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AMAZON ANOPHELES BIOLOGY. XII. OCCURRENCE OF ANOPHELES SPECIES, MALARIA CONTROL AND TRANSMISSION DYNAMICS IN THE URBAN ZONE OF ARIQUEMES (RONDÔNIA)

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AMAZON ANOPHELINE BIOLOGY. XII. OCCURRENCE OF ANOPHELES SPECIES, MALARIA CONTROL AND TRANSMISSION DYNAMICS IN THE URBAN ZONE OF ARIQUEMES (RONDÔNIA)(1)

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SUMMARY

Data on incidence and distribution of **Anopheles** species in Ariquemes (RO) reveal that variability is greater in the periphery of the city and that **Anopheles darlingi** is recorded in practically all collection points. Entomological study showed different penetration levels of the species in the urban area, Sectors 1 and 3 being identified as malaria free; Sectors 2 and 4 showing risk at the periphery; and the Industrial Area and Special Areas Sector, the BNH Complex, Sector 5 and Old Town constituting high malaria risk sectors. These last areas had the highest mosquitoes per man/hour indices, with variations being noted in the sampling frequency and in conformance with the location of the urban area. Vector population density measurements reveal seasonal changes, the lowest figures being recorded during the winter. Malaria transmission is discussed in consideration of: 1) the role of the city's physical structure during the establishment phase, 2) the river banks bordering the urban area and their relationship to the anopheline development cycle, 3) behavioral patterns of the species' biting habits, correlated with natural environments and ecologically altered areas, and 4) the importance of environmental management in malaria control, reduction of vector population density. In order to contain the migratory process of the vector, a protective belt is proposed for the city, consisting of a sparse growth of forest, also including biological protection to encourage

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the zoophilic tendency of the anophelines. The results of natural infection obtained in autocthonal malaria areas permit identification of **A. darlingi** as a vector, and the possibility that other species are involved in transmission is discussed.

KEY TERMS: **Anopheles**; Malaria; Population density; Seasonal moves; Biting activity; Vector; Malaria control.

INTRODUCTION

The Amazon region of today is subjected to extensive environmental alteration from installation of major industrial projects. These activities introduce modifications into the ecosystem, affecting the integrated organism/atmosphere complex and among diseases, Malaria, as pointed out in the literature[3, 29, 35], is the first to appear in areas which are undergoing changes. Chief among the parameters which lead to the appearance of malaria, initially as an endemic are: 1) extensive appearance of the vector(s) in regions undergoing change and 2) the fact that immigrant human populations frequently come from areas free of the disease, and they are more susceptible than local populations to **Plasmodium** infection[29, 39, 35]. Classic examples of this occurred during the construction period of the Madeira-Mamore railroad in the Amazon rubber exploration era.

Occupation of the Western Amazon Region has increased since construction of Highway BR-364 (Cuiabá/Porto Velho) and BR-319 (Manaus/Porto Velho). In this process, BR-354 formed the link between this region of the Amazon and the densely populated centers of the Southeastern and Southern regions of the country. Beyond this aspect, the trace of this highway has been the site of large settlement centers, especially in the State of Rondônia. As a result of the heavy human migration into these areas, the settlement of migrant populations has been accompanied by maximum intensity appearance of malaria.

Among the municipalities of the State of Rondônia, Ariquemes stands out as one of the major settlement projects stemming from the increased human migration. It also stands out as being the city having the highest incidence of malaria in that State. Records indicate that the occurrence indices of **Plasmodium falciparum** are almost double those of **P. vivax.** Ariquemes has extensive areas of fertile lands, yet on the other hand, as indicated by TADEI[34, 35, 36], preliminary data from entomological studies for **Anopheles** species are demonstrating that **A. darlingi**, the chief vector of human malaria in the Amazon region, is recorded in practically all locations studied. This aspect, associated with the high migration into the region are elements pointing toward an aggravated incidence of malaria in the city[36].

The facts laid out above show the importance of conducting an entomological study for species of **Anopheles** in Amazon areas to be occupied, so that vector-based measures for controlling this disease can be established. In consideration of these aspects, this study presents the results of an entomological study carried out internally and in the peripheral areas of Ariquemes, including the specific variability and extension of appearance of the anophelines in the different sectors of the city.

MUNICIPALITY OF ARIQUEMES

DESCRIPTION

The Municipality of Ariquemes was founded in 1916, on the banks of the Rìo Jamari, by the Ma--- Cândido M.S. Rondon. The original purpose of the town was for installation of telegraph stations of the Cuiabá-Santo Antônio de Madeira line. In addition to the "Arikemes" Indians, who were the original inhabitants of the site, the city held the telegraph station employees and some [obliterated]. The early center of Ariquemes still exists, marked by telegraph station activities, but the center of the population was [obliterated] near the city's main settlement street at the height of manual mining of cassiterite. With the discovery of ore in the municipality, an airport was built, which centralized [obliterated] and commercial establishment; then [obliterated] became more numerous for transportation of the ore extracted and defining new [obliterated] for the area.

The historic evolution of the city can be broken down into three sequential economic cycles, RUBBER, CASSERITE and AGRICULTURE. With the end of the RUBBER economic cycle, which commodity was the principal factor in the first phase of the municipality, mining of ore became the preponderant factor in keeping the city alive. From 1971, when manual mining of the ore was prohibited, Ariquemes reverted to being more of a travel stop along BR-364. The passage of this highway right through the city was important for keeping it alive after the RUBBER and CASSERITE cycles had run their course.

In 1971, the National Institute of Colonization and Agrarian Reform (INCRA) instituted studies in the area, culminating in creation of the "Burareiro" and "Marechal Dutra" Planned Settlement Projects. In 1975 these projects went into the implementation phase, and from this we have a third cycle - AGRICULTURE - for Ariquemes.

In 1976 "New Ariquemes" was founded to receive the influx of human migration in response to the Settlement Centers program. It was initially intended to transfer Old Ariquemes into its new counterpart. The initial plan included elimination of the original downtown area, since it was cut through the middle by BR-364, which served as its main street. Despite these plans, the old town center of Ariquemes remained, and today it is included as a district in the urban plan. The city started out as Sector 1, which was totally occupied in the year of founding, after which the buildup of Sector 2 was initiated. At present the municipality has about 102,000 inhabitants; the city is expanding its urban perimeter, and Sector 6, the most recent, is practically complete (details are shown on the city map, Figure 1).

MATERIAL AND METHODS

The entomological study for **Anopheles** species in the urban and adjoining areas of Ariquemes gathered data on both the winged and larval forms of the insect. The data were obtained in two phases, in accordance with activity in the area. The first, with lesser activity was conducted in July/August 1981, and the second, from

August 1984 through the first half of 1985.

The immature specimens were collected from breeding grounds located at the periphery of the city, where conditions were favorable for anopheline reproduction. Figures 2 to 4 show the general characteristics of these breeding grounds, located along the banks of the Nações (Figure 2), the Sector 2 riverbank (Figure 3), and the farm areas located in the Grandes Areas and Nobre Area Sector (Figure 4). As shown by these figures, breeding grounds which presented unaltered characteristics, such as those in the Nações banks, as well as those in areas modified by man, such as the pasture lands in the Grandes Areas and Nobre Area Sector and Sector 2 riverbank, were selected for sampling.

For sampling of the immature forms specimens were collected using a rectangular white enamelled tray, 32 cm long, 23 cm wide and 6 cm deep. At the selected site, the tray was placed so as to induce a flow of water from the breeding source into the tray, carrying with it the immature forms present at the site. Then the 3rd and 4th stage larvae were collected with a dropper and transferred to flasks to make up a sample. These collections were carried out in the edges of the breeding grounds, among plants (grasses, macrophytes, algae, etc.), dry leaves, rotting tree limbs and trunks, and also from rocky areas, when present. When tree trunks and branches were present in the more central areas of the breeding grounds, samples were also collected near them.

To quantify the samples, an area of about three meters of the breeding ground was selected. The larvae were collected by immersing the tray at different positions in this area, several times, until no more larvae appeared in it after withdrawal. At collection points where it was impossible to lay out an area of these dimensions, sampling was done in a smaller area, but the same procedure of repeated immersions of the tray was employed at each site.

After collection, the larvae were fixed in MACGREGOR solution[28] and transported to the laboratory for subsequent mounting and identification of the species. A potash solution was used for clarification and creosote was used for diaphanization. In cases where it was impossible to identify the species from the immature form, their incidence was determined from the hatching of larvae coming directly from the breeding grounds.

The winged insects were collected near the jungle surrounding the city, in the different sectors and in the urban area, at various points along the periphery. The specimens were captured with a suction apparatus when they landed on a person to feed. The collection time was set at between 6:00 P.M. and 10:00 P.M. for the various sampling points. For each collection, the number of "bait" persons and collectors was noted, for purposes of calculating the index of anophelines per man/hour for each sector of the city.

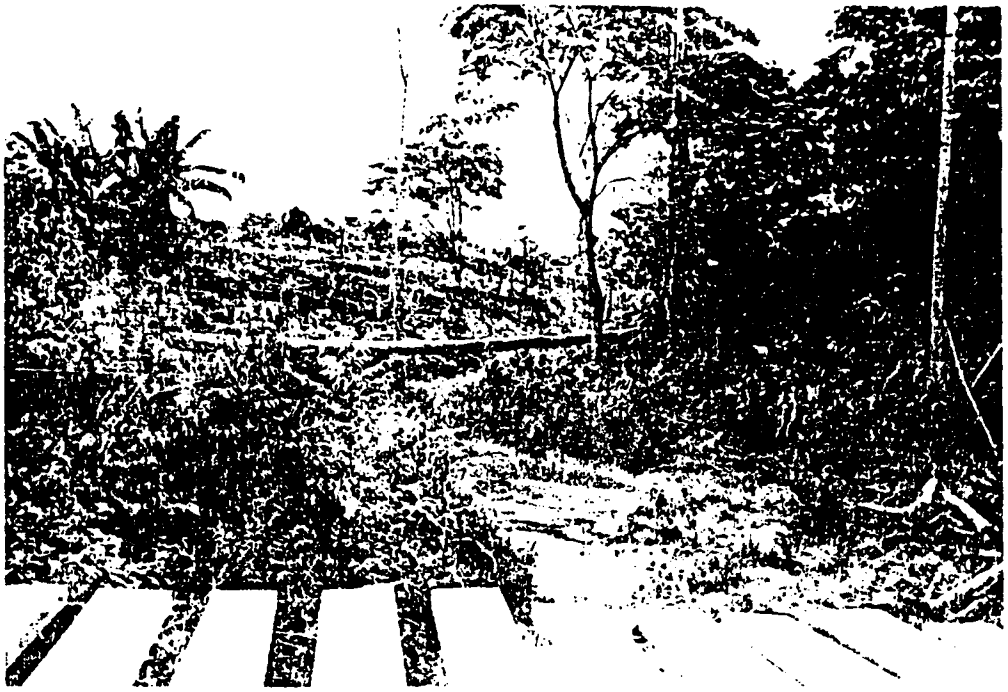
However, to measure biting activity, collections were also made with 6 hours of observation (between 6:00 P.M and midnight) and with 12 hours (between 6:00 P.M. and 6:00 A.M. the following morning).

A

B

Fig. 2. Views of the breeding grounds on the Nações riverbank. View A shows the area at the beginning of winter; B, in midwinter.

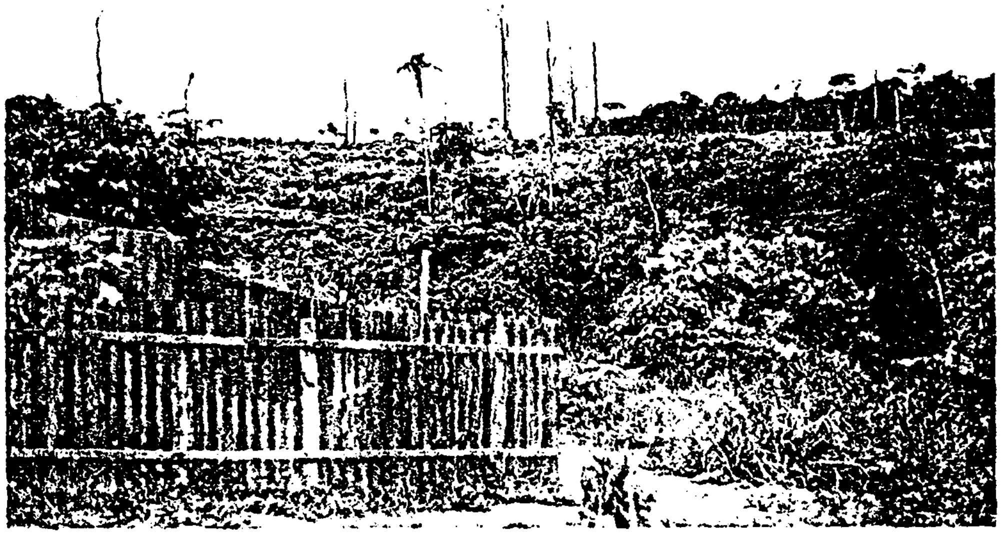
A



B

Fig. 3. Sector 2 riverbank [remainder of legend illegible]

A



B

Fig. 4. General view (A) and breeding ground details (B) near the farmlands of the Grandes Areas and Area Nobre Sector.

Mature insects were collected near the Nações, along its banks, and in the jungle, in the Industrial Area and in the BNH complex. In the Grandes Areas and Area Nobre Sector, as the farmlands are predominant, the collections were made near the stream running through them, in pasture areas and near the farm dwellings, under homeside conditions (Figure 4). In Old Town the collections were also near dwellings and some collection points were located at the edge of the jungle and within it, in view of its proximity to Old Town.

In the urban areas of the different sectors, the collections were made sequentially from the perimeter inward toward the center of the city. The collections were made around dwellings, and to the extent they were positive in peripheral sites, new collection points were laid out in the more internal areas of each sector, so as to cover the area as a whole, moving in a direction toward the center of the city. Successive repetition of this procedure made it possible to delimit the sampling points which were located from the periphery toward the center, classifying them as positive or negative, according to the number of anophelines recorded. There was no need to establish collection points in Sector 1, since the collections were already shown to be negative in areas of Sectors 2 and 3. Collections were also made in the Alamedas, where vegetation favored the presence of the mature insect.

The customary method of dissection was used to study natural infection of the anophelines. The specimens collected were dissected and the stomach and salivary glands were examined for presence of oocysts and sporozoites, respectively. The analyses were carried out with a phase microscope (Zeiss WL).

Both the winged and immature specimens were taken to a laboratory set up adjacent to the Municipal Health Department, for preparation and the initial tests in the identification process. Subsequently, all materials were sent to Manaus for final determination. For taxonomic identification of the Oswaldo and Strodei series especially[18], slide samples were made of the male genitalia.

The specimens taken were incorporated into the entomological collection of the Malaria Vector Laboratory of the Amazonian National Research Institute and that of the Biology Department of the Institute of Biosciences, the Humanities and Exact Sciences, UNESP, São José do Rio Preto Campus, São Paulo.

RESULTS

Tables 1 and 2 describe the anopheline collection points with the results and respective reference numbers in Figure 5. The winged insects (Table 1) were collected at 166 points in the city and its vicinity. As can be verified from the figure, these sites were sufficient to cover the entire urban area for recording occurrence of the mature insect. The immature forms (Table 2) were collected along the river banks bordering the city, with a total of 56 collections. The number of collections was greater along the banks of the Nações, due to their proximity to the urban zone and the fact that conditions there were excellent for anopheline breeding.

Considering all the material collected during the two periods of activity in the urban zone, 15 species of **Anopheles** were recorded, belonging to the subgenera **Nyssorhynchus**, **Arribalzagia** and **Anopheles**.

Subgenus **Nyssorhynchus** Blanchard, 1902

Anopheles triannulatus (Neiva 7 Pinto, 1922)

Anopheles galvaoi Causey, Deane & Deane, 1943

Anopheles rangeli Gabaldón, Cova-Garcia & López, 1940

Anopheles argyritarsis Robineau - Desvoidy, 1827

Anopheles evansae (Brèthes, 1926)

Anopheles benarrochi Gabaldón, Cova-Garcia & López, 1941

Anopheles nuñez-tovari Gabaldón, 1940

Anopheles oswaldoi (Peryassú, 1922)

Anopheles albitarsis Lynch Arribálzaga, 1878

Anopheles braziliensis (Chagas, 1907)

Anopheles strodei Root, 1926

Subgenus **Arribalzagia** Theobald, 1903

Anopheles mediopunctatus (Theobald, 1903)

Subgenus **Anopheles** Meigen, 1818

Anopheles peryassui Dyar & Knab, 1908

Anopheles mattogrossensis Lutz & Neiva, 1911

Tables 3 to 5 refer to collections taken in the first phase, the data for which were obtained in July/August 1981. The specimens taken with 6 hours of observation (Table 3) were obtained in the central areas of Sectors 2 and 3 and from Old Town. Collections were made at three points in Sector 2, four in Sector

TABLE 1

Description of collection points and results, for winged anophelines in the different sectors of the city of Ariquemes (RO) /228

Site	Result
SETOR 02	
– Alameda Juriti (1)	negativo
– Alameda Sabiá (2)	negativo
– Alameda Canário Pardo	
Ponto 1 (3)	negativo
Ponto 2 (4)	negativo
Ponto 3 (5)	negativo
– Alameda da Guanumbi (6)	negativo
– Alameda Maracanã	
Ponto 1 (7)	negativo
Ponto 2 (8)	negativo
Ponto 3 (9)	negativo
– Avenida Rio Pardo	
Ponto 1 (10)	positivo
Ponto 2 (11)	positivo
Ponto 3 (12)	positivo
SETOR 03	
– Alameda da Brasília (13)	negativo
– Alameda Fortaleza	
Ponto 1 (14)	negativo
Ponto 2 (15)	negativo
– Alameda Natal	
Ponto 1 (16)	negativo
Ponto 2 (17)	negativo
Ponto 3 (18)	negativo
Ponto 4 (19)	negativo
– Alameda João Pessoa	
Ponto 1 (20)	negativo
Ponto 2 (21)	negativo
– Alameda Recife	
Ponto 1 (22)	negativo
Ponto 2 (23)	negativo
– Alameda Aracajú	
Ponto 1 (24)	negativo
Ponto 2 (25)	negativo
– Alameda Maceió (26)	negativo
– Alameda Vitória (27)	negativo
– Alameda Rio de Janeiro	
Ponto 1 (28)	negativo
Ponto 2 (29)	negativo
– Alameda São Paulo	
Ponto 1 (30)	negativo
Ponto 2 (31)	negativo
– Alameda Curitiba (32)	negativo
– Alameda Porto Alegre (33)	negativo
SETOR 04	
– Avenida Jarú	
Ponto 1 (34)	positivo
Ponto 2 (35)	positivo
Ponto 3 (36)	positivo
Ponto 4 (37)	positivo
– Alameda Bougain Villea	
Ponto 1 (38)	negativo
Ponto 2 (39)	negativo
Ponto 3 (40)	positivo
– Alameda Flor do Ipê	
Ponto 1 (41)	negativo
Ponto 2 (42)	negativo
Ponto 3 (43)	negativo
– Alameda Papoulas (44)	negativo
– Alameda Orquídeas	
Ponto 1 (45)	negativo
Ponto 2 (46)	negativo
– Alameda Vitória (47)	negativo
– Avenida Vimbere	
Ponto 1 (48)	positivo
Ponto 2 (49)	positivo
– Alameda Lírio	
Ponto 1 (50)	positivo
Ponto 2 (51)	positivo
– Avenida Canaã – junto ao Igarapé do Horto (52)	positivo
SETOR 05	
– Rua Alagoas (53)	positivo
– Rua Rio Grande do Norte (54)	positivo
– Rua Sergipe	
Ponto 1 (55)	positivo
Ponto 2 (56)	positivo
Ponto 3 (57)	positivo
– Rua Bahia	
Ponto 1 (58)	positivo
Ponto 2 (59)	positivo
– Rua Espírito Santo	
Ponto 1 (60)	positivo
Ponto 2 (61)	positivo
– Rua Goiás	
Ponto 1 (62)	positivo
Ponto 2 (63)	positivo
Ponto 3 (64)	negativo
– Rua Distrito Federal	
Ponto 1 (65)	negativo
– Rua Minas Gerais	
Ponto 1 (66)	negativo
Ponto 2 (67)	negativo
Ponto 3 (68)	positivo
– Avenida Machadinho (69)	positivo
– Rua Roraima (70)	positivo
– Rua Paraná (71)	negativo
– Rua Santa Catarina (72)	negativo
SETOR 06	
– Rua Vinícius de Morais	
Ponto 1 (73)	positivo
Ponto 2 (74)	positivo
– Rua Gregório Matos (75)	positivo
– Rua Basílio da Gama (76)	positivo
CONJUNTO BNH	
– Avenida Candeias (77)	positivo
– Rua Ouro Preto (78)	positivo

Site	Result
Nova Vida	
nto 1 (79)	positivo
nto 2 (80)	positivo
nto 3 (81)	positivo
. Ariquemes (82)	negativo
Rio Preto	
nto 1 (83)	negativo
nto 2 (84)	positivo
nto 3 (85)	positivo
nto 4 (86)	positivo
a Porto Velho (87)	negativo
a Costa Marques (88)	positivo
a Colorado D'Oeste (89)	negativo
a Vilhena	
'onto 1 (90)	positivo
'onto 2 (91)	negativo
a Cacoal	
onto 1 (92)	positivo
Ponto 2 (93)	positivo
Ponto 3 (94)	positivo
ua Presidente Médici (95)	positivo
ua Ji-Paraná	
Ponto 1 (96)	positivo
Ponto 2 (97)	positivo
.ua Guajará-Mirim (98)	negativo
A INDUSTRIAL E SETOR REAS ESPECIAIS	
ua Jatuarana (99)	negativo
Rua Curimatã	
Ponto 1 (100)	negativo
Ponto 2 (101)	positivo
Ponto 3 (102)	positivo
Ponto 4 (103)	positivo
Rua Boto (104)	negativo
Rua Tarimã	
Ponto 1 (105)	positivo
Ponto 2 (106)	positivo
Ponto 3 (107)	positivo
Avenida Candeias	
Ponto 1 (108)	positivo
Ponto 2 (109)	positivo
Ponto 3 (110)	positivo
Rua Pirarucu (111)	negativo
Avenida Jarú	
Ponto 1 (112)	positivo
Ponto 2 (113)	positivo
Rua Venezuela (114)	positivo
Rua Guianas-Gurgel (115)	positivo
Igarapé das Nações (Gurgel)	
Ponto 1 (116)	positivo
Ponto 2 – Fazenda Boa Vista (117)	positivo
R-364	
Ponto 1 – Cascavel (118)	positivo
Ponto 2 – Cascavel (119)	positivo
Ponto 3 – Cascavel (120)	positivo
Ponto 4 – Serraria Daltiba (121)	positivo
Ponto 5 – (122)	positivo
Ponto 6 – (123)	positivo
Ponto 7 – (124)	positivo
Ponto 8 – (125)	positivo
BR-421	
Ponto 1 – Matadouro (126)	positivo
Ponto 2 – Sítio Pingo D'Ouro (127)	positivo
VILA VELHA	
Ponto 1 – BR 364 (128)	negativo
Ponto 2 – Aeroporto (129)	negativo
Ponto 3 – Captação D'água (130)	negativo
Ponto 4 – (131)	positivo
Ponto 5 – (132)	negativo
Ponto 6 – (133)	negativo
Ponto 7 – (134)	positivo
Ponto 8 – Taberna (135)	negativo
Ponto 9 – Telégrafo (136)	positivo
Ponto 10 – (137)	negativo
Ponto 11 – (138)	positivo
SETOR DE GRANDES ÁREAS E ÁREA NOBRE	
– Sítio Sem Porteira (139)	positivo
– Sítio do Sargento	
Ponto 1 (140)	positivo
Ponto 2 (141)	positivo
Ponto 3 (142)	positivo
Ponto 4 (143)	positivo
– Sítio do Morro	
Ponto 1 (144)	positivo
Ponto 2 (145)	positivo
Ponto 3 (146)	positivo
Ponto 4 (147)	positivo
Ponto 5 (148)	positivo
Ponto 6 (149)	positivo
– BANACRE	
Ponto 1 (150)	positivo
Ponto 2 (151)	positivo
Ponto 3 (152)	positivo
– Chácara do Emílio	
Ponto 1 (153)	positivo
Ponto 2 (154)	positivo
– Chácara do Luis	
Ponto 1 (155)	positivo
Ponto 2 (156)	positivo
Ponto 3 (157)	positivo
Ponto 4 (158)	positivo
– Zé Preto	
Ponto 1 (159)	positivo
Ponto 2 (160)	positivo
– Fundos Hospital	
Ponto 1 (161)	positivo
Ponto 2 (162)	positivo
Ponto 3 (163)	positivo
Ponto 4 (164)	positivo
Ponto 5 (165)	positivo
– Chácara (166)	positivo

* "negativo" = negative; "positivo" = positive

( ) = Reference number of Figure 5 (FULL CIRCLE)

TABLE 2

Description of collection points and results, for larval forms in the stream banks adjoining the city of Ariquemes (RO)

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Site	Result
SETOR 02	
– Igarapé do 2	
Ponto 1 (01)	negativo
Ponto 2 (02)	negativo
Ponto 3 (03)	negativo
Ponto 4 (04)	positivo
SETOR 04	
– Igarapé 004	
Ponto 1 (05)	negativo
Ponto 2 (06)	negativo
Ponto 3 (07)	positivo
Ponto 4 (08)	negativo
Ponto 5 (09)	positivo
SETOR 06	
– Mina Velha (10)	positivo
– Lago da Mina Velha (11)	positivo
– Igarapé da Mina Velha	
Ponto 1 (12)	negativo
Ponto 2 (13)	negativo
Ponto 3 (14)	negativo
– Casa do Corbeli (15)	positivo
– Igarapé do 08	
Ponto 1 (16)	negativo
Ponto 2 (17)	positivo
Ponto 3 (18)	positivo
Ponto 4 (19)	positivo
IGARAPÉ DAS NAÇÕES	
– Gurgel	
Ponto 1 (20)	positivo
Ponto 2 – Fazenda Boa Vista (21)	positivo
Ponto 3 (22)	positivo
Ponto 4 (23)	positivo
Ponto 5 (24)	positivo
Ponto 6 (25)	positivo
Ponto 7 (26)	positivo
Ponto 8 (27)	positivo
Ponto 9 (28)	positivo
Ponto 10 (29)	positivo
Ponto 11 (30)	positivo
Ponto 12 (31)	positivo
– BNH	
Ponto 1 (32)	positivo
Ponto 2 (33)	positivo
Ponto 3 (34)	positivo
Ponto 4 (35)	positivo
Ponto 5 (36)	positivo
Ponto 6 (37)	positivo
Ponto 7 (38)	positivo
Ponto 8 (39)	positivo
– BR-364	
Ponto 1 (40)	positivo
Ponto 2 (41)	positivo
Ponto 3 (42)	positivo
Ponto 4 (43)	positivo
Ponto 5 (44)	positivo
– BR-421	
Ponto 1 (45)	[illegible]
Ponto 2 (46)	[illegible]
SETOR DE GRANDES ÁREAS E ÁREA NOBRE	
– Reservatório do INCRA (47)	positivo
– Construtora Centro Oeste	
Ponto 1 (48)	positivo
Ponto 2 (49)	positivo
– Fazenda São Francisco (50)	positivo
– Igarapé do Luis (51)	positivo
– Igarapé do Zé Preto (52)	positivo
– Igarapé do Emílio (53)	[illegible]
– Lago do Emílio	
Ponto 1 (54)	[illegible]
Ponto 2 (55)	[illegible]
– Chácara Pedrotti (56)	[illegible]

* "negativo" = negative; "positivo" = positive

( ) = Reference number of Figure 5 (EMPTY CIRCLE)

TABLE 3

Incidence of **Anopheles** species, winged form, collected between 6:00 P.M. and Midnight in Sectors 2 and 3 and Old Town during the period July/August, 1981 (Ariquemes - Rondônia)

Species	TIME FRAME						Total
	18 – 19	19 – 20	20 – 21	21 – 22	22 – 23	23 – 24	
Anopheles darlingi	226(50,1)	147(32,6)	73(16.2)	05(1,1)	0	0	451(76,0)
Anopheles triannulatus	65(80,3)	12(14,8)	04(4.9)	0	0	0	81(13,7)
Anopheles oswaldoi	12(44,5)	07(25,9)	07(25,9)	01(3,7)	0	0	27(4,6)
Anopheles mediopunctatus	0	03(50,0)	02(33,3)	01(16,7)	0	0	06(1,0)
Anopheles nuñez-tovari	05(100)	0	0	0	0	0	05(0,8)
Anopheles galvaoi	03(100)	0	0	0	0	0	03(0,5)
Anopheles evansae	12(66,7)	05(27,8)	01(5,5)	0	0	0	18(3,0)
Anopheles albitarsis	02(100)	0	0	0	0	0	02(0,3)
Anopheles argyritarsis	01(100)	0	0	0	0	0	01(0,1)
TOTAL	326(54.9)	174(29.3)	87(14,6)	7(1,2)			594

( ) = percentage

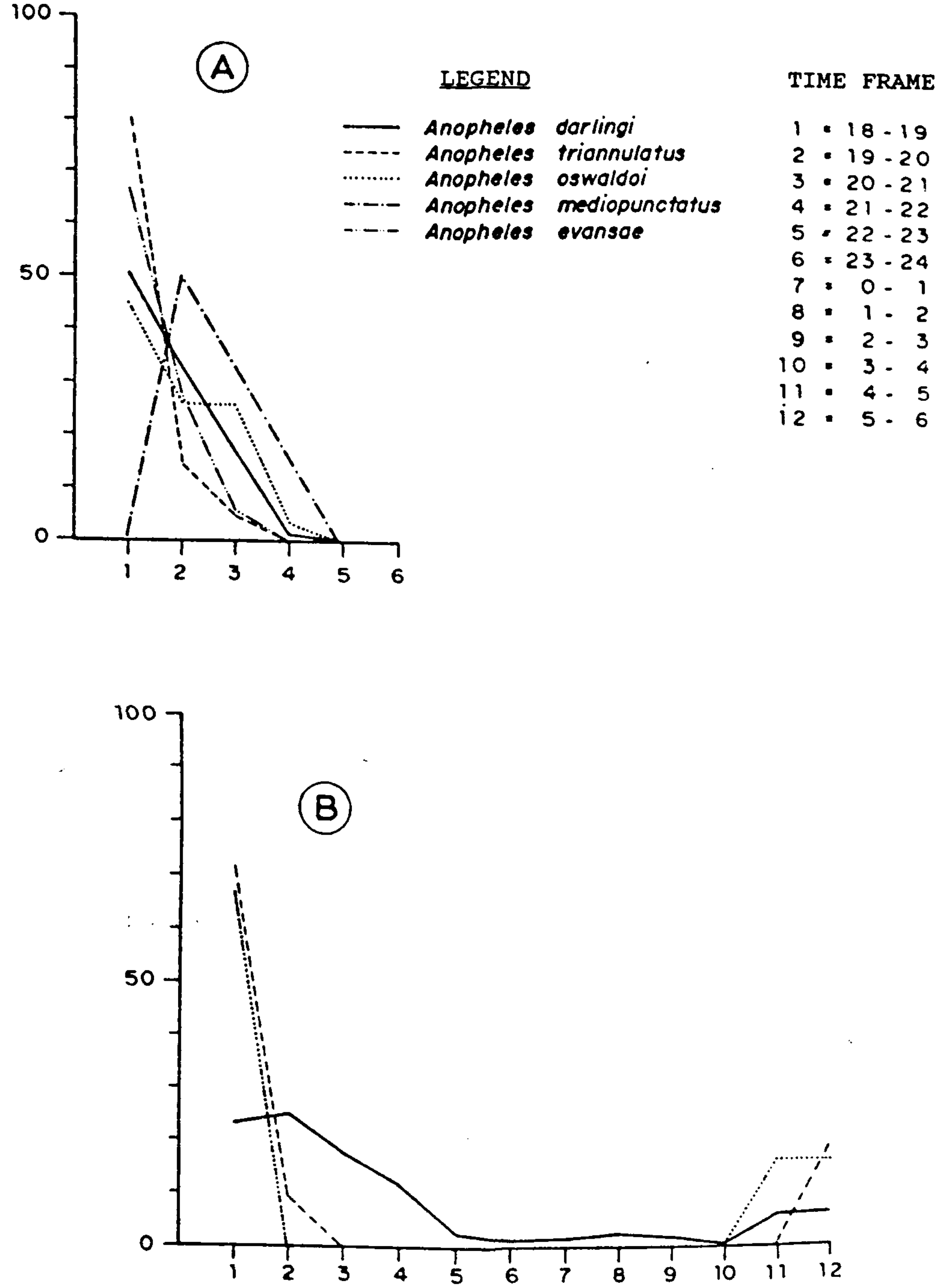

Figure 6. Graphical representation of the frequencies of Anopheles species observed in the different time frames. A represents 6 hour observations. B represents 12 hour observations. Ordinate: percentage of total. Abscissa: time frame.

TABLE 4

Incidence of **Anopheles** species, winged form, collected between 6:00 P.M. and 6:00 A.M. the following morning, at peripheral points of the city during the period July/August, 1981 (Ariquemes - Rondônia)

Species	TIME FRAME												Total
	18 – 19	19 – 20	20 – 21	21 – 22	22 – 23	23 – 24	0 – 1	1 – 2	2 – 3	3 – 4	4 – 5	5 – 6	
Anopheles darlingi	72(23,4)	77(25,0)	55(17,9)	37(12,0)	07(2,2)	03(1,0)	05(1,6)	07(2,2)	05(1,6)	02(0,7)	19(6,2)	19(6,2)	308(91,1)
Anopheles oswaldoi	04(66,6)	0	0	0	0	0	0	0	0	0	01(16,7)	01(16,7)	06(1,8)
Anopheles triannulatus	15(71,4)	02(9,6)	0	0	0	0	0	0	0	0	0	04(19,0)	21(6,2)
Anopheles rangeli	0	02(100)	0	0	0	0	0	0	0	0	0	0	02(0,6)
Anopheles mediopunctatus	0	0	01(100)	0	0	0	0	0	0	0	0	0	01(0,3)
TOTAL	91(26,9)	81(24,0)	56(16,6)	37(10,9)	07(2,0)	03(0,8)	05(1,5)	07(2,1)	05(1,5)	02(0,6)	20(6,0)	24(7,1)	338

(   ) = percentage

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3 and two in Old Town. Nine species were captured, with **A. darlengi** representing 76% of the total catch. The other more frequent species were **A. triannulatis** and **A. oswaldoi**. This table also includes the data relating to biting activity at the different hours of observation. Figure 6A represents the species which occur with a frequency of greater than 1%. It is observed that all of these species, with the exception of **A. mediopunctatus** show high activity during the first hour, falling off at a rate of about 50% per hour thereafter, and disappearing after 9:00-10:00 P.M.. Other species shown on Table 3 show activity only in the first hour, with capture of only a few specimens.

Table 4 includes the collections at peripheral points of Ariquemes, data being collected at 3 points in Gurgel (Nações riverbanks), one point at Fazenda Boa Vista (near the Nações banks, at BR-364), and in the INCRA reservoir, located in the Grandes Areas Sector. Five species of **Anopheles** were detected, and **A. darlingi** was again the most frequent, representing 91.1% of the total sample. As was seen on Table 3, the other two most frequent species were **A. oswaldoi** and **A. triannulatus**. The results relating to biting activity, which in this case covered 12 hours of observation, are depicted graphically on Figure 6B. It can be seen that **A. darlingi** exhibits a biting pattern which sets it apart from the others: its pattern is continuous, but with two peaks, one at nightfall, and the other, less pronounced, at dawn. The other species (**A. triannulatis** and **A. oswaldoi**) show activity only in the early evening, ending at about 8:00 P.M., with a new peak appearing in the early morning, between 4:00 and 6:00 A.M..

The sampling of immature forms carried out in July/August of 1981 is shown on Table 5, broken down by collection site. It is observed that there are differences in the variety of species per site, especially in the figures recorded for **A. darlingi**, which show a high occurrence at Gurgel, located on the banks of the Nações. Table 5 also highlights the extension of occurrence of some species which were collected at a great many of the sites: **A. triannulatis, A. rangeli, A. nuñez-tovari** and **A. oswaldoi.** Of the total specimens (4904) collected on that occasion, it can be seen that 83% of the material was taken from Gurgel (banks of the Nações).

The data shown on Tables 6 to 12 were obtained during the second period of activity, between August 1984 and June 1985. Collection of the mature specimens, depicted on Figure 5, in the various Sectors of the city, are included on Table 6. **A. darlingi** was recorded at all sites, and the species represented 82.8% of all the mature insects collected. The next most frequent species was **A. triannulatus** (11%), and then **A. evansae** (3.3%). The other species showed values of under 1%. **A. triannulatus**, like **A. darlingi**, was recorded in all sectors. As was observed during the July/August 1981 activities, wherein a high incidence of anoph- elines was verified in Gurgel (banks of the Nações), located in the Industrial Area and Special Areas Sectors, this was reestablished in the second period (Table 6), when 65.7% of the anophelines collected were captured at this site. In view of this characteristic, Gurgel was designated a Collection Station, and samplings were taken during 1984 and 1985. The results are shown on Table 7, and it is observed that **A. darlingi** was recorded during the entire period, and presents incidence variations depending on the period considered. The other species occur in low frequencies and do not show a continuous picture in recording of samples. **Anopheles triannulatus,** however, was recorded with low incidence in three samplings. Taking into account the total anophelines collected, it is verified that there are variations in density, and that the frequencies diminish from August 1984 to January 1985, beginning to rise again in February 1985.

The results obtained from collection of the larvae in the different sectors of the city are shown on Table 8. A high variability can be observed, since nine species of **Anopheles** were recorded, and the greater incidence of larvae was also verified at the banks of the Nações (71.2% of the total collected), as had been the case in 1981. **A. darlingi** was once again the most frequent species recorded at the banks, representing 63% of the total collected, and the results for **A. triannulatus** and **A. oswaldoi** were also repeated. Anopheline larvae were also verified in Sectors 2 and 4, but the material was not identified, as the specimens were all in the second and third stages. The incidence in Sector 6 was very low.

A comparison of the species incidence shown on Table 8 with that observed in 1981 shows that **A. darlingi, A. triannulatus** and **A. oswoldoi**, the most frequent species in the first sampling, were also predominant in 1984/1985 (Table 8). As to variability, the first sampling shows two more species than the second.

Given the high incidence of anophelines in the Nações area, samplings were carried out to evaluate vector population density at given points, during different periods (Table 9). The results reveal that **A. darlingi** and **A. triannulatus** were recorded in all collections, the first representing 61.1% of all material collected, and the second, 20.4%. The third most frequent species was **A. oswaldoi**, repeating the results obtained in 1981 (Table 5). It is also observed that there is a variation in population density, the overall computed values remaining relatively constant from August to November 1984, with a decrease from December to April 1985, and an increase in May and June. At the specific level, it is shown that **A. darlingi** presents elevated frequencies up to December 1985[sic], and reductions starting in February 1985. For **A. triannulatus** and **A. oswaldoi**, however, density reductions are recorded starting in November 1984.

As we have mentioned, the collection points of Figure 5 are described in Tables 1 and 2. To delimit the extent of anopheline occurrence in the urban area, a procedure of recording positive and negative points, going from the periphery toward the center of town was adopted, as described in the methodolgy. This entomological research procedure made it possible to evaluate the degree of incidence and distribution of the **Anopheles** species in the sectors of the city.

By considering the recording of positive and negative points

TABLE 5

Incidence of **Anopheles** species, larval form, in the different sectors of Ariquemes (RO), collection of which was made during the period July/August, 1981

Site	SPECIES*											Total
	1	2	4	5	7	8	10	11	12	13	14	
Gurgel	1740(42,9)	872(21,4)	8(0,2)	51(1,2)	342(8,4)	321(8,0)	30(0,73)	688(17,0)	1(0,02)	–	6(0,15)	4059(83,0)
Setor IV	–	25(16,9)	9(6,0)	14(9,5)	55(37,2)	–	–	42(28,4)	–	–	3(2,0)	148(3,0)
Reserv. do INCRA	–	5(7,5)	–	62(92,5)	–	–	–	–	–	–	–	67(1,4)
Matadouro (BR-421)	–	90(40,0)	–	–	–	7(3,1)	43(19,1)	80(35,6)	5(2,2)	–	–	225(4,6)
Faz. Boa Vista (BR-364)	21(26,3)	9(11,3)	–	6(7,5)	–	–	5(6,2)	36(45,0)	–	3(3,7)	–	80(1,6)
Estrada do Aeroporto	–	12(12,6)	–	62(65,3)	–	–	6(6,3)	8(8,4)	–	7(7,4)	–	95(1,9)
Serraria 1 - (Vila Velha)	–	14(14,9)	–	–	–	21(22,3)	13(13,8)	46(49,0)	–	–	–	94(1,9)
Chácara S. José (Vila Velha)	–	15(38,5)	–	–	–	13(33,3)	8(20,5)	3(7,7)	–	–	–	39(0,8)
Chácara Campinas	–	–	–	–	10(100)	–	–	–	–	–	–	10(0,2)
Matadouro Velho (Km 4)	–	21(24,1)	–	5(5,7)	–	–	21(24,9)	40(46,0)	–	–	–	87(1,8)
TOTAL	1761(36,0)	1063(23,0)	17(0,34)	200(4,0)	407(8,0)	362(7,4)	126(2,0)	943(19,2)	6(0,01)	10(0,03)	9(0,02)	4904

( ) = percentage

* = See listing of species on page 40.

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TABLE 6

Incidence of **Anopheles** species, winged form, in the different sectors of Ariquemes (RO), collection of which was made during the period August 1984 to June 1985

Site	SPECIES*													Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Setor 2	8(100)	–	–	–	–	–	–	–	–	–	–	–	–	8(0,3)
Setor 4	88(24,6)	250(69,8)	9(2,5)	3(0,8)	1(0,3)	1(0,3)	2(0,6)	3(0,8)	1(0,3)	–	–	–	–	358(13,4)
Setor 5	72(97,3)	2(2,7)	–	–	–	–	–	–	–	–	–	–	–	74(2,8)
Setor 6	2(100)	–	–	–	–	–	–	–	–	–	–	–	–	2(0,07)
Conjunto BNH	88(97,8)	2(2,2)	–	–	–	–	–	–	–	–	–	–	–	90(3,4)
Área Industrial e Setor de Áreas Especiais	1739(99,3)	9(0,5)	–	–	1(0,05)	–	–	–	2(0,1)	1(0,05)	–	–	–	1752(65,7)
BR-364/421	45(83,3)	1(1,9)	–	–	–	–	–	8(14,8)	–	–	–	–	–	54(2,03)
Vila Velha	110(71,0)	18(11,6)	–	–	–	5(3,2)	–	19(12,3)	–	–	3(1,9)	–	–	155(5,8)
Setor de Grandes Áreas e Área Nobre	54(31,2)	21(12,1)	–	–	9(5,2)	–	–	58(33,5)	–	4(2,3)	15(8,7)	11(6,4)	1(0,6)	173(6,5)
TOTAL	2206(82,8)	303(11,4)	9(0,3)	3(0,1)	11(0,4)	6(0,2)	2(0,07)	88(3,3)	3(0,1)	5(0,2)	18(0,7)	11(0,4)	1(0,03)	2666

(   ) = percentage

* = See listing of species on page 40.

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TABLE 7

Incidence of **Anopheles** species, winged form, in the Gurgel Collection Station (Ariquemes - Rondônia)

Site	SPECIES*							Total
	1	2	3	4	5	9	10	
nício)	561(89,0)	60(9,5)	06(0,9)	01(0,2)	01(0,2)	01(0,2)	–	630(34,2)
inal)	443(99,1)	04(0,9)	–	–	–	–	–	447(24,3)
o	312(100)	–	–	–	–	–	–	312(17,0)
	190(99,5)	–	–	–	01(0,5)	–	–	191(10,4)
ro	35(100)	–	–	–	–	–	–	35(2,0)
ro	04(100)	–	–	–	–	–	–	04(0,2)
	04(100)	–	–	–	–	–	–	04(0,2)
ro	07(100)	–	–	–	–	–	–	07(0,4)
	12(100)	–	–	–	–	–	–	12(0,6)
	25(100)	–	–	–	–	–	–	25(1,4)
início)	78(95,2)	02(2,4)	–	–	–	–	02(2,4)	82(4,5)
final)	89(100)	–	–	–	–	–	–	89(4,8)
L	1760(95,8)	66(3,6)	06(0,3)	01(0,05)	02(0,1)	01(0,05)	02(0,1)	1838

( ) = Percentage

* = See listing of species on page 40.

TABLE 8

Incidence of **Anopheles** species, larval form, in the different sectors of Ariquemes (RO), collection of which was made during the Period August 1984 to June 1985

Site	SPECIES*									Total
	1	2	5	6	8	9	10	11	12	
:or 2**										
tor 4**										
tor 6	–	2(33,3)	–	–	3(50,0)	–	–	1(16,7)	–	6(0,4)
ırapé das ıções-Gurgel	481(54,9)	220(25,1)	14(1,6)	1(0,1)	25(2,9)	–	18(2,1)	116(13,3)	–	875(52,4)
ɔnjunto BNH	264(84,0)	14(4,5)	3(1,0)	–	16(5,1)	–	2(0,6)	15(4,8)	–	314(18,8)
R-364/421	20(7,3)	166(60,8)	6(2,2)	–	27(9,9)	4(1,5)	10(3,7)	36(13,1)	4(1,5)	273(16,4)
ɛtor de Grandes ɹreas – Área ‹obre	16(8,0)	108(54,0)	6(3,0)	11(5,5)	27(13,5)	–	1(0,5)	23(11,5)	8(4,0)	200(12,0)
:OTAL	781(46,8)	510(30,6)	29(1,7)	12(0,7)	98(5,9)	04(0,3)	31(1,9)	191(11,4)	12(0,7)	1668

( ) = percentage
* = See listing of species on page 40.
** Occurrence of anopheline larvae; material not identified

TABLE 9

Incidence of **Anopheles** species, larval form, at points of the Nações banks of the city of Ariquemes (RO)

Date	SPECIES*								Total
	1	2	5	6	8	10	11	15	
1984									
August	58(26,0)	104(46,7)	12(5,4)	–	17(7,6)	05(2,2)	27(12,1)	–	223(17,2)
October (early)	66(52,0)	34(26,8)	01(0,8)	–	–	–	25(19,6)	01(0,8)	127(9,8)
October (late)	162(72,3)	33(14,7)	01(0,5)	–	–	–	28(12,5)	–	224(17,3)
November (early)	140(61,7)	45(19,8)	–	–	–	02(0,9)	36(15,9)	04(1,7)	227(17,6)
November (late)	198(88,4)	09(4,0)	–	–	07(3,1)	–	10(4,5)	–	224(17,3)
December	119(82,7)	04(2,8)	03(2,1)	–	12(8,3)	–	06(4,1)	–	144(11,1)
1985									
February	07(25,0)	12(42,8)	–	–	01(3,6)	–	08(28,6)	–	28(2,2)
March	07(31,8)	05(22,7)	–	–	–	–	10(45,5)	–	22(1,7)
April	03(23,1)	01(7,7)	–	01(7,7)	–	–	08(61,5)	–	13(1,0)
May	12(44,4)	11(40,8)	–	–	–	04(14,8)	–	–	27(2,0)
June	20(54,1)	06(16,2)	--	–	–	06(16,2)	–	05(13,5)	37(2,8)
TOTAL	792(61,1)	264(20,4)	17(1,3)	01(0,08)	37(2,9)	17(1,3)	158(12,2)	10(0,8)	1296

( ) = percentage

* See listing of species on page 40

for the presence of **A. darlingi**, shown in Tables 1 and 2, it was possible to plot the extent of penetration of the species into the urban area, as well as to map its occurrence in the periphery, represented by the hash-marked region in Figure 5. Examination of this figure makes it possible to confirm that there are different degrees of occurrence of the species in the city, as well as areas free of anophelines. Sectors 1 and 3 are of the latter classification; the Industrial Area and Special Areas Sector, the BNH Complex and Sector 5 are high occurrence districts, having a record in over 50% of the area in each of these sectors. This aspect becomes evident when it is considered, for example, that of 22 sampling points in the BNH Complex, 73% were positive; or that 79% of 19 in the Industrial Area and Special Areas Sector were positive. The extent must be greater in Sector 6, but collections were limited just to the area on the map, since when the collections were taken, the Sector was still in the establishment phase. For Sectors 2 and 4, occurrence is only peripheral. When we consider the left boundary of BR-364, BR-421 and the Grandes Areas and Area Nobre Sector, we can confirm that they are areas extensively infested with **A. darlingi**.

For an evaluation of anopheles incidence by sampling in the different sectors of the city, Tables 10 and 11 present anopheles per man/hour indices which refer to the period from August 1984 to February 1985. In accordance with the physical sector location in the city, it was possible to identify peripheral sectors, the results for which are shown on Table 10. The data of Table 11 relate to the more central urban sectors of the city, and in these sectors it was also possible to classify the internal or peripheral collection points, according to their location within each sector.

Table 10 includes the points of mosquitoes per man/hour. In these results, the period of August-October 1984 draws attention, having high mosquitoes/man/hour indices of 112. These readings are lower in the period December 1984 - February 1985, when a drop in vector population density was verified. These indices also show a reduction in averages for each sector and by month. For the indices of sectors more centrally located with respect to the physical structure of the city (Table 11), it is confirmed that the points classified as peripheral within these sectors show, on average, higher values than those classified as internal. This is a consequence of the proximity of the sectors to the surrounding jungle, as illustrated in Figure 7 (BNH Complex - A and Sector 5 - B). The data pertaining to the Industrial Sector show mosquitoes per man/hour indices for both peripheral and internal points. This fact is explained by jungle strips remaining in the sector between lots at the time the samples were taken.

The natural infection study utilized dissection of specimens collected at the Gurgel Collection Station and at the BNH Complex (Table 12). During collection, the specimens were separated from hour to hour for computation of the infection index during the different periods. A total of 210 specimens of **A. darlingi** were dissected, with analysis of all the stomachs and a slightly lower number (199) of salivary glands. An overall infection index of 1%

TABLE 10

Anophelines per man/hour indices observed in the peripheral sectors of the city of Ariquemes (RO)

Sector		PERIOD						
		Aug84	Sep84	Oct84	Nov84	Dec84	Jan85	Feb85
Gurgel		9,2	64,0	112,0	2,7	0,7	1,0	1,8
		18,3	46,0	21,0	0,8	–	–	–
		4,5	–	8,1	8,0	–	–	–
		5,3	–	–	–	–	–	–
		40,0	–	–	–	–	–	–
		34,5	–	–	–	–	–	–
	média	19,2	55,0	47,0	3,8	0,7	1,0	1,8
Fundos Cascavel		5,0	–	–	–	–	–	–
		7,5	–	–	–	–	–	–
	média	6,2	–	–	–	–	–	–
Vila Velha		0,5	–	–	0,5	0,5	–	–
		–	–	–	0,5	4,5	–	–
		–	–	–	–	0,5	–	–
		–	–	–	–	0,5	–	–
		–	–	–	–	5,5	–	–
		–	–	–	–	11,5	–	–
		–	–	–	–	1,5	–	–
	média	0,5	–	–	0,5	3,5	–	–
Setor de Grandes Áreas e Área Nobre		–	–	–	0,5	11,5	1,0	0,5
		–	–	–	0,8	3,0	6,5	6,3
		–	–	–	0,5	9,0	5,5	0,8
		–	–	–	–	2,5	2,75	–
		–	–	–	–	1,5	5,8	–
		–	–	–	–	1,0	3,0	–
		–	–	–	–	8,0	–	–
		–	–	–	–	7,0	–	–
	média	–	–	–	0,5	5,4	4,0	4,0

"média" = average

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TABLE 11

Anophelines per man/hour indices observed in different sectors of the city, and classified as peripheral or internal according to location in the urban area (Ariquemes-Rondônia)

Sector	PERIPHERAL					INTERNAL				
	Aug/84	Sep/84	Oct/84	Nov/84	Feb/85	Aug/84	Sep//84	Oct/84	Nov/84	Feb/85
Setor 2	–	2,0	–	–	–	–	–	–	–	–
	–	1,0	–	–	–	–	–	–	–	–
	–	1,0	–	–	–	–	–	–	–	–
média		1,3	–	–	–	–	–	–	–	–
Setor 4	17,3	–	–	–	–	0,5	0,5	–	–	–
	23,8	–	–	–	–	–	–	–	–	–
	4,0	–	–	–	–	–	–	–	–	–
	3,5	–	–	–	–	–	–	–	–	–
	40,0	–	–	–	–	–	–	–	–	–
	7,5	–	–	–	–	–	–	–	–	–
média	16,0	–	–	–	–	0,5	0,5	–	–	–
Setor 5	–	–	0,8	–	–	–	–	3,5	–	–
	–	–	5,0	–	–	–	–	2,0	–	–
	–	–	3,0	–	–	–	–	3,5	–	–
	–	–	2,5	–	–	–	–	–	–	–
	–	–	2,3	–	–	–	–	–	–	–
	–	–	0,5	–	–	–	–	–	–	–
	–	–	0,5	–	–	–	–	–	–	–
	–	–	2,5	–	–	–	–	–	–	–
	–	–	2,0	–	–	–	–	–	–	–
média	–	–	2,1	–	–	–	–	3,0	–	–
Setor 6	–	–	–	–	0,5	–	–	–	–	–
	–	–	–	–	0,5	–	–	–	–	–
média	–	–	–	–	0,5	–	–	–	–	–
BNH	–	–	6,5	2,5	–	–	–	2,0	2,0	–
	–	–	6,5	–	–	–	–	2,0	–	–
	–	–	6,5	–	–	–	–	–	–	–
	–	–	8,5	–	–	–	–	–	–	–
	–	–	5,0	–	–	–	–	–	–	–
	–	–	1,5	–	–	–	–	–	–	–
			0,5	–		–	–	–	–	
			0,5				–	–	–	
média			4,4	2,5				2,0	2,0	
Setor Industrial	7,5	31,8	2,0			0,5	17,0	–	0,5	
	8,5	18,0	0,5			6,0			–	
						12,0			–	
média	8,0	[illegible]	1,25			6,1	17,0	–	0,5	

"média" = average

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A

B

Fig. 7. BNH Complex (A) and Sector 5 (B) and their relation to the surrounding jungle.

was established, and then modified when the computation was broken down by hours. In the first hour of observation (6:00 P.M. to 9:00 P.M.) the index remains the same, but the value is twice as great (3%) for the period from 8:00 P.M. to 9:00 P.M.

TABLE 12

Natural infection index of **Anopheles darlingi** from samples collected at different hours of the night and at two locations (Gurgel and BNH Complex) of the Urban Zone of Ariquemes (RO), during the period August 1984 to June 1985.

Examined	TIME FRAME								Total
	1800-1900		1900-2000		2000-2100		2100-2200		
	N	P	N	P	N	P	N	P	
Stomach	96	1(1)	77	0	32	1(3)	5	0	210(1)
Salivary Glands	93	1(1)	74	0	32	1(3)	4	0	199(1)

( ) = Percentage of infection; N=Negative; P=Positive

DISCUSSION

The genus **Anopheles** comprises a complex group of species of medico-sanitary significance. Only through intense entomological activity is it possible to gain a better understanding of the degree of diversity and the epidemiological index of the species, as well as evaluate the receptivity of an area, and consequently its level of vulnerability. For the species of the genus, entomological research makes it possible to evaluate the potential for malaria, indicating the time it is most necessary to take counteraction measures, which may be isolated or coordinated, depending on environmental conditions.

Within the context of Brazil, the State of Rondônia is distinguished by a high incidence of malaria, and a comparison of the indices for 1977 and 1985 shows that the population of the State increased by 366%, while the incidence of malaria increased by 449%. On the other hand, if municipalities are considered in isolation, some show a reduction in malaria rate. In the Machadinho Project, for example (Municipality of Ariquemes), the frequency of malaria from **P. falciparum** decreased by about 20% from the previous year, since only 29% of cases were recorded in the first half of 1987, in relation to 12,994 verified in 1986. There was an increase in incidence of **P. vivax** as the expected index of 50% materialized at 67.8% in the first half of 1987. Apart from the Machadinho Project, other locations in the State can be cited to show variations in the prevalence of malaria from **P. falciparum** and **P. vivax** as a function of population size.

Thus, studies of **Anopheles** species are of fundamental importance, when conducted in furtherance of control campaigns. Behavioral patterns as well as adaptation conditions become important parameters for the interrelationships which they present as the means to be adopted in reducing man/vector contact.

The entomological research data for **Anopheles** species conducted in the urban zone of Ariquemes contribute a knowledge of the specific diversity as well as of the extent of occurrence of **A. darlingi** and of other anopheline species in the city and also information on biological aspects of the species which is important in control strategies.

Taking the **A. darlingi** occurrence, we see that it was recorded throughout the periphery of the city, with points of greater or lesser penetration, depending on the sector contemplated. Figure 5, the delimited area shows those points which were positive for occurrence of **A. darlingi**, indicating the sectors of greater malaria risk. Based on the positive and negative points, the area where the vector has been recorded was laid out, making it possible to gauge the extent of penetration into the city for the various sectors. Even so, the lines plotted do not reflect a fixed, immutable area; the dimensions vary with the anopheles population fluctuations at the periphery, which are subject to environmental fluctuations and seasonal variations. The area laid out can be considered to be a maximum expression of the occurrence of anophelines in the urban area for the period of the samplings. The mosquitos per man/hour indices demonstrate that exposure is markedly greater at the peripheral points than those of the interior.

Thus, based on the delimitations shown on Figure 5, we can put together the following classification of the malaria risk in the city of Ariquemes: Sectors 1 and 3 - malaria-free areas; Sectors 2 and 4 - areas of risk at the periphery; Industrial Area and Special Areas Sector, the BNH Complex, Sector 5 and Old Town - areas of high malaria risk. These same sectors were identified by the preliminary TADEI[36] report on occurrence of anophelines in the Municipality of Ariquemes.

The sectors of greater risk, that is, the Industrial Area and Special Areas Sector, the BNH complex and Sector 5, are so classified on the basis of the results of entomological research which revealed the importance of the banks of the Nações in the breeding cycle of the anophelines. The proximity of these sectors to the stream banks and the adjoining vestiges of primary growth jungle which border the city at this point (Figures 2 and 7) make them particularly susceptible to anopheline migration for the blood meal. As shown in the entomological study for immature forms, the banks present a high incidence of anophelines, chiefly **A. darlingi** (Tables 5, 8 and 9), which indicate the area to be the point of development of the immature forms of the **Anopheles** species until emergence of the imago.

Since there are no other water deposits in the vicinity of the three sectors for reproduction of the species, it has been established, on the basis of the entomological study, that the breeding cycle of the anophelines occurs as outlined below, and is reflected in the malaria transmission scheme in the urban area:

1. Primary growth - possibly used as shelter for the adults until occurrence of mating and for development of the gonotrophic cycle, following the blood meal. Natural shelter for the adults, following subsequent meals.
2. Banks of the Nações - Natural breeding ground for anopheles, providing sites for laying eggs and development of the larval stages up to emergence of the imago.
3. Human population of the city's periphery - Site of the blood meal (protein source) for the anopheline populations, chiefly **A. darlingi**, for development of the gonotrophic cycle.

Thus, the data from the entomological study make it possible to diagnose the breeding cycle of the anopheline populations in these locations, by identifying the points of a) adult habitation; b) development of immature forms and c) the protein source. A knowledge of these parameters is important in establishing malaria control measures, as it permits identification of the level(s) at which the measures will be most efficient in controlling the vector, that is: 1) the adult level, when still in the jungle, or after the blood meal; 2) the immature form level, while still in the larval stages; 3) the adult level, on man/vector contact, at the moment of the blood meal.

For malaria control in the urban area of Ariquemes, with the vector in the situation demonstrated by the data from the entomological study, it is important, first of all, to take individual protective measures (screens on the houses and mosquito netting), which have immediate effects in reducing the man/vector contact. At the same time, environmental management constitutes a basic measure because it involves altering the habitat to dislodge the **Anopheles** species from their breeding sites. As emphasized by TADEI[34, 36], in preliminary reports on urban malaria control in Ariquemes, measures of this type should reach or control the vector at all levels of the biological cycle.

In the area of individual protective measures, the literature provides evidence of their efficacy. TADEI et al[39] reported that in Vila Rasgão, constructed in 1925 for employees of Light Hydroelectric Company, malaria was eradicated by screening of the houses. The value of these individual measures is also borne out by analyzing the literature referring to construction of the Madeira-Mamoré Railroad and other projects in the Amazon region.

Malaria autocthony records reveal high indices for areas of **A. darlingi** penetration into the city. for the Industrial Area and Special Areas Sector, migration of the anophelines is facilitated by the bush remnants existing in the area, permitting migration as far as areas adjoining Sectors 1 and 3. This anopheline penetration area, stretching from the Nações banks denotes a migratory extension of the mosquito of about 2000 meters from the breeding ground (in this case, admitted to be the Nações banks). These data are in agreement with the literature, which records a flight radius for **A. darlingi** of approximately 2000 meters, which can be extended up to 5000 meters with favorable winds[12, 41].

Bearing in mind the migration of the vector, it is possible to correlate the physical structure of the Ariquemes urban area with its implications for malaria transmission. As can be seen in Figure 1, which shows the layout of the city in detail, the alamedas form a green area of vegetation, which may have had its influence on urban malaria incidence when the city was founded in 1976. Figure 8 (a recent aerial photograph) shows the alamedas as they are today, and it can be seen that they are now practically deforested, with sparse bushes and creeping ground cover consisting generally of grasses. But, when the city was established, the Sector 1 alamedas presented primary growth, constituting a continuous extension of the jungle around the city. This situation

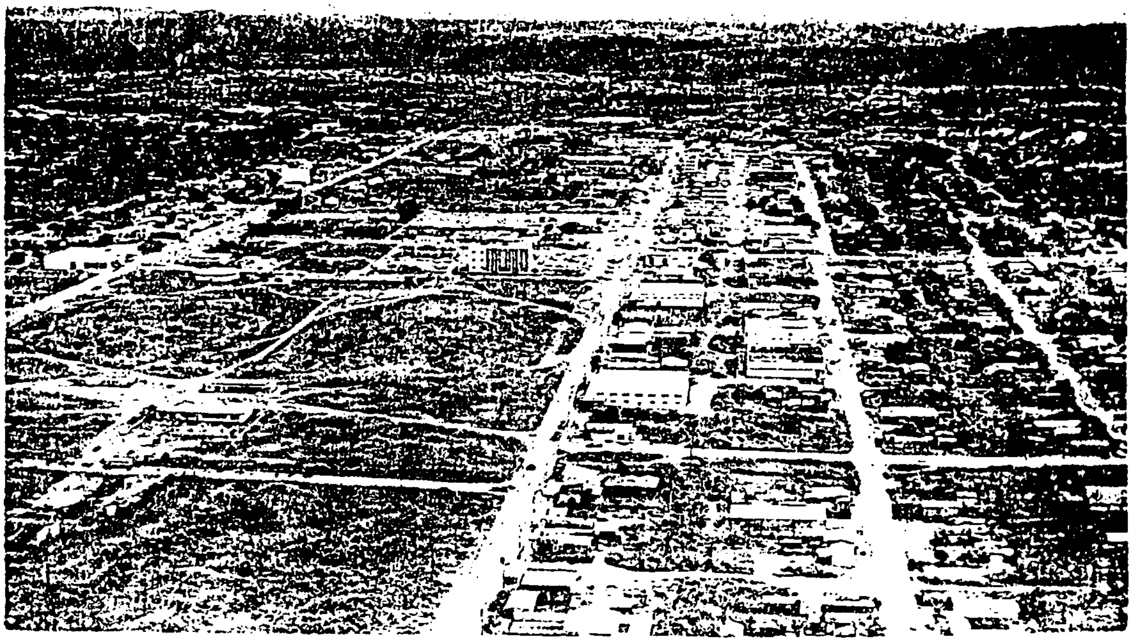

Fig. 8. City of Ariquemes - current view of the alamedas

(primary growth in the alamedas and primary growth surrounding) extending continuously into the city, facilitated migration of the anophelines to human/vector contact, thus contributing to a high autocthony of urban malaria. Also, as the houses were constructed with their porches, living rooms, bedrooms facing on the alamedas, the arrangement provided even greater contact with the growth, and consequently, with the anophelines. These factors were aggravated by a high prevalence of urban malaria in Ariquemes when the city was founded.

Anopheles darlingi has an extensive flight radius and the periphery of the city has relatively high densities of vector population, apart from being in contact with the jungle (Figure 7), which offers elements facilitating migration of the vector. Under these conditions, in order to reduce the prevalence of urban malaria, there is a pressing need to adopt measures aimed at reducing the population density of anophelines at the periphery, so as to contain the migratory process into these critical areas. Control of the nearby breeding grounds is a fundamental measure in containing density, employng environmental management to alter the natural habitat of reproduction, biological control and, as a last resource, utilization of larvicides.

For control of the migratory process and human/vector contact, we stress the importance of a protective belt between the urban area and the surrounding jungle, as proposed by TADEI et al[39] for the Tucuruí Hydroelectric residential area, which also presented **A. darlingi** at the periphery. This belt would be constituted by sparse vegetation, consisting of large trees and bushes; this area, depending on soil conditions, could have small pasture areas. These take on importance as biological protection for the residential areas, by providing an alternate source for the hematophagous activity of the anophelines, encouraging development of zoophilia.

This protective area around Ariquemes could oscillate between 1000 and 1500 meters, following the guidelines set forth by TADEI et al[39], based on observance of **A. darlingi** behavior at study points on BR-174 (Manaus/Boa Vista). The authors describe how the security band described above might be sufficient to isolate the human population from contact with the anopheline populations at the periphery, bearing in mind the vector migratory estimates verified along that highway.

Among the measures for control of the subgenus **Kerteszia**, in the southeastern region of the country, for malaria endemic regions, an area of protection around the population centers has also been suggested[11]. As these species reproduce in the growing areas of the bromeliaceae, in this area, such plants would be eliminated, with manual removal of the epiphytic and terrestrial species; employment of herbicides was also indicated[16].

Viewing the Amazon region as a whole, it is possible to detect innumerable areas with characteristics similar to the area of the Municipality of Ariquemes, where environmental conditions are extremely favorable for development of **A. darlingi** populations in high density. This being the case, the foregoing conditions might be taken as a model for the Amazon region in installation of urban centers. These should always be surrounded by an area of protection aimed at isolating the peripheral human population from contact with the vector. As the cities grow this protective belt would be expanded outward to keep pace with the urban area.

Along the same lines, for exploration of the rural area, the same premises would hold true, that is, dwellings would be sited on the highest ground, at the greatest possible distance from standing water concentrations, which, in those regions, are the natural breeding ground for the anophelines. Location on the highest ground makes for being as far as possible from the reproduction sites, diminishing the probability of human/vector contact.

Residences near breeding grounds show a much greater anopheline density than those situated at the points most elevated and remote from the breeding grounds. Apart from this aspect, it is important to explore the area to be used for agriculture and/or stockraising diametrically opposite the habitation and in concentric circles around it. Adoption of this procedure generates a natural protective band around the rural area residence, which expands outward in a circle. This band is expanded if the points of contact of residential lots are nearby and occupy the exploration center.

An aspect to be emphasized in urban conditions based on the areas shown in Figure 5, is the protective band which can be laid out for DDT application. Since the data of the entomological study were obtained in both winter and summer, thereby covering the periods of greater and lesser anopheline population density, the band can be limited to the peripheral areas, application of DDT being unnecessary in Sectors 1 and 3 and part of 2 and 4. These areas, occupying the central urban position, constitute anopheline-free areas, where the insecticide is not needed. The remainder of the city and vicinity, where the anophelines are concentrated, must continue to be subjected to the normal scheme of biannual applications. This is especially true of the Industrial Area and Special Areas Sector, the BNH Complex, Sector 5 and Old Town, which present a high risk.

The data on population density of the anophelines, obtained at different times of the year (Tables 7 and 9), show a variation, both in the winged adults and in the immature forms. Observation of the results has made it possible to verify that there is a correlation between population density reduction and the winter season. This correlation is more evident for the winged forms than the immature; for the latter, the data reveal a certain stability when we consider the total species. At the beginning of winter, population density was already in evidence by December 1984. These results are in accordance with the fact that, in tropical regions, mosquito population density variations correlated with seasonal changes, can be affected by nonavailability of reproduction sites, which are in direct relation to the precipitation system pattern (among others [21, 30, 33, 40, 42]). Data on the behavior of anopheline populations of the region show that during the winter, the reproduction sites are relocated from the permanent breeding grounds in lakes and ponds near the banks of the rivers and in the riverbeds themselves, to temporary breeding grounds inside the jungle, made up of the innumerable puddles and pools that form there during this period.

Availability of the reproduction sites mentioned above, which increases in early winter broadens the occurrence area of anophelines, with repercussions in malaria prevalence, since this provides increased man/vector contact. This derives from the fact that in regions where the permanent breeding grounds are remote from residential areas, the wintertime formation of temporary breeding sites places the vector in position to influence the nearby habitations. This aspect of broadening the anopheline occurrence area during the winter, especially for **A. darlingi**, was emphasized by GALVÃO[22] in studies conducted in the city of Belém (Pará), and discussed by DEANE[15] for other Amazon locations. From the data obtained at Ariquemes, we can establish a reduction in larval density during the winter, which commences later with respect to the adult density, in overall terms. However, when frequency of the individual species is examined (Table 9), we find that **A. darlingi** and **A. triannulatus** display an opposite behavioral pattern. The latter shows a reduction starting in August 1984, and adults were captured only in the first samplings. But for **A. darlingi** the data on winged insects showed a continuous reduction from August 1984, while the larva, for the same period showed an increase, reaching its peak in November 1984, the incidence dropping off thereafter. As the collection station is near the Nações banks, these results can be interpreted in the light of the biannual DDT applications carried out at the beginning of the period. It is probably that while there is a high density of anophelines at the beginning of the six-month period (August 1984), only a small number of the females manage to complete the reproductive cycle after feeding. This number later grows, with reduced pressure from the insecticide, which is gradually thinned away from walls and vegetation over the six-month period. In this scheme, a greater number of females are probably able to get to the breeding ground and leave descendants following the blood meal. On the other hand, a higher density of larvae in November, for a corresponding reduction in winged insects can be understood to be the result of the effects of winter precipitation, which impedes travel of the adults for the blood meal. Starting with this period, the density is low in both forms, owing to the environmental alterations provoked by the winter season.

Also in relation to broadening of the reproduction sites during the rainy season, data on the genetic structure of the natural **A. darlingi** populations of the Amazon region, obtained on the basis of chromosomal polymorphism analysis show that the species is more polymorphic during this period. These results were interpreted to be an adaptative strategy of the species, which gives it a greater adaptative plasticity, making it more apt to explore the different environments offered by the winter season[40]. In the Amazon region, then, for natural populations of **A. Darlingi**, modifications are to be expected in the population density of the species, correlated with winter and summer seasonal changes. MORAN[42] notes that in tropical rain forests, animal populations undergo changes in structure and size in response to seasonal changes. On the other hand, WOLDA & GALINDO[42] report population density modifications in areas which apparently have no pronounced seasonal changes.

The results on biting activity refer to collections with six hours of observation, conducted at points of Sectors 2 and 3 and Old Town (Table 3), and with twelve hours at peripheral points of the city - gurgel, Boa Vista Plantation and the INCRA Reservoir (Table 4). It was established, for the six-hour points located in the most central area of the city, that the activity fell off around 9:00 - 10:00 P.M., with no anophelines being collected during the 10:00 - 11:00 and 11:00 - 12:00 time frames. Considering the species with frequencies of above 1% - **A. darlingi, A. triannulatus, A. oswaldoi, A. mediopunctatus** and **A. evansae** - it was noted that, except for the next to last, these species showed greatest biting activity in the first hour of observation (6:00 to 7:00 P.M.). The data for the peripheral points, however, showed that **A. darlingi** remained active throughout the night, with a peak at the beginning, between 6:00 and 10:00 P.M., and another, less intense, between 4:00 and 6:00 in the morning. the other species were recorded only in the first hours of collection, but **A. oswaldoi** and **A. triannulatus** were also collected at dawn. These results agree with the pattern observed by TADEI et al.[39] for the **Anopheles** species of the Tucuruí region, but in that region, the early night activity was most frequent during the second hour of observation (7:00 - 8:00 P.M.). Considering **A. darlingi**, it showed a bimodal pattern, with continual activity, which was recorded for populations of different geographical origin in the Amazon region[5, 6, 15, 32, 39, 41].

On the other hand, **Anopheles** species can be characterized by their biting activity pattern under continuous observation[17, 26, 39]. This pattern is in relation to the circadian rhythm, but it can be affected by genetic and environmental factors; in extreme cases, the latter can impede this activity in spite of the indication of the circadian rhythm[1, 4, 13, 38]. Also, in species polymorphic for chromosomal inversions, variations can be seen in carriers of different genetic constitutions. This phenomenon has been recorded in different species of **Anopheles**, in relation to the circadian rhythm, frequency of cross-breeding, period of pupation and emergence of the imago, and in observation of specific gene adjustments to variations relating to exophilia and endophilia[7, 8, 9, 10, 23, 24, 25].

While there are multiple factors which interfere in the biting activity behavioral pattern of the anopheline species, as we have discussed, this pattern in the Amazon region can be characterized in the light of 1) the natural environment and 2) the ecologically altered areas of the region. In the first case, it is established that the behavioral pattern of the species for biting activity shows a continuous spectrum of activity which extends through the day or through the night, and often shows an activity peak at nightfall and another, of lower intensity, at dawn. This pattern is recorded in the jungle or in areas close to the breeding grounds. The pattern is also seen in dwellings located at the edge of the primary growth, as well as when the dwelling is near standing water related to either primary or secondary growth. Also, in the winter this continuous activity can be seen in areas where only nocturnal, not diurnal activity is normally recorded. This derives from the fact that during this period, with dispersion of the anopheline reproduction sites, these areas come into close association with the breeding grounds that branched out more generally from the permanent ones of the summer.

Ecologically altered areas can be broken down into two categories: areas with established modifications and recently altered areas. These two situations can be found in the regions of the huge Amazon Colonization Projects. The established areas are those which were earlier colonized, and have become stabilized for agriculture and stockraising. The recently altered areas are those still under development, the modification of which is in progress, with deforestation and occupation of the new lands. In these two categories, different biting activity behavioral patterns can be detected in the species of **Anopheles**. Since the settlements are located off the highways and in the vicinity of the projects, an area is cleared between the access road and the primary growth, often varying between 500 and 1000 meters. The living quarters are constructed near the highway. This arrangement, in areas of anopheline occurrence, especially **A. darlingi**, creates a situation in which a portion of the anopheline population migrates in the direction of the residence to obtain human blood. After the blood meal, the process of returning to the jungle and/or breeding ground is initiated, for development of the gonotrophic cycle and oviposition. In areas of recent deforestation and in cases where the residence is still very close to the jungle, a diurnal and nocturnal pattern is seen. As the terrain becomes more occupied, the diurnal activity is proportionately reduced. As a function of the rate of occupation and distance of house from jungle, the activity becomes limited to the night alone. In areas which have been established for 3-5 years, where the residence-jungle distance is about 500-800 meters, it can be seen that activity is restricted to the nocturnal period, with the greatest intensity at twilight. In the wintertime this pattern undergoes modifications due to the innumerable temporary breeding grounds that are formed in and around the jungle, altering the residence/primary growth isolation. The continuous activity pattern, that is, the presence of anophelines throughout the night, will depend on the population density, interrelated with the residence/jungle distance, since the latter will lead to a greater exposure of anophelines at the time of feeding. Low population density often shows an activity pattern restricted to early evening, discontinuing between 8:00 and 9:00 P.M..

Considering the data on biting activity obtained at peripheral and internal points of the urban area of Ariquemes, it has been established that, within the described patterns, the internal points, with low densities of the mosquitoes (the lower range of mosquitoes/man/hour indices), are typical of the pattern of altered areas with low population density. As in the colonization areas, here the vector has farther to migrate, and fewer of them reach the internal sectors, and the pattern is limited to the early evening hours. For the peripheral points, activity continued through the night, showing a pattern in which the residence is in association with the primary growth and/or breeding ground. In fact, the locations where readings were obtained all night long represented residences located near the Nações banks, adjoining a vestigial primary growth. Under these conditions, a continuous pattern is to be expected, as described and, in the winter, even the return of daytime activity, due to the increase in vector population density. This pattern was not observed systematically in this study, but daytime anopheline activity was noted at the observation points in these locations.

The literature on malaria vector anopheline species of the Amazon region (among others[11, 14, 15, 19, 20, 27, 31]) has been built on data obtained by the usual method of dissection for investigation of oocysts and sporozoites. From these data, a variety of species have been identified as vectors. **Anopheles darlingi** is mentioned as the principal one, responsible for transmission in the interior and 4/5 of the entire country[19]. Data from Ariquemes, also obtained by dissection, permits us to cite **A. darlingi** as a transmitter in that city. As shown on Table 12, an infection level of 1% was detected, by the presence of both sporozoites and oocysts. An interesting aspect to be highlighted from these results is that the infection rate is highest (3%) during the 8:00 - 9:00 P.M. time frame. This parameter might lead to debate on the [etaría - no reference] structure of the natural populations of **Anopheles**, the preliminary data of which have evidenced a greater frequency of femenuliparous specimens in the early hours and omniparous ones in the later periods. In this case, the latter would be of greater epidemiological importance considering the greater likelihood of being infected, from having experienced a series of meals.

Also in relation to the infection, **A. darlingi** can also be mentioned as a vector in those autocthonous areas where the samples were obtained, by the fact that it is frequently the only species in contact with man. Nevertheless, other species cannot be ruled out as transmitters in Ariquemes. ARRUDA et al[2] report that in Pará, species other than **A. darlingi** were found to be infected (**A. nuñez tocari, A, triannulatus, A. albitarsis** and **A. oswaldoi**) through radioimmunoassay tests and immunoenzymatic tests, with monoclonal antibodies (IRMA and ELISA). Recent studies conducted on line C90 of the "Burareiro" Settlement Center, by means of immunoenzymatic tests (ELISA), **Plasmonium vivax** infection was recorded for **A. strodei, A. nuñez tovari, A. triannulatus, A. galvaoi** and **A. peryassui.** Infection by the two species of **Plasmodium** was recorded only for **A. darlingi** (TADEI et al[37], preliminary report). The data were discussed considering considering the malaria cases in the location, the anopheline population density and the incidence of species biting man and animals. These results reveal a high index of infection for **A. galvoi** and the density studies show a greater contact of the species with man for the period of greater infection. It was also verified that there is a residual fraction of the **A. darlingi** population in contact with man during the periods of low density, and the hypothesis was advanced that this fraction is related to the continued transmission of malaria. Based on these results, it is possible that other species are involved in transmission in Ariquemes.

NUMBERING KEY FOR SPECIES USED IN TABLES 5 to 9

1	Anopheles darlingi	9	Anopheles benarrochi
2	Anopheles triannulatus	10	Anopheles nuñez-tovari
3	Anopheles galvaoi	11	Anopheles oswaldoi
4	Anopheles peryassui	12	Anopheles albitarsis
5	Anopheles rangeli	13	Anopheles braziliensis
6	Anopheles argyritarsis	14	Anopheles mattogrossensis
7	Anopheles mediopunctatus	15	Anopheles strodei
8	Anopheles evansae		

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REFERENCES

1
ALVERSON, D.R. & NOBLET, R. - Response of female black flies to selected meteorological factors. **Environ. Ent., 5:** 662-665, 1976.

2
ARRUDA, M.; CARVALHO, M.B.; NUSSENZWEIG, R.s.; MARACIC, M.; FERREIRA, A.W. & COCHRANE, A.H. - Potential vectors of malaria and their different susceptibility toi **Plasmodium falciparum** and **Plasmonium vivax** in northern Brazil identified by immunoassay. **Amer.J.trop.Med.Hyg., 35:** 873-881, 1986.

3
BOYD, M.F. Epidemiology of malaria: factors related to the intermediate host. IN: BOYD, M.F., ed. - **Malariology.** Philadelphia, W.B. Saunders, 1949, V. 1, p 551-607.

4
BRADY, J. - Circadian changes in central excitability - the origin of behavioural rhythms in tsetse flies and other animals? **J.Ent.(Ser. A), 50:** 79-95, 1975.

5
CHARLWOOD, J.D. & HAYES, J. - Variações geográficas no ciclo de picada do **Anopheles darlingi** Root no Brasil. Geographical variations in the biting cycle of the Root **Anopheles darlingi** in Brazil. **Acta amaz. (Manaus), 8:** 601-603, 1978.

6
CHARLWOOD, J.D. & WILKES, T.J. - Studies on the age-composition of samples of Root **Anopheles darlingi** (Diptera: Culicidae) in Brazil. **Bull. ent. Res., 69:** 337-342, 1979.

7
COLUZZI, M. - Inversion polymorphism and adult emergence in **Anopheles stephensi. Science, 176:** 59-60, 1972.

8
COLUZZI, M. ; SABATINI, A.; PETRARCA, V & DI DECO, M.A. - Polimorfismo cromosomico e Lunghezza dell'uovo in **Anopheles stephensi.** Chromosomal polymorphism and length of the egg in **Anopheles stephensi. Parassitologia, 14:** 18-21, 1972

9
COLUZZI, M.; DI DECO, M. & CANCRINI, G. - Ulteriori osservazioni sulla lunghezza dell'uovo in **Anopheles stephensi** in relaziore al polimorfismo cromosomico. Further observations on the length of the egg in **Anopheles stephensi** in relation to chromosomal polymorphism. **Parassitologia, 16:** 107, 1974.

10
COLUZZI, M.; SABATINI, A.; PETRARCA, V. & DI DECO, M.A. - Chromosomal differentiation and adaptation to human environments in the **Anopheles gambie complex. Trans. roy. Soc. trop. Med. Hyg., 73:** 483-497, 1979.

11
COUTINHO, J.O. - **Contribuição para o conhecimento das espécies do subgênero Kertszia (Diptera-Culicidae): sua importância na transmissão da malária. Contribution toward understanding of the species of the Kertszia subgenus (Diptera-Culicidae): its importance in transmission of malaria.** São Paulo, 1946. (Doctoral Thesis - University of São Palo Medical School).

12
COVA-GARCIA, P. - Notas sobre los anofelinos de Venezuela y su identificación. Notes on the Venezuelan anofelines and their identification. Caracas, Editora Grafos, 1961.

13
DALMAT, H.T. - The black flies (Diptera: Simulidae) of Guatemala and their role as vectors of onchocerciasis. **Smithsonian Miscellaneous Collections, 125**(1): 1-425, 1955.

14
DEANE, L.M. - Observações sobre a malaria na Amazônia Brasileira. Observations on malaria in the Brazilian Amazon Region. **Rev. Serv. Saúde públ. (Rio de J.), 1:** 3-60, 1947.

15
DEANE, L.M.; CAUSEY. O.R. & DEANE, M.P. - Notas sobre a distribuição e a biologia dos anofelinos das regiões Nordestina e Amazônica do Brasil. Notes on the distribution and biology of the anophelines of the Northeastern and Amazon regions of Brazil. **Rev. Serv. Saúde públ. (Rio de J.), 1:** 827-965, 1948.

16
DOWNS, W.G. & PITTENDRIGH, C.S. - Bromelia Malaria in Trinidad, British West Indies. **Amer. J. trop. Med., 26:** 47-66, 1946.

17
ELLIOT, R. The influence of vector behaviour on malaria transmission. **Amer. J. Trop. Med. Hyg., 21:** 755-763, 1972.

18
FARAN, M.E. & LINTHICUM, K.J. - A handbook of the Amazonian species of **Anopheles (Nyssorhynchus)** (Diptera, Culicidae). **Mosquito Systematics, 13:** 1-81, 1981.

19
FERREIRA, E. - Distribuição geográfica dos anofelinos no Brasil e sua relação com o estudo atual da erradicação da malária. Geographical distribution of anophelines in Brazil and its relation to the present study of malaria eradication. **Rev. bras. Malar., 16:** 329-348, 1964.

20
FORATTINI, O.P. - **Entomologia médica.** Volume 1: Parte geral, **Diptera, Anophelini. Medical entomology.** Volume 1: General Section, **Diptera, Anophelines.** São Paulo, Faculdade de Higiene e Saúde Pública, 1962.

21
GALINDO, P.; TRAPIDO, H.; CARPENTER, S.J. & BLANTON, F.S. - The abundance cycles of arboreal mosquitoes during six years at a sylvan yellow fever locale in Panama. **Ann. ent. Soc. America, 49:** 543-547, 1956.

22
GALVÃO, A.L.A.; DAMASCENO, R.G. & MARQUES, A.P. - Algumas observações sobre a biologia dos anofelinos de importância epidemiológica de Belém, Pará. Some observations on epidemiologically important anopheline biology in Belém, Pará. **Arch. Hig. (Rio de J.), 12:** 51-111, 1942.

23
JONES, M.D.R. - Inversion polymorphism and circadian flight activity in the mosquito **Anopheles stephensi** List. (Diptera Culicidae). **Bull. ent. Res., 64:** 305-311, 1974.

24
JONES, M.D.R.; HILL, m. & HOPE, A.M. - The circadian flight activity of the mosquito **Anopheles gambiae:** phase setting by the light regime. **J. exp. Biol. 47:** 503-511, 1967.

25
JONES, M.D.R.; CUBBIN, C.M. & MARSH, D.- The circadian rhythm of flight activity of the mosquito **Anopheles gambiae:** the light response rhythm. **J. exp. Biol., 57:** 337-346, 1972.

26
LACEY, L.A. & CHARLWOOD, J.D. - On the biting activities of some anthropophilic Amazonian Simuliidae (Diptera). **Bull. ent. Res., 70:** 495-509, 1980.

27
LANE, J. - **Neotropical Culicidae.** Volume 1: **Dixinae, Chaoborinae** and **Culinae,** tribes **Anophelini, Toxorhynchitini** and **Culicini** (genus **Culex** only). São Paulo, University of São Paulo, 1953.

28
MACGREGOR, M.E. - **Mosquito Surveys.** London, Baillère, Tindall and Cox, 1927.

29
MEIRA, D.A.; PITA, H.J. & BARRAVIERA, B - Malária no municipio de Humaitá, Estado do Amazonas. 1. Alguns aspectos epidemiológicos e clinicos. Malaria in the municipality of Humaitá, State of Amazonas. 1. Some epidemiological and clinical aspects.**Rev. Inst. trop. S. Paulo, 22:** 124-134, 1980.

30
MORAN, E.F.- **Developing the Amazon,** Bloomington, Indiana University Press, 1981.

31
RACHOU, R.G. - Anofelinos do Brasil: comportamento das espécies vetoras de malária. Anophelines of Brazil: behavior of malaria vector species. **Rev. bras. Malar., 10:** 145-181, 1958.

32
ROBERTS, D.R.; HOCH, A.L.; PETERSON, N.E. 7 PINHEIRO, F.P. - Programa multidisciplinario de vigilancia de las enfermedades infecciosas en zonas colindantes con la carretera transamazónica en Brazil. IV. Estudio entomológico. Multidisciplinary monitoring program of infectious diseases in zones bordering the trans-Amazon highway in Brazil. IV. Entomological Study.

33
STANDFAST, H.A. & BARROW, G.J. - Studies on the epidemiology of arthropod-borne virus infections at Mitchell River Mission, Cape York Peninsula, North Queensland. I. Mosquito collections, 1963-1966. **Trans. roy. Soc. trop. Med. Hyg., 62:** 418-429, 1968.

34
TADEI, W.P. - Dinâmica da transmissão da malária humana na zona urbana da cidade de Ariquemes (Rondônia). **Ciênc. e Cult., 37:** 65, 1985.

35
TADEI, W.P. - Biologia de anofelinos amazônicos. X. Ocorrência de espécies de **Anopheles** nas áreas de imfluência das Hidrelétricas de Tucuruí (Pará) e Balbina (Amazonas). Biology of Amazon anophelines. X. Occurrence of **Anopheles** species in the areas of influence of the hydroelectric installations of Tucuruí (Pará) and Balbinas (Amazonas). **Rev. bras. Engenh., 1(4):** 71-78, 1986.

36
TADEI, W.P. - Biologia de anofelinos amazônicos. XI. Estudos em populações de **Anopheles** e controle da malária em Ariquemes (Rondônia). Biology of Amazon anophelines. XI. Studies of **Anopheles** populations and malaria control in Ariquemes (Rondônia). **Acta** amaz. (Manaus) **18** (Suplemento Polonoroeste), 1988a.

37
TADEI, W.P.; CARVALHO, M.B.; SANTOS, J.B.M.F.; FERREIRA, A.W. 7 NUSSENWEIG, R.S. - Dinâmica da transmissão da malária em Rondônia e suscetibilidade das espécies de **Anopheles** aos **Plasmodium vivax** e **Plasmodium falciparum**, identificada por teste imunoenzimático. In: CONGRESSO DA SOCIEDADE BRASILEIRA DE MEDICINA TROPICAL. Dynamics of malaria transmission in Rondônia and susceptibility of **Anopheles** species to **Plasmodium vivax** and **Plasmodium falciparum**, identified by immuno-enzymatic test. In: CONGRESS OF THE BRAZILIAN TROPICAL MEDICINE SOCIETY, 24, Manaues, 1988. **Programa e resumos.** Manaus, 1988, p. 26, res. No. 019.

38
TADEI, W.P. & CORREIA, J.M. - Biologia de anofelinos amazônicos. IV. - Observações sobre a atividade de picar de **Anopheles nuñez-tovari** Gabaldón (Diptera, Culicidae). Biology of Amazon anophelines. IV. - Observations on biting activity of **Anopheles nuñez-tovari** Gabaldón (Diptera, Culicidae). **Acta amaz. (Manaus), 12:** 71-74, 1982.

39
TADEI, W.P.; MASCARENHAS, B.M. 7 PODESTÁ, M.G. - Biologia de anofelinos amazônicos. VIII, Conhe mentos sobre a distribução de espécies de **Anopheles** na região de Tucuruí - Marabá (Pará). Biology of Amazon anophelines. VIII. Information on distribution of **Anopheles** species in the region of Tucuruí - Marabá (Pará). **Acta amaz. (Manaus), 13:** 103-140, 1983.

40
TADEI, W.P. & SANTOS, J.M.M. - Biologia de anofelinos amazônicos. VII. Estudo da variação de freqüências das inversões cromossômicas de **Anopheles darlingi** Root (Diptera, Culicidae). Biology of Amazon anophelines. VII. Study of frequency variation of chromosomal inversions of **Anopheles darlingi** Root (Diptera, Culicidae). **Acta amaz. (Manaus), 12:** 759-785, 1982.

41
VAN THIEL, P.H. - Malaria problems arising from the construction of a reservoir in the interior of Surinam. **Trop. geogr. Med. 14:** 259-278, 1962.

42
WOLDA, H. 7 GALINDO, P. - Population fluctuations of mosquitoes in the non-seasonal Tropics. **Ecol. Ent. 6:** 99-106, 1981.