in British Honduras, all being taken inside houses. The species in Central America has, therefore, the same habits as in South America, as Gabaldon (5) says: "Es una de las especies mas domesticas que se han encontrado, y rehusa comunmente a caer en trampas-establo (con un burro por cebo)".<sup>3</sup>

#### *The presence of A. darlingi in Guatemala*

Through the courtesy of Dr. Julio Herrera and Dr. J. Romeo de Leon, of the Division de Malariologia of the Departamento de Sanidad of Guatemala, the writer was enabled to examine the mosquito collection of the Division. Six female specimens of *A. darlingi*, all corresponding to the material taken in British Honduras, were found, which had been collected in 1932 at Panzos, on the Rio Polochic, about 50 kilometers west of El Estor, near the entrance of this river into Lago Izabal (Golfo Dulce). Panzos is some 135 kilometers (80 miles) west of Puerto Barrios, the principal Atlantic port of Guatemala.

<sup>3</sup> "It is one of the most domestic species encountered, and commonly refuses to fall into stable-traps (baited with a donkey)."

*The presence of A. darlingi in Spanish Honduras*

The writer suspected the presence of *A. darlingi* in Spanish Honduras, from certain data obtained there in 1925. During the winter of 1924-1925, Dr. M. A. Barber and the writer, assisted by Dr. H. C. Clark, made malaria surveys of the Tela Division of the United Fruit Company, on the north coast of Spanish Honduras (6). A report of this survey reads in part: "Only *A. albimanus* and *A. argyritarsis* emerged from our larval collections. In houses the following adults were found: *A. albimanus*, *A. argyritarsis*, and *A. vestitipennis*. *A. albimanus* was by far the most abundant in houses, but the other two species were not uncommon." On page 216 of the same report it is stated: "In the Dakota Camp, Colorado District, after a rather thorough search in the quarters and neighboring houses, 19 adult Anopheles were found, 12 of which were trapped under bed nets. Species: *A. argyritarsis* 15, *albimanus* 4."

At the time this survey was made, the writer had little opportunity for purely taxonomic investigations. The only text available was the four-volume Monograph of Howard, Dyar and Knab, which did not mention *A. darlingi*, as this species was not described until 1926, a year after our surveys were made.

*A. argyritarsis* is never found in houses or attacking man in the Panama Canal Zone, although there it is one of the commonest jungle species. The reported abundance of this species in houses in Spanish Honduras led the writer to believe that the species might be *A. darlingi*. Through the courtesy of the General Manager of the Medical Department of the United Fruit Company, a visit was made to the Tela Division in November, 1940, and adult females of *A. darlingi* were found in houses at "Kilometer 17" between Tela and La Ceiba, some five miles from the site of the abandoned Dakota Camp. A few typical larvae were also found. Thus it is extremely probable that *A. darlingi* has been present in Spanish Honduras for more than 15 years. It was surely present in nearby Guatemala as early as 1932.

*The possible connection of A. darlingi with severe malaria in British Honduras and Guatemala*

Without knowledge at the present time of the actual distribution of *A. darlingi* in British Honduras, Guatemala, and Spanish Honduras, it is obviously impossible to state definitely what role it plays in malaria transmission in these countries. However, something may be said regarding malaria in the areas where *darlingi* is known to be present, or where it may be present.

According to Dr. Vernon F. Anderson and Dr. L. Ram of the Medical Department at Belize, and Stann Creek District, respectively, malaria infections are notably severe and pernicious in the valley of Stann Creek, and in various parts of the southern portion of British Honduras, inland from Punta Gorda. *A. darlingi* is present in these areas. *A. albimanus* occurs there, as collections of adult mosquitoes have shown its presence, and as this species is a potent vector of malaria, it may be responsible. Thirty children were surveyed by the writer on March 20, 1940, at St. Joseph's School, twenty miles inland from Stann Creek Village, and a malaria parasite rate of 37 per cent was found. This survey was made during the dry season.

Dr. Julio Herrera S. of the Direccion de Lucha Antimalarica of the Departamento de Sanidad of Guatemala, informed the writer that the town of El Estor, on the northwest shore of Lago de Izabal, in Guatemala, with a population of 571, had a spleen rate of 65 and blood parasite rate of 45 per cent in 1939. The municipality of Panzos (where *A. darlingi* was first collected by Dr. J. Romeo de León of the Direccion de Lucha Antimalarica in 1932), with a population of 6,156, had a spleen rate of 37 per cent among 370 persons examined. No parasite indices are available for this municipality. The age-groups in which these rates were obtained were not stated. According to the figures generously made available by Dr. Herrera, there has been a gradual diminution in general mortality in the Republic of Guatemala from 1931 to 1938. This decrease was not noted in the Departamento de Alta Verapaz, in which El Estor and Panzos are situated; on the contrary, there has been an increase in malaria mortality from 3.65

per thousand in 1931, to 4.69 per thousand in 1938. Deaths from malaria were said to number 1,331 in 1938, in an estimated population of about 283,561 in this Departamento.

Some of this increase was undoubtedly owing to an influx of laborers building a road from Panzos to Pancajche. Before 1938 these laborers lived in unscreened temporary camps.

It is, of course, impossible to state how much of the increase of malaria in the Departamento de Alta Verapaz was owing to the presence of *A. darlingi*. However, as this species was first found in Panzos in 1932, and the increase in malaria in the region began in 1935, before the Panzos-Pancajche road was started, it is possible that *darlingi* may have had something to do with the increase.

Dr. H. W. Kumm of the Rockefeller Foundation made a short survey in British Honduras in August 1940, and has kindly given me access to his unpublished findings. He found *A. darlingi* adults in two areas in British Honduras, in Stann Creek Valley, and in the Toledo District inland from the town of Punta Gorda. Most of his specimens were taken in houses, but some were taken at horse-bait in the Stann Creek Valley. Larvae were found in a variety of situations, but almost all were in shaded or partly shaded places. In no case were they found near the sea-coast, but always at some distance inland. One positive gland infection was found in 24 *A. darlingi* dissected from the Toledo district, and one stomach with oöcysts was found in 32 specimens from Stann Creek Valley.

#### PRESENT STATUS OF OUR KNOWLEDGE OF *A. DARLINGI* IN CENTRAL AMERICA

*A. darlingi* is not known to exist in Panama or Costa Rica, both of which are nearer Venezuela, where it is present, than are Guatemala or British Honduras. The writer has spent the last ten years in Panama, and has never encountered the species there. The Health Department of the Panama Canal constantly makes collections of larvae and adult mosquitoes, which are accurately identified, and *A. darlingi* has never been found. With Dr. H. W. Kumm and Sr. Horacio Ruiz, the writer has just completed a



mosquito survey of Costa Rica (7). Although a number of Anopheline species was added to the known fauna of this country, *A. darlingi* was not found.

Very little entomological work has been done in Nicaragua, and with the exception of the observations of Dr. H. C. Clark (8), of Dr. M. A. Barber and the writer (6), and of F. M. Root (9), little work has been done in Spanish Honduras. None of these workers mention the occurrence of *A. darlingi* in Central America, although Root later described the species from Brazil.

The writer surveyed a number of labor camps of the Guatemala Division of the United Fruit Company between Quirigua and Puerto Barrios, in January 1925, and found nothing but *A. albimanus* in the laborers' houses. Severe malaria was present in some camps, with rates as high as 54.5 per cent (10). Dr. M. A. Barber worked in the region around Quirigua, Guatemala, about midway between Puerto Barrios on the Atlantic Coast and Panzos, in the autumn of 1939, but did not find *A. darlingi* there (11). Dr. W. V. King of the Bureau of Entomology of the U. S. Department of Agriculture kindly sent specimens collected by Dr. Barber, to the writer, for examination. The larvae and males examined were all *A. argyritarsis*.

Mosquito surveys in the Republic of Guatemala have been made by the Seccion de Lucha Antimalarica since 1928. Unfortunately, relatively few surveys have been made on the Atlantic coast, probably because of difficult transportation. At any rate, *A. darlingi* was found only once, if the mosquito collections in the Departamento de Sanidad are a true criterion.

As previously stated, *A. darlingi* has been taken in houses, blood-filled, at Panzos, Guatemala, in 1932, and at Dog Creek and Silk Grass Creek in the Stann Creek District, British Honduras, in November 1939 and March 1940, respectively; and in Stann Creek Valley and the Toledo District, inland from Punta Gorda, in British Honduras, in August 1940. It was also found at "Kilometer 17" between the towns of Tela and La Ceiba, Spanish Honduras, in November 1940.

It is not believed that airplanes were responsible for the introduction, if it is an introduction, of *A. darlingi* into Central Amer-

ica. No direct lines from South America reach the Atlantic coast of the countries in which it has been found in Central America. It seems likely from the fact that it was present in Guatemala in 1932, and in Spanish Honduras before 1925, that its introduction cannot be laid to air transportation, as intercontinental commercial airplane transportation did not exist at these times.

#### NOTES ON *A. DARLINGI* AS A VECTOR OF MALARIA

While it is dangerous to assume that a species, which is an active transmitter of malaria in one faunal region, will be a vector in another region, some of the data already known concerning *A. darlingi* as a vector of malaria are given below.

In 1930 N. C. Davis (12) first incriminated *A. darlingi* as a vector of malaria. At Belém, State of Pará, Brazil, he dissected 197 specimens, finding 22.3 per cent of midguts infected.

In 1931, Davis and Kumm (13) made dissections of *A. darlingi* at Franca, State of Bahia, Brazil, and found 28.7 per cent of 240 adults infected.

In 1931, Kumm (14) found 3 out of 5 females infected, at Itapira, Bahia, Brazil.

At Porto Velho, Amazonas, Brazil, in 1932, Shannon (15) found 8.9 per cent of 56 females infected. He states: "*An. darlingi* appears to be by far the most dangerous vector and was found practically throughout the (Amazon) region, from Belém (near the mouth of the river) to Peru and also on the northern border of Bolivia."

Giglioli (16) states concerning *A. darlingi* in British Guiana, "We, therefore, ultimately conclude that *A. darlingi* is the sole malarial vector of practical importance in this Colony."

On the other hand, to show the relative inefficiency of *A. albimanus*, the principal vector of malaria in Central America and the West Indies, the following data on dissections of females caught in native huts in Panama are given (17): Among 952 *A. albimanus* dissected by the writer, an oöcyst rate of only 0.52 per cent was found. Among 4,201 persons surveyed monthly during the 8 months in which dissections were made, a malaria parasite rate of 15.6 per cent was found.

RECOMMENDATIONS FOR FURTHER WORK IN  
CENTRAL AMERICA

The presence of *A. darlingi* in Central America raises several interesting problems. The way the species was introduced, if it is an introduction, should be investigated, as information on this point would be useful in preventing the introduction of other noxious insects. The present distribution of *A. darlingi* should be determined. This should be attempted only after the rains have begun, preferably in July or August. Studies should be made of the epidemiology of malaria in regions where *darlingi* is found to be present in Central America. Above all, dissections of a long series of female adults caught in human habitations should be made, to determine the percentage of infection of the species. There is always the possibility that the species may be less susceptible to malaria in a different environment than it is in South America, although recent experiences with the introduced *A. gambiae* in northern Brazil indicate that this is a forlorn hope. Investigations should be made of the biology and ecology of the species, and entomological investigations, particularly with respect to egg-characters, should be made, for comparison with similar investigations made in South America.

## SUMMARY

The dangerous vector of malaria, *Anopheles darlingi* Root, has been found in three places in Central America, in British Honduras, in Guatemala, and in Spanish Honduras. It has not hitherto been known north of Venezuela, in South America.

Severe malaria is known to be present in British Honduras and in Guatemala, and this may be associated with the presence of *A. darlingi*.

The species has probably been present for at least 15 years in Spanish Honduras.

The present status of *A. darlingi* in Central America is discussed.

Notes on the literature, showing the very high natural infection rates of this species in South America, are given.

Suggestions as to future investigations are outlined.

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