

DISTRIBUTION AND ECOLOGY OF THE ANOPHELES MOSQUITOES OF THE CARIBBEAN REGION

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THE biological characteristics that determine whether an *Anopheles* mosquito is harmless or a dangerous malaria vector are its susceptibility to malaria parasites, blood preferences, attraction to human habitations, range of flight, longevity, and abundance. To be abundant enough to be dangerous, usually a wide range of breeding places must be available to the mosquito; ordinarily those species that are restricted to a special type of water are too scarce to play an important role in malaria transmission. With our present knowledge it is impossible to outline the characteristics that make various types of water favorable or unfavorable as breeding places for the Caribbean Anophelines. Beattie (1932) made a study of the physico-chemical factors of *A. tarsimaculatus* (= *aquasalis*?) breeding waters in Trinidad, but could find no correlation between larval incidence and pH, carbon dioxide, organic nitrogen, dissolved oxygen, nitrites, nitrates, or phosphates, although ammonia nitrogen repelled the ovipositing females. In general, the Caribbean anophelines can be divided into two groups: those that require sunlight for breeding, and those that require shade. Some of the former are apt to be more closely associated with man, as they are often abundant in cleared areas near human habitations; the latter are typically forest species. Most species are found in fresh water, one prefers brackish water, while others will breed in both fresh and brackish water. Some species are rather closely associated with certain kinds of aquatic vegetation, and often this association seems to be more than a mere concentration of larvae in protected places.

Twenty-nine species of anophelines have been found in the Caribbean region, from Panama to the southern border of the United States. Several of them really belong to the temperate fauna, and to avoid duplication, little mention will be made of them in this paper.

NOTES ON THE SPECIES

Chagasia bathanus was described by Dyar from specimens collected near Gatun, Canal Zone, by Mr. C. H. Bath (Curry 1928; Dyar 1928). It has been recorded from western Panama (Komp 1929a), Costa Rica (Kumm, Komp and Ruiz 1940), British Honduras (Kumm 1940b), and Venezuela (Gabaldon, Herrera and Perez-Vivas 1940). Martini (1935) says that a single specimen was captured by Dampf in the State of Chiapas, Mexico. The larvae prefer shaded water along the edges of streams; they have a predilection for shady pools in the streams (Kumm, Komp and Ruiz 1940), but are also found in running water. The species may be abundant in certain restricted localities, but it is a rare mosquito. Adult females have been captured while they were feeding on horses (Kumm, Komp and Ruiz 1940), but apparently they seldom feed on man.

A. (Stethomyia) kompi is rather rare, but has been recorded from Brazil (Shannon 1933), Venezuela (Gabaldon 1939a), Panama (Curry 1931b; Edwards 1930), and Costa Rica (Kumm, Komp and Ruiz 1940). Komp (1940b) states that in Panama the larvae are found in stream pools at the end of the rainy season, and are rarely abundant. The adults will bite man.

A. albimanus, the most important malaria vector of the Caribbean region, is dis-

tributed from Brownsville, Texas (King 1937), to the northern part of South America. King doubts the identity of specimens taken in New Orleans, and although a number of adults were captured by MacDonell in Key West in 1904, the species did not become established there (King 1937). According to Hoffmann (1932, 1938a), its range in Mexico includes the Gulf Coast from Brownsville to the State of Quintana Roo, but north of Tampico it is rather scarce. South of Tampico it is the predominant Anopheline, and breeds not only in the littoral, but extends inland to an altitude of 400 meters along the river valleys. The northern part of the Peninsula of Yucatan is very dry, and here *A. albimanus* is found near villages and other human habitations where water is stored in artificial reservoirs. Swamps that form in isolated areas along the coast during the rainy season are inhabited by the species. In the southern part of the Peninsula there are more "natural" breeding places; here Hoffmann also took the species inland in uninhabited forest areas. On the Pacific coast of Mexico it is distributed from Guatemala to the northern part of the State of Sinaloa. This region is much drier than is the Gulf Coast; thus *A. albimanus* is not so abundant here. Although the natural range of *A. albimanus* in Mexico is limited to the coastal areas, occasionally it is found farther inland at higher altitudes, especially during the rainy season. Hoffmann records it from Monterrey, Nuevo Leon, 545 meters above sea level, and from the village of Autlan, in the State of Jalisco, 1,003 meters above sea level.

Molloy (1932) says that *A. albimanus* is "constantly encroaching on the highlands of Central America," and de Leon's (1933b) map shows it to be not only along the Atlantic and Pacific coasts of Guatemala, but inland as far as Guatemala City, at an altitude of 4,500 feet. It has been taken in a number of localities in El Salvador (Larde Arthes 1921; Sutter 1939). Nicaragua (Kumm 1929b), Spanish Honduras (Whitmore, Roberts and Jantzen 1929), and British Honduras (Kumm 1940b). In Costa Rica it is the predominant species

(Barber and Komp 1927; Kumm, Komp and Ruiz 1940; Kumm and Ruiz 1939b; Root 1924c), especially in the lowlands, but breeding may be heavy in drying river beds at elevations of 2,500 feet (Salisbury and Corrigan 1927). Kumm and Ruiz (1939b) found it in 85 localities at less than 1,000 feet elevation, in six from 1,000 to 3,000 feet, and not at all above 3,000 feet.

Published records from Panama, excepting those from the Canal Zone, seem to be rather meagre, but there are enough to show that the species is present throughout the country, at least in the coastal areas (Barber, Komp and Newman 1929a; Dunn 1934; Komp 1929a; Komp 1929b; Kumm 1929b).

A. albimanus is found in many of the West Indian Islands. It appears to inhabit almost all of Cuba (Carr, Melendez and Ros 1940; Kumm 1929b; Malaret 1929), but Carr, Melendez and Ros (1940) state that in the Province of Oriente it is most abundant in areas less than 1,000 feet above sea level. Hoffman (1926), Root (1927) took it in a number of localities in Haiti, including La Vanneau with an elevation of 2500 feet, but it is more prevalent at lower altitudes (Mink 1933). It is distributed throughout Puerto Rico, from the mountains to the seashore (Earle 1930b; Root 1922; Tulloch 1937), and although it may be taken in most parts of Jamaica, it seems to be scarce in those areas of the Island that have an elevation of 500 feet or more, while it is especially abundant in the lowlands (Boyd and Aris 1929). Russo (1927) says that it is the most important anopheline in Santo Domingo. It has been reported from St. Thomas (Hoffman 1930), St. Croix (Kumm 1929b), Culebra (Hoffman 1940), Vieques (Howard, Dyar and Knab 1917b), Tortola (Hoffman 1930), Nevis (Hoffman 1930), Montserrat (Hoffman 1930), Antigua (Edwards and Box 1940), St. Vincent (Senevet 1936), Dominica (Senevet 1936), Guadeloupe (Francois-Julien 1930; Senevet 1938), and Barbados (Kumm 1940b; Seagar 1928). It is absent from Grenada (Earle 1936b; Root and Andrews 1938), St. Lucia (Earle 1936b), Martinique (Senevet 1936),

and although Beattie (1932) records it from Trinidad, Komp showed that this record is probably erroneous, in which F. W. Edwards concurs (Komp 1937b, 1940b).

As King (1937) has pointed out, its distribution shows that *A. albimanus* is essentially a mosquito of hot, humid climates. Although outside of the area covered by this Symposium, it is of interest to consider briefly the distribution of *A. albimanus* in northern South America, where, for no apparent reason, we find the southern limit of its range. Campos' record from Guayaquil, Ecuador, has been confirmed by King and Stone, who examined the male terminalia of Campos' specimens (King 1937). Komp (1937b) says it occurs for some distance up the Magdalena River in Colombia, but Antunes (1937) did not include it in his list of species from the interior of Colombia (Intendencia of Meta). In these western countries the mountains and climate may form a natural barrier to a southward extension of the *A. albimanus* range. In Venezuela, Gabaldon (1938, 1939a) has taken *A. albimanus* in large numbers in certain localities on or near the coast, but not in others farther inland. Gabaldon states that the eastern limit of the range is Carupano; Komp (1937b) could not find it near the mouth of the San Juan River, in the Orinoco drainage.

A. albimanus breeds in a great variety of water collections, either fresh or brackish, and the chief requisite for breeding seems to be an abundance of sunlight. During the rainy season it is found in rain pools; other favored breeding places are seepages, irrigation ditches (Earle 1930b), and quiet, sunlit waters of lakes, backwashes of streams, swamps, and ponds. Hoffmann (1938c) says that the breeding water must be in a biological equilibrium, exposed to sun, and rich in microorganisms but without putrefaction; as these conditions are more apt to exist in permanent and semi-permanent water collections, temporary rain pools are not suitable for breeding at the beginning of the rainy season, but require time to develop a biological equilibrium. In larger

bodies of water *A. albimanus* larvae must find protection from fish in various types of floating aquatic vegetation. Of these the Characeae, *Utricularia*, and *Naias* are especially favorable, when the water level is such that these plants can form thick mats on the surface. In these mats *A. albimanus* larvae not only are protected from their enemies, but find enough food to enable them to breed in tremendous numbers. In the Canal Zone, Curry (1934) has described the great abundance of the larvae among these plants during the dry season, when the level of Gatun Lake drops several feet, allowing the plants to reach the surface of the water and form extensive mats. Hoffman (1930, 1940) collected larvae in crab holes in Haiti, Nevis, and Montserrat; the water in these crab holes was as low as two feet below the surface of the ground. Perhaps the species becomes adapted to these unusual breeding places during periods of drought. Certain artificial water collections may become favorable breeding places; thus in the dry coastal areas of the northern part of the Peninsula of Yucatan, *A. albimanus* is dependent for its existence upon the tanks, water troughs, and similar artificial containers that are used for the storage of water near the villages (Hoffmann 1938a), while Clark (1932) found larvae in barrels and troughs in which algae were growing on the bottom and sides. In Cuba, water is piped from the hills to all parts of the Preston Division of the United Fruit Company, and excess water from the terminal pipes forms "water-faucet" drains, which were ideal for *A. albimanus* breeding (Malaret 1929). Kumm, Komp and Ruiz (1940) call attention to their discovery of larvae in an iron drum full of rain water.

The adult is a strong flier. In Panama, towards the close of the dry season, a sudden rise occurs in the number of adults found in sanitized areas. Curry (1934) believes that these mosquitoes originate in the mats of aquatic plants far away in Gatun Lake; therefore they must be able to fly 12 miles or more. Curry does not consider this to be a single, sustained flight,

but that the distance is covered in a series of short flights, during which the mosquitoes feed on gametocyte carriers outside of the sanitized areas, causing many of the mosquitoes to become infected with malaria, thus carrying the disease to inhabitants of the sanitized areas. According to Le Prince and Orenstein (1916), who observed flights of large numbers of *A. albimanus* and *A. aquasalis* in the Canal Zone, the mosquitoes become active during twilight; in the evening they flew from a brackish water area to Gatun, and in the early morning they returned to the breeding places. These mosquitoes flew from a half mile to a mile at right angles to the strong dry season winds, above ground that had very little protection in the form of bush or grass. Judging from the actions of birds feeding on the flying insects, flight took place from less than six feet to 30 or 40 feet above the surface of the ground. Jobbins (1940) in Panama also observed flight of *A. albimanus* between 6:30 and 7:30 P.M. Apparently copulation takes place only during twilight hours (Rozeboom 1936).

The seasonal abundance of *A. albimanus* seems to be directly related to rainfall. Gabaldon (1939a) shows this in his Venezuelan records. Nevertheless, in some areas where breeding is largely confined to impounded waters or rivers, the dry season favors the appearance of certain types of aquatic vegetation in which breeding is especially heavy. This is the case in Gatun Lake in the Canal Zone (Curry 1934), and in the Chagres River, where Jobbins (1940) and Clark, Komp and Jobbins (1940) noted the peak of emergence in 1939 to be in April, several weeks before the onset of the rainy season. In Mexico there is a marked reduction of *A. albimanus* during the dry winter season, and in some areas the larvae disappear, while the females pass through the winter in a state of inactivity (Hoffmann 1938a). Giaquinto Mira (1936) noted that during the long dry season at Champerico, Guatemala, the females remained in crab holes containing water and did not mature their eggs until the coming of the rainy season.

The females feed readily on man, but also attack animals; in fact, the observations of Earle and Howard (1936) in Puerto Rico indicate a marked preference by *A. albimanus* for horses and oxen, and while goats and pigs were not so attractive as horses and oxen, the mosquitoes fed on them as readily as they did on man. Le Prince and Orenstein (1916) noticed that a horse was more attractive than men. In the villages of Las Guacas and Santa Rosa, in Panama, Rozeboom (1938a) caught 578 *Anopheles* in native huts, of which 472 were *A. albimanus*, but of 349 female anophelines taken while they were feeding on pigs near these villages, only four were *A. albimanus*.

The females are very domestic, and within most of its range *A. albimanus* is the most common anopheline found in houses. But the females do not remain long in houses; most of them return to the jungle or to their breeding places, soon after feeding or early in the morning (Barber and Komp 1927; Green 1922). They do not seem to congregate in preferred daytime resting places (Earle and Howard 1936; Rozeboom 1938a), although Le Prince and Orenstein (1916) saw large numbers on the leeward side of trees near extensive breeding places.

A. triannulatus was described by Neiva and Pinto (1922); unfortunately this misleading name has priority over *A. bachmanni* Petrocchi, 1925 (Galvão and Barretto 1938). The species was described from Brazil, but it has been collected as far north as Puntarenas, Costa Rica (Kumm, Komp and Ruiz 1940). In Panama the larvae are found within the cup-shaded enclosure formed by the crown of leaves of *Pistia* (water-lettuce), and where extensive areas of these plants exist, *triannulatus* may be very abundant. In other countries, the larvae may breed among other aquatic plants; even in Panama they are often found among the floating stems of *Jussiaea natans* (Curry 1931b; Rozeboom 1935). Adults of *triannulatus* have been observed attacking man outdoors (Rozeboom 1935), but they do not seem to enter human dwellings readily, even in the immediate vicinity

of the breeding places; on the other hand large numbers have been observed feeding on pigs (Rozeboom 1938a). Hill (1934) concluded that this mosquito definitely prefers animal blood.

A. strodei was described from Brazil, but in the Caribbean region it has been reported from Panama (Curry 1932), Costa Rica (Kumm, Komp and Ruiz 1940), and recently from Veracruz, Mexico, by Vargas (1940b). This species breeds in a variety of water collections. During the rainy season it may be found in rain pools, but in Panama its chief breeding places are clear, cool pools in drying creeks. Kumm, Komp and Ruiz (1940) state that in Costa Rica the larvae were taken from slowly running streams in the sunshine; however, the larvae may also be abundant in partially shaded waters. In Panama the larvae are most abundant at the end of the rains, in January. Little is known concerning the habits of the adults. Occasionally the females may be captured in houses, but they seem to be attracted to animals more than to man (Kumm, Komp and Ruiz 1940); however, in a locality in São Paulo, Brazil, Correa (1938) found that 95.3 per cent of the anophelines he captured in houses were *A. strodei*, and two of 163 females dissected showed oocysts.

A. aquasalis was considered to be a variety of *A. tarsimaculatus* by Curry (1932), who distinguished it from var. *aquacaelestis* (= *oswaldoi*) on morphological characters and by its breeding habits. Rozeboom and Gabaldon (1941) consider *A. tarsimaculatus* to be a synonym of *A. albimanus*, while *aquasalis*, a member of a group of mosquitoes lumped under the name "*tarsimaculatus*," was raised to specific rank by these authors. In Panama the species is found only along the Atlantic coast. The brackish water "*tarsimaculatus*" listed from Costa Rica by Kumm, Komp and Ruiz (1940) is also this species. Hoffmann (1929b) discovered a few specimens of "*tarsimaculatus*" (= *strodei* ?) in Veracruz (Panuco), but considered that they were accidentally introduced. The "*tarsimaculatus*" that Root and Andrews (1938)

concluded was the malaria vector in Grenada is really *aquasalis*, and perhaps so is the brackish water "*tarsimaculatus*" of Trinidad. Senevet (1936, 1938) reports "*tarsimaculatus*" from Martinique and Guadeloupe, and Edwards and Box (1940) include it in their list of mosquitoes from Antigua. The larvae breed in brackish water along the seacoast, in swamps, ditches, and similar situations. Occasionally they will breed in fresh water; in Costa Rica, Kumm, Komp and Ruiz (1940) found them once in a fresh-water stream about fifty yards from the sea, while in Trinidad, in times of great abundance, they develop temporarily several miles inland in rice fields, drains, and other collections of fresh water (de Verteuil 1933; de Verteuil and Spence 1937). Beattie (1932) states that *A. aquasalis* has no apparent preference for light or shade; Curry (1932) believes it prefers fairly well shaded places; Kumm, Komp and Ruiz (1940) made three collections in Costa Rica, all of them in water exposed to sunlight. Earle (1936b) noted that in Grenada it would breed in densely shaded mangrove swamps. The adults are strong fliers; Curry (1932) speaks of the huge swarms that used to fly into Colon and Cristobal, in Panama, from swamps located several miles from these cities, and in Trinidad adults migrate inland from the coastal swamps at least three miles away (de Verteuil and Spence 1937). It is puzzling that this mosquito, considered to be a vector of malaria in some of the Lesser Antilles, is not attracted to man in Panama, where, in former years, the appearance of great numbers of *A. aquasalis* in the cities was not followed by a rise in the malaria rate (Curry 1932). This is a marked contrast to the observations of Earle (1936b), who had no difficulty in finding *A. aquasalis* adults in houses in Grenada and St. Lucia. The biting and trapping experiments of Earle and Howard (1936) showed that in these islands *A. aquasalis* was attracted to man much more readily than to a calf or a donkey.

A. oswaldoi has been reported from Panama (Curry 1932), Trinidad (de Verteuil

1933), and from several South American countries, but it has not been found as far north as Costa Rica (Kumm, Komp and Ruiz 1940). It breeds in fresh, well shaded water in pools or swamps. Being a "jungle" mosquito, it is not closely associated with man, and although it will attack man when its haunts are invaded, it does not seem to be attracted to man's habitations (Curry 1932; Rozeboom 1938a).

A. rangeli is a species recently described by Gabaldon, Cova-Garcia and Lopez (1940). Perhaps this species should not be included with the Caribbean anophelines, but it is mentioned because we know that it is present in Trinidad, and because it has been confused with *A. aquasalis*. Rozeboom and Gabaldon (1941) have found specimens of *A. rangeli* among material collected by Root in Venezuela and Trinidad; the species must be quite common in these countries. It breeds in fresh, shaded water that contains an abundance of vegetation (Gabaldon, Cova-Garcia and Arevalo 1940).

A. anomalophyllus is a rare mosquito. The type specimens were collected as larvae from the running water of a small, shaded stream near Almirante, Panama (Komp 1936b). It was found recently in Costa Rica by Kumm, Komp and Ruiz (1940).

A. albitarsis is widespread in South America; the northern limit of its range seems to be Costa Rica (Kumm, Komp and Ruiz 1940). It is evident that the species is composed of several races or subspecies (Galvão and Lane 1937b; Root 1926, Rozeboom 1937a), although the taxonomic relationships between the races are not yet entirely clear. In Panama the larvae breed in a rather restricted area of Gatun Lake, in the mats of *Chara*, *Naias*, and *Utricularia* that produce such large numbers of *A. albimanus*; these mats are exposed to full sunlight (Curry 1934). In Costa Rica the larvae were taken from a sunny pond with algae, and vertical and horizontal vegetation (Kumm, Komp and Ruiz 1940). The rice fields of Trinidad furnish suitable water for larval development (de Verteuil 1933), while Gabaldon (1939a) says that the most important breed-

ing places in Venezuela are lakes full of *Pistia* and *Eicchornia*. Although it is a dangerous mosquito in parts of South America, in Panama it does not attack man and does not enter man's habitations, even in the immediate vicinity of the breeding places (Curry 1934).

A. argyritarsis is distributed throughout the Caribbean region, from tropical Mexico (Hoffmann 1929b) to South America (Clark 1926; Curry 1925; Giaquinto Mira 1936; Hoffmann 1932; Komp 1937a; Kumm, Komp and Ruiz 1940; Kumm and Ruiz 1939b; de Leon 1936b; Martini 1935; Sutter 1939); it also inhabits much of South America, and some of the Caribbean islands: Trinidad (Beattie 1932; Howard, Dyar and Knab 1917b), Grenada (Earle 1936b; Howard, Dyar and Knab 1917b; Root and Andrews 1938), St. Lucia (Earle 1936b; Howard, Dyar and Knab 1917b; Senevet 1936), Guadeloupe (Francois-Julien 1930; Senevet 1938), Dominica (Hoffman 1930; Howard, Dyar and Knab 1917b; Senevet 1936), Martinique (Howard, Dyar and Knab 1917b; Montestruc 1936; Senevet 1936), St. Vincent (Howard, Dyar and Knab 1917b; Senevet 1936), and Antigua (Edwards and Box 1940; Howard, Dyar and Knab 1917b). Theobald's records of the species from the Greater Antilles probably concern *A. albimanus* (Boyd and Aris 1929; Howard, Dyar and Knab 1917b). *A. argyritarsis* breeds in clear waters of small, partly shaded or sunlit streams; it is found along the grassy edges of running streams, and it also breeds in quiet pools in streams, and in pools in drying stream beds, as well as in grassy rain pools. The females do not seem to attack man readily, and are not often found in man's habitations (Earle 1936b; Hoffmann 1929b; Kumm, Komp and Ruiz 1940).

A. darlingi was described by Root (1926) from specimens collected in Brazil. It is widespread in South America, and for some time it was thought that records from Venezuela and Colombia represented its most northern distribution, but in 1940 Komp proved that it is also present in Guatemala and British Honduras. Shannon (1933)

considers that in the Amazon Valley the larvae are especially adapted to flood-water. In Brazil, Barretto (1938) could find few *A. darlingi* larvae in ditches, small pools, and small swamps, but obtained many larvae from the edges of an impoundment, where the water was deep, without current, and well shaded by trees with branches reaching down into the water; these branches prevented wave action in the water underneath them, and in this pooled water, where there was some floatage but little vegetation, the larvae were concentrated. In British Honduras, Kumm (1940b) collected larvae along the edges of streams, in deeply shaded water. The adults feed readily on man, and can be taken in large numbers in man's habitations (Davis 1931; Gabaldon 1938; Giglioli 1940; Shannon 1933).

A. eiseni has a range which includes much of South America and extends northward through Central America as far as tropical Mexico (Aguilar 1931; Curry 1931b; Dyar 1928; Giaquinto Mira 1936; Howard, Dyar and Knab 1917b; Kumm, Komp and Ruiz 1940; Kumm and Ruiz 1939b; de Leon 1936b; Martini 1935), but it seems to have been found on none of the islands, except Trinidad (Beattie 1932). It is another "jungle" mosquito, breeding in densely shaded, clear, fresh waters of small streams, pools, and swamps. Simmons (1939) collected many larvae from coconut husks, while Kumm, Komp and Ruiz (1940) found them even in tree holes and bromeliads. Locally the species may be very abundant; for example, Simmons (1939) says that it was one of the most common species on the Fort Sherman Reservation in the Canal Zone during the fall and winter of 1935 and 1936. Very little is known concerning the biology of the adults, but the females do not seem to be attracted to man and seldom enter houses (Gabaldon 1939a; Simmons 1939).

A. grabhami has been reported from Cuba (Carr, Melendez and Ros 1940), Jamaica (Boyd and Aris 1929; Howard, *et al.* 1917b; Theobald and Grabham 1905), Haiti (Clark 1926; Mink 1933), Santo Domingo

(Howard, Dyar and Knab 1917b), Puerto Rico (Earle, 1936a; Howard, Dyar and Knab 1917b; Tulloch 1937; Wells 1930), and St. Thomas (Hoffman 1930). Theobald and Grabham (1905) noted that in Jamaica the larvae would develop in any stagnant water, and Boyd and Aris (1929) also found them in all types of breeding water on the island, including upland streams with swift currents, and brackish water along the coast, where they were associated with the larvae of *A. albimanus*. Earle (1936a) showed that in Puerto Rico the larvae are much less tolerant of salt than are the larvae of *A. albimanus*, and that they will occur in densely shaded waters, including "pastures where the growth of grass is so dense that one's weight is almost supported on it as it overgrows water courses." The adults will attack man; some authors (Root 1922; Theobald and Grabham 1905) consider the species to be an ardent blood sucker that feeds on man readily in the evening, but others (Boyd and Aris 1929; Earle 1936a) conclude that it prefers the blood of animals. It is not often found in houses (Earle and Howard 1936), and is not especially abundant.

A. crucians has been found in Cuba (Carr, Melendez, and Ros 1940; Kumm 1929b), Jamaica (Boyd and Aris 1929; Kumm 1929b), along the Caribbean littoral of Mexico (Hoffmann 1932), and British and Spanish Honduras (Clark 1926; Kumm 1929b, 1940b; Martini 1935; Whitmore, Roberts and Jantzen 1929). Martini (1935) gives a record from Iguala, State of Guerrero, Mexico, and another from Lago Peten, Guatemala. Tulloch (1937) includes *A. crucians* in his list of brackish-water mosquitoes from Puerto Rico. In Jamaica, Boyd and Aris (1929) collected larvae from streams, seepages, and ponds, in sunlit or slightly shaded water; no larvae were found in brackish water. According to Vargas (1940a), both *A. crucians* var. *crucians* and var. *bradleyi* are present in Mexico, in the states of Tamaulipas and Veracruz.

A. punctipennis was reported from Jamaica by Theobald and Grabham (1905); however, Boyd and Aris (1929) point out

that this record is doubtful; *A. punctipennis* has never been taken in Jamaica since Grabham's time. Hoffmann (1932) speaks of its presence in the littoral zone of the Gulf of Mexico and in the "northern zone" of Mexico; Martini (1935) gives records from Sonora, Tamaulipas (Tampico), and Veracruz (Pueblo Viejo). Hoffmann (1937) collected larvae from a shaded pool near Ixmiquilpan, in the state of Guanajuato, Mexico.

A. pseudopunctipennis is the most widespread of the New World Anophelini, ranging from Oklahoma and California to Argentina. Shannon, Davis, and del Ponte (1927) show that its distribution coincides to a great extent with that of the western mountains, and that apparently it is essentially a mountain species, occurring in the lowlands only where special conditions permit its existence. According to Hoffmann (1932) it inhabits almost all of Mexico between the eastern and western mountain ranges; only areas that are six or seven thousand feet above sea level are free from it. It extends along the entire Mexican Pacific littoral, from California to Guatemala, but does not seem to be so abundant along the Caribbean coast, although it is present in the littoral zone north of Veracruz. South of Veracruz it appears only in the winter. It is found in the villages of Yucatan. It has been collected in all of the Central American countries (Aguilar 1931; Barber and Komp 1927; Clark 1926; Giacinto Mira 1936; Howard, Dyar and Knab 1917b; Komp 1929b; Kumm, Komp and Ruiz 1940; Kumm and Ruiz 1939b; Larde Arthes 1921; Martini 1935; Molloy 1932; Sutter 1939), and also in Trinidad (Kumm 1929b) and Grenada (Earle 1936b; Root and Andrews 1938).

The larvae of *A. pseudopunctipennis* require a great deal of sunlight for their development, and the preferred breeding places are pools and eddies in shallow or drying streams, especially those containing mats of green algae. In streams the larvae can be found not only in such mats of algae, but also in shallow, quiet or running water, where they cling to leaves or other bits of

floatage dammed behind rocks or sand bars. Other breeding places are seepages, especially those in dry beds of subterranean streams (Hoffmann 1932), ground pools, and even artificial water containers such as fountains and tanks (Hoffmann 1932). Because the preferred breeding places are shallow, drying streams, this species is especially abundant in mountainous areas, and at the time of the year when the streams are not flushed out by heavy rains. Thus, in Panama and in parts of Central America, *A. pseudopunctipennis* is most prevalent during the dry season (Clark 1932; Molloy 1932; Simmons 1939). However, in some regions the dry season causes a diminution in the number of favorable breeding places, so that the numbers of the mosquito decrease. In northwestern Argentina the lowland breeding places disappear during the prolonged dry season, and *A. pseudopunctipennis* must maintain itself during this unfavorable period in springs and other fresh water collections in the mountains (Shannon 1930). Rainfall is the most important climatic factor in determining abundance in the Rimac Valley of Peru, and here too the mosquito survives the dry season by breeding in the restricted fresh water collections in the mountains, reestablishing itself in the more numerous lowland breeding places after the onset of the rains in the higher altitudes results in the formation of pools along the margins of rivers and streams. Here the peak of abundance occurs between January and June, the rainy season of the highlands (Shannon 1930). Hoffmann (1938b) calls the typical streampools "winter breeding places of concentration"; this author says that when the rains come the larvae are washed from these pools and are distributed over wide areas. In the Valley of Mexico the species is less abundant during the dry winter months; during December, January, and February, when the temperature drops below the freezing point at night, only large larvae are found in the breeding places, while small larvae appear about the middle of March. During the cold weather the males

disappear, and only the females are found in the resting places (Hoffmann 1929a).

The habits of the adults seem to differ in various parts of the *A. pseudopunctipennis* range. In the highlands of Mexico the females will fly for considerable distances to enter houses and feed on man (Hoffmann 1929b; Vargas 1938). The species is considered to be a dangerous malaria carrier in the highlands of Guatemala (Giaquinto Mira 1936; Molloy 1932), but in Costa Rica, where Kumm, Komp and Ruiz (1940) collected many larvae, only a few adults were captured in houses by these workers. The females do not fly far, and are not attracted to houses, in the Canal Zone (Curry 1925); they are not attracted to man in Grenada (Earle 1936b), although in this island, during July and August at least, *A. pseudopunctipennis* is the most common Anopheline (Root and Andrews 1938). In Argentina it is a dangerous blood-sucker (Davis 1927). The suspicion that the species is divided into geographical races or subspecies has not been confirmed on morphological grounds, although there are two kinds of *A. pseudopunctipennis* eggs in California (Herms and Freeborn 1920; Herms and Frost 1932), both of which are unlike the eggs from Panama (Rozeboom 1937b), Costa Rica (Kumm 1940a), and Mexico (Vargas 1939b). The writer has examined *A. pseudopunctipennis* eggs from western Oklahoma which were identical in morphology with those he described from Panama. Vargas (1939b) considers the form in California, the egg of which was described by Herms and Frost (1932), to be different enough to merit specific rank; he calls this mosquito *A. boydi*.

A. parapunctipennis ranges through the highlands from Mexico to Panama (Kumm and Ruiz 1939b; Vargas 1940a). Komp (1936a) collected larvae in a large cold spring on the slopes of Chiriqui Volcano in western Panama. This rare species was first found by Dampf (Martini 1935) in the state of Chiapas.

A. hectoris was described from Guatemala by Giaquinto Mira (1931); it is also found in the mountains of Mexico. Dampf

(Martini 1935) took it near San Cristobal, Chiapas, 2,000 meters above sea level. Apparently only the adult had been captured in Mexico until April, 1940, when Mazzotti discovered larvae in Ciudad de las Casas, Chiapas (Vargas 1940a, 1940b). According to de Leon (1936a, 1936b) it is the characteristic anopheline species in the higher mountain regions of Guatemala, and breeds in small, shallow, slowly-flowing streams filled with algae. The adults are said to attack man (Molloy 1932).

A. vestitipennis is comparatively rare, but it ranges from the tropical regions of Mexico to South America (Aguilar 1931; Barber and Komp 1927; Clark 1926; Curry 1931a; Dyar 1928; Giaquinto Mira 1936; Hoffmann 1929b, 1932; Kumm 1940b; Kumm, Komp and Ruiz 1940; de Leon 1936b; Martini 1935), and is also present in Cuba (Carr, Melendez and Ros 1940), Puerto Rico (Wells 1930), Jamaica (Boyd and Aris 1929), and Dominica (Dyar 1928). The larvae develop in shaded, fresh-water streams, seepages, ponds, and rain pools (Boyd and Aris 1929; Kumm, Komp and Ruiz 1940). The adult females will attack man, and Hoffmann (1929b) has found adults in houses.

A. punctimacula has a wide distribution in the New World tropics, including all of the Central American countries (Aguilar 1931; Barber and Komp 1927; Clark 1926; Curry 1931a, 1931b; Howard, Dyar and Knab 1917b; Kumm 1940b; Kumm, Komp and Ruiz 1940; Kumm and Ruiz 1939b; Simmons 1939; Sutter 1939) and tropical Mexico (Hoffmann 1932; Martini 1935). It breeds in clear, cool, densely shaded waters in small streams, ponds, and swamps, where it may be associated with larvae of *A. eiseni*, *A. oswaldoi*, and *A. apicimacula*. The adults will feed on man as well as on animals, and will visit human habitations in search of blood (Kumm, Komp and Ruiz 1940; Rozeboom 1938a; Simmons 1936a, 1939).

A. apicimacula has been reported from Mexico (Hoffmann 1932; Howard, Dyar and Knab 1917b; Martini 1935), all of the Central American countries (Aguilar 1931;

Clark 1926; Curry 1931a, 1931b; Giaquinto Mira 1936; Howard, Dyar and Knab 1917b; Kumm, 1940b; Kumm, Komp and Ruiz 1940; Kumm and Ruiz 1939b; de Leon 1936a, 1936b; Martini 1935; Sutter 1939), Trinidad (Beattie 1932), and several South American countries. Its breeding places are similar to those of *A. punctimacula*, *A. eiseni*, and *A. oswaldoi*. Only a few adults have been taken inside houses, and the females seem to feed on animals much more readily than they do on man (Kumm, Komp and Ruiz 1940; Simmons 1939).

Martini (1935) identified specimens collected by Dampf in Yucatan, British Honduras (Blue Creek, Rio Cacao) and Guatemala (San Miguel, Lago Peten), as *A. intermedius*; this species has not been found since in Mexico (Vargas 1940a).

A. quadrimaculatus inhabits the Gulf coast of Mexico as far south as Tuxpan, Veracruz, but records from the interior of Mexico actually refer to a race of *A. maculipennis* (Dampf 1935; Hoffmann 1935).

A. maculipennis var. *aztecus* was described by Hoffmann (1935) from the states of Guanajuato and Michoacan, Mexico. The larvae breed in canals, irrigation channels, and clear water pools in which algae and protozoa are present. This form is not so dependent on clean water as is *A. pseudopunctipennis*, so that it is replacing the latter species in the outskirts of Mexico City, where urbanization results in a pollution of the water available to the mosquitoes. The larvae are encountered in the

breeding places throughout the year, even when a layer of ice forms over the surface of the water (Hoffmann 1935). The females do not seem to be attracted to man, and Vargas (1939a) has described a condition of anophelism without malaria in a locality in the State of Mexico, in which this form was the only anopheline present.

Vargas (1940b) reports the finding of *A. maculipennis* var. *freeborni* at Imuris, Sonora.

A. atropos is included in this list because Carr, Melendez and Ros (1940) discovered it recently in Cuba. It was found once, in Havana Province, in an animal-baited trap. Martini (1935) reported it from the interior of Mexico, but Hoffmann (1936) points out that Martini's specimens were really *A. aztecus*.

A male of *A. walkeri* has been taken in Tuxpan, Veracruz, Mexico (Vargas 1940a).

A. barberi was discovered by Sr. A. Martinez Palacios at Imuris, Sonora, Mexico (Vargas 1940c).

A. neivai breeds only in water caught in the leaf-bases of certain water-holding plants, such as the epiphytic and terrestrial bromeliads. The species ranges from tropical Mexico to Panama, and southwards into Ecuador; records of *cruzei*, from Panama northwards, actually refer to *A. neivai* (Komp 1937a). It may be quite abundant and may bite man freely, in the neighborhood of its breeding places (Komp 1937a).

A. xelajuensis was described from Guatemala by de Leon (1938).