



Ecology

Entomological profile and new registers of the genera *Anopheles* (Diptera, Culicidae) in a Brazilian rural community of the District of Coxipó do Ouro, Cuiabá, Mato Grosso

Adaiane Catarina Marcondes Jacobina¹, Jozeilton Dantas Bandeira², Fábio Alexandre Leal dos Santos^{1,2}, Elisângela Santana de Oliveira Dantas^{1,3} & Diniz Pereira Leite-Jr^{1,2,4}✉

1. Universidade Federal de Mato Grosso – UFMT, Cuiabá-MT - Brasil. 2. Centro Universitário de Várzea Grande - UNIVAG, Várzea Grande-MT - Brasil. 3. Instituto de Bociências - Universidade do Estado de São Paulo “Júlio de Mesquita Filho” - UNESP - Rio Claro - Brasil. 4. Universidade de São Paulo, USP – São Paulo, SP - Brasil.

EntomoBrasilis 13: e0848 (2020)

Edited by:

William Costa Rodrigues

Article History:

Received: 16.iv.2019

Accepted: 16.iv.2020

Published: 06.v.2020

✉ Corresponding author:

Diniz Pereira Leite-Jr

✉ djbiologico@gmail.com

ORCID orcid.org/0000-0002-5934-8613

Funding agencies:

FAPEMAT

Abstract. The order Diptera is constituted of insects that possess numerous varieties of habitats, these winged, commonly called mosquitoes, comprise a monophyletic group. Malaria transmitters in Brazil are represented by mosquitoes of the *Anopheles* genus, being its principal vector species *Anopheles (Nyssorhynchus) darlingi* Root. Collectings were accomplished in the rural area of Cuiabá in the region of Coxipó do Ouro/MT, and a total 4,773 adult mosquitoes of the genus *Anopheles* were obtained. The prevailing species in the collectings where *An. (Nys.) darlingi* with 3,905 (81.8%), considered the vector of major epidemiological expression in the region, followed by *Anopheles (Nyssorhynchus) argyritarsis* (Robineau-Desvoidy) 267 (5.6%) and *Anopheles (Nyssorhynchus) triannulatus* (Neiva & Pinto) 226 (4.7%). This report might be useful to entomological surveillance, demonstrating that the Coxipó do Ouro/MT locality might be elected as an area to be monitored, once the presence of such vector in this type of environment indicates a potential malaria transmission risk for the neighbouring regions in the state of Mato Grosso.

Keywords: *Anopheles darlingi*; Culicidae; Malaria; Mosquito; Tropical Medicine.

The order Diptera is constituted of insects that possess numerous varieties of habitats, these winged, commonly called mosquitoes or stilt, comprise a monophyletic group (REIDENBACH 2009); belong to the order Diptera, suborder Nematocera, suborder Culicomorpha and family Culicidae, which is divided into two subfamilies, Culicinae and Anophelinae. The Culicinae are recognized 11 tribes, with 110 genera and approximately 3,570 species described (HARBACH 2020).

The subfamily Anophelinae has three genera and includes 489 species formally described and constituted by species of the genus *Bironella*, present only in the Australian region, *Chagasia*, restricted to the neotropical region, and *Anopheles*, cosmopolitan, presenting 476 species formally described and named eight subgenres; *Anopheles* (185 species), *Baimaia* (1), *Myzomia* (= *Cellia*) (225), *Christya* (2), *Kerteszia* (12), *Lophopodomyia* (6), *Nyssorhynchus* (40) and *Stethomyia* (5) (HARBACH 2020). Of the three genera, the only one of major importance is the genus *Anopheles*, cosmopolitan mosquitoes responsible for malaria transmission (CONSOLI & OLIVEIRA 1994; COLLUCI & SALLUM 2006).

The geographic distribution of *Anopheles* is wide and can be found in several niches, from deserts to tropical forests (KISZEWSKI *et al.* 2004). Some species have considerable plasticity of adaptation to sites and different types of habitats

(JOHN 2008).

Mosquitoes of the genus *Anopheles* are arthropods responsible for the transmission of the etiologic agent of malaria. Five species of protozoa of the genus *Plasmodium* can cause human malaria: *Plasmodium falciparum* Welch, *Plasmodium vivax* Grassi & Feletti, *Plasmodium malariae* Feletti & Grassi, *Plasmodium ovale* Stephens, and *Plasmodium knowlesi* Sinton e Mulligan. In Brazil, there are three species associated with malaria in humans: *P. vivax*, *P. falciparum* and *P. malariae*. *Plasmodium ovale* is restricted to certain regions of the African continent and to imported cases of malaria in Brazil. *Plasmodium knowlesi*, a monkey parasite that has been recorded in human cases, occurs only in Southeast Asia. Man is the main reservoir of epidemiological importance for human malaria (BRASIL 2017). The vectors of malaria in Brazil are popularly known as “carapanã”, “muriçoca”, “sovela”, “mosquito-nail” and “bicudo” (BRASIL 2017).

In Brazil, the subgenus of the Anophelines of medical importance are *Nyssorhynchus* and *Kerteszia*, and in the first subgenus is the species considered the main vector of *Anopheles (Nyssorhynchus) darlingi* (Root) malaria that is considered the vector of major epidemiological expression because it prefers feeding by human blood, and found in great abundance in environments domesticated by man (FORATTINI 2002; COLLUCI & SALLUM 2006), this mosquito is highly

anthropophilic and endophagic, stinging in and around the residences (BRASIL 2017).

Mato Grosso state, which is part of the endemic area, currently responsible for 1.0% of malaria cases (BRASIL 2011). The distribution of the cases of the disease presents a not homogeneous behavior and is especially concentrated the municipality of Colniza, considered medium risk and Nova Bandeirantes, considered low risk (MATO GROSSO 2016). Malaria control is based on early diagnosis, case management and vector control, and for the latter method it is necessary to know the behavior of the vector in the target locality (BRASIL 2017).

Even malaria suffering declining in number year by year still poses problems for the authorities by their difficult control. In the state of Mato Grosso, according to the state health department's survey, 216 cases were reported in the year 2016. In that same year, the five municipalities of Mato Grosso with the highest number of cases were: Colniza, Aripuanã, Juína, Brasnorte and Rondolândia (PARENTE *et al.* 2012).

Data from the World Health Organization (WHO 2013) indicate that malaria is the tropical infectious-contagious disease that causes most social and economic problems in the world, only outnumbered by AIDS deaths (PARENTE *et al.* 2012).

One of the major concerns regarding this vector is reproductive success in the face of anthropic environmental impact, human changes, such as human settlements, agriculture and indigenous peoples, miners and hydroelectric enterprise construction (HIWAT & BRETAS 2011).

It is essential to develop entomological studies that subsidize options in the adoption of control mechanisms that effectively reduce the rate of transmission and mortality caused by malaria.

The present study reports the occurrence of the anophelines fauna and behavior of the species that occur in the community of Coxipó do Ouro, Cuiabá district, seeking to understand the entomological link in the transmission of malaria in the municipality of Mato Grosso.

MATERIAL AND METHODS

Area of study. Sampling of specimens was performed, between January/2014 and November/2016, from 17:00 to

23:00 h, totaling six h of catch for three consecutive nights in each of the five months of each year (Table 1). A total of 4,773 winged adults female and 62 larvae were collected in rural areas of Cuiabá-MT in the community of Coxipó do Ouro 15°27'20.98" S; 55°58'35.22" W (Figure 1).

Mosquito collection. For the collections of adult females *Anophelines* specimens, two methods were used: Shannon trap and Method of capture by human attraction (Human Landing Catch method/HLC) as recommended by WHO (2013) and MARCONDES *et al.* (2007), where captors are fully protected and using black stockings of thick tissue covering the legs of the catchers so that the insect has difficulty performing blood repast, but is still attracted. Adult female mosquitoes were captured between 17:00 and 23:00 h.

The human bait collections were performed on three consecutive nights by four individuals working in teams of two in three-hour shifts, capturing *Anophelines* mosquitoes using the technique with "Castro's catcher" suction tube (MARCONDES *et al.* 2007; RIBEIRO *et al.* 2013).

After capture, the insects were stored in entomological pots of plastic containers of volume 500 mL, inserted with a maximum of 40 to 50 insects. The collected specimens were conditioned and fed with cotton soaked in sugar water (10%) and stored in polystyrene boxes, covered with a wet towel, thus avoiding the presence of predators and helping the survival of the captured insects.

For sampling of the immature *Anophelines* was used the method of shellfuls in the borders of the River Coxipó do gold being 50 shellfuls per month of sampling sampled totaling 750 shellfuls. The collected larvae were counted and identified with a Coleman optical microscope with a 100x magnification at the Entomology Laboratory of the Universidade Federal do Mato Grosso (Federal University of Mato Grosso). Identification was performed using the keys for classification of CONSOLI & OLIVEIRA (1994) and FORATTINI (2002).

Morphological identification of Diptera. The collected adult individuals were stored in appropriate containers, sorted, identified, assembled and preserved in the Entomology laboratory of the Universidade Federal do Mato Grosso (UFMT). The collected specimens were identified in the Medical Entomology Laboratory of the Faculty of Medicine of the Federal University of Mato Grosso in small

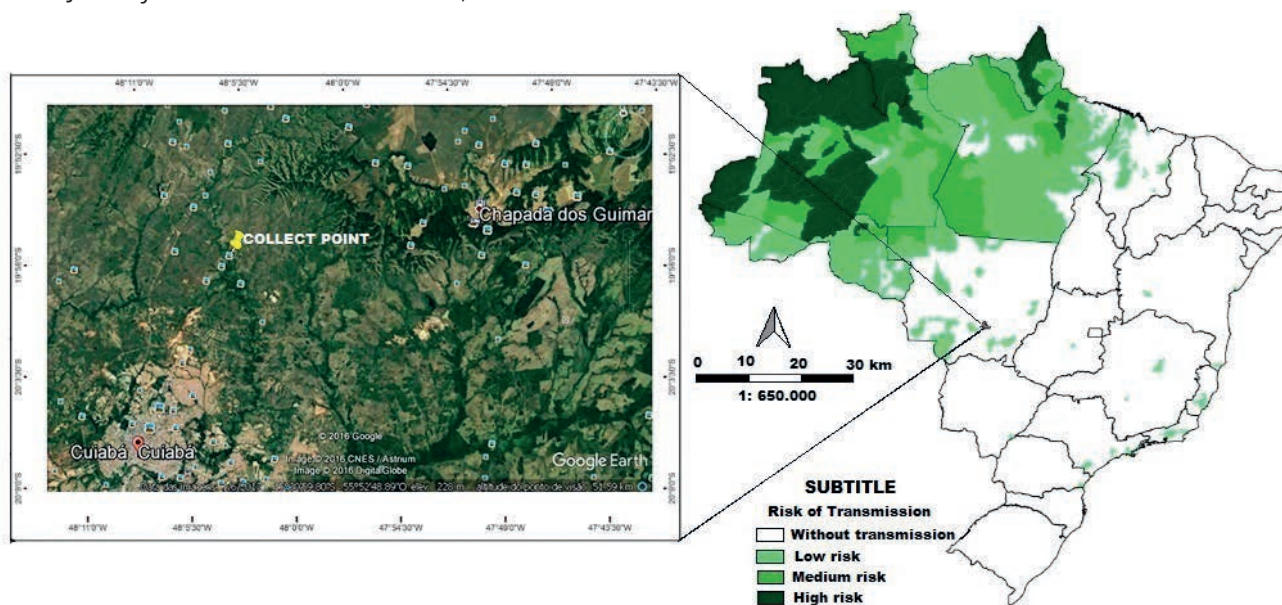


Figure 1. Location of the collection point in the region of the Coxipó do Ouro river, Mato Grosso, Brazil, from 2014 to 2016 (left). Risk map of Brazil by municipality of infection. Source: Sivep-Malaria and Sinan /SVS/MS/2017 (right).

groups (30 specimens), the mosquitoes adults female were killed in the freezer at -20°C for 5 min. Using microscope-40X stereoscope, for identification at the specific level using the taxonomic keys: ZAVORTINK (1927); DEANE *et al.* (1947); LANE (1953); FARAN & LINTHICUM (1981); CONSOLI & OLIVEIRA (1994); FORATTINI (2002).

RESULTS AND DISCUSSION

Mato Grosso is located in the Central West region of Brazil, and the biome is closed as a characteristic. The Cerrado is the second largest Brazilian and South American plant formation, and is considered the most biodiverse savanna formation in the world, surpassed only by the Amazon Forest. In Mato Grosso the area occupied by this biome is approximately 300,000 km², equivalent to 34% of the state territory. Due to its location, it shares specimens with most Brazilian biomes (Amazon Forest, Caatinga and Atlantic Forest) (BRASIL 2018). Characteristic of tropical regions, the Cerrado presents two well-defined seasons: rainy summer and dry winter (DANTAS *et al.* 2016).

Fifteen campaigns were carried out for collecting adults and larvae, during the period studied (2014, 2015, 2016) there were a total of 750 shellfuls to obtain immature specimens. From this technique, 62 were positive for Anophelines larvae, 20 larvae of the species *An. argyritarsis* were identified, and the others only at the generic level.

A total of 4,773 adult females of the genus *Anopheles* were collected from January 2014 to November 2016, representing seven morphospecies: *Anopheles (Nyssorhynchus) darlingi* (Root) 3,905 (81,8%), *Anopheles (Nyssorhynchus) argyritarsis* (Robineau-Desvoidy) 267 (5,6%), *Anopheles (Nyssorhynchus) triannulatus* (Neiva & Pinto) *Anopheles (Nyssorhynchus) albitarsis* (Lynch-Arribálzaga) 144 (3,0%), *Anopheles (Nyssorhynchus) minor* (Lima) 111 (2,3%), *Anopheles (Nyssorhynchus) benarrochi* (Galbadon) 67 (1,4%) e *Anopheles (Nyssorhynchus) oswaldoi* (Periassú) 53 (1,1%) (Table 1).

The species with the highest number of individuals collected was the *An. darlingi* species with 3,905 individuals, totaling 81.8% of the specimens collected in 2014, 2015 and 2016. *An. darlingi* is the main vector of malaria in Brazil probably throughout the continent South American (FORATTINI 2002; COLLUCCI & SALLUM 2006, BRASIL 2019).

Considering its role as the main transmitter of *Plasmodium falciparum* (Welch), it is responsible for the transmission of other species of *Plasmodium vivax* (Grassi & Feletti) and *Plasmodium malariae* (Feletti & Grassi) (BRASIL 2017). Other authors in their research, concluded that *Anopheles* species may be involved in the transmission dynamics, in addition to the *Plasmodium* protozoan, may be involved in microfilariae

transmission (AMUZU *et al.* 2010) and arboviruses (MEDLOCK *et al.* 2005).

Specimens of the genus *Plasmodium* may also parasitize non-human primates and constitute a natural reservoir for human malaria. The only two parasite species described in South American primates are *Plasmodium brasilianum* (Gonder & Von Berenberg-Gossler) having this species, a wide geographic distribution, being found in the Amazon Rainforest from Panama to Brazil (PERELMAN *et al.* 2011) and *Plasmodium simium* (Grassi & Feletti) species found in Atlantic Forest areas of the South and Southeast regions (DE ALVARENGA *et al.* 2015) of may under special conditions infect humans (LALREMUATA *et al.* 2015).

Reports of anthroponotic were described in Brazil and Venezuela concerning these two species. Venezuelan researchers LALREMUATA *et al.* (2015) argued in their studies that human infections occurring in that country denote that *P. brasilianum* in Venezuela were genetically identical to *P. brasilianum* in host monkeys and *P. malariae* in humans. The records reported by BRASIL *et al.* (2017) showed the evidence found in the Atlantic Forest in Rio de Janeiro/Brazil on *P. simium*, indicating that this species may correspond to the description of a sixth type of human malaria.

Most malaria cases are concentrated in the Amazon region (Acre, Amapá, Amazonas, Maranhão, Mato Grosso, Pará, Rondônia, Roraima and Tocantins). However, there are reports of cases of the disease being carried out in endemic areas in other Brazilian states (BRASIL 2019) (Figure 1).

These records of human movement between regions with few or many endemic diseases confirm the risk of malaria due to the presence of the vector in both environments as recorded in these collections. Recreation with bars and clubs of associations and economic activities involved are among the main activities that put people at risk of contracting *Plasmodium* and disseminating them in other regions (TADEI *et al.* 2007).

In a study conducted in localities near the Manso hydroelectric station in the State of Mato Grosso (FORATTINI 1993; RIBEIRO *et al.* 2007); these researchers collected specimens of Anophelines in the area of implantation of this plant, being also identified a high number of individuals of the species *An. darlingi*, corroborating with the records found in this study.

Epidemiologically, the presence of specimens of the genus *Anopheles* can be considered an important genus Culicidae family that includes many species vectors of *Plasmodium* causing human malaria. In Brazil, 11 species of them have epidemiological importance and great impact in the transmission of the disease: *An. (Nys.) darlingi*; *Anopheles*

Table 1. Distribution of species of anophelines captured in relation to the years 2014, 2015, 2016 collected in the district of Coxipó do Ouro, in the city of Cuiabá/MT, Brazil.

Species captureded	January			March			June			September			November			Total		(N)	%	
	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015			2016
<i>An. (Nyssorhynchus) albitarsis</i>	0	17	18	10	9	10	16	0	144	8	14	0	14	8	12	48	48	48	144	3,0
<i>An. (Nyssorhynchus) argyritarsis</i>	27	12	18	32	5	18	23	17	267	0	25	7	32	17	26	114	76	77	267	5,6
<i>An. (Nyssorhynchus) benarrochi</i>	7	6	5	0	8	4	4	0	67	7	3	0	12	0	5	30	17	20	67	1,4
<i>An. (Nyssorhynchus) darlingi</i>	585	387	345	235	152	208	292	342	3905	98	186	125	162	296	201	1372	1363	1170	3905	81,8
<i>An. (Nyssorhynchus) minor</i>	12	12	6	0	15	0	7	10	111	13	8	2	9	0	6	41	45	25	111	2,3
<i>An. (Nyssorhynchus) oswaldoi</i>	5	0	2	2	4	2	2	3	53	6	0	4	4	4	10	19	11	23	53	1,1
<i>An. (Nyssorhynchus) triannulatus</i>	28	10	16	5	0	10	32	0	226	39	19	10	7	0	19	111	29	86	226	4,7
Total	664	444	410	284	193	252	376	372	4773	171	255	148	240	325	279	1735	1589	1449	4773	100

(*Nyssorhynchus aquasalis* Curry; *An. (Nys.) albitarsis*; *Anopheles (Nyssorhynchus) marajoara* Galvão & Damasceno; *Anopheles (Nyssorhynchus) janconnae* Wilkerson & Sallum; *Anopheles (Nyssorhynchus) deaneorum* Rosa-Freitas; *An. (Nys.) oswaldoi*; *Anopheles (Kerteszia) cruzii* Dyar & Knab; *Anopheles (Kerteszia) bellator* Dyar & Knab e *Anopheles (Kerteszia) homunculus* Komp (BRASIL 2017).

We can observe that three of these species were identified in this study: *An. triannulatus* (140, 4.2%), third largest species in a sample of specimens identified in this study, followed by *An. albitarsis* (96; 2.9%); *An. oswaldoi* (28; 0.8%), showing the amplitude, adaptability and dispersion of the genus *Anopheles* in the regions of Mato Grosso.

Three species of captured *Anopheles* are important in the epidemiology of malaria transmission: *An. darlingi* is considered one of the most efficient malaria vectors in the Americas region (FORATTINI et al. 1993; SINKA et al. 2011); *An. triannulatus* was considered to be one of the important vectors in Mato Grosso (MISSAWA et al. 2011), and was found naturally infected with *Plasmodium* (SINKA et al. 2011), and this species is incriminated in the transmission of malaria in Brazil (TADEI & DUTARY-THATCHER 2000), Peru and Venezuela (BENARROCH 1931; ARAMBURÚ et al. 1999), a fact that MORENO et al. (2013) tracked the distribution of this transmitter in several countries of the globe.

Still, *Anopheles argyritarsis* Robineau-desvoidy, where we cite the captures of the field insertions of its immature forms, recorded in this study, showing the importance of this vector in Mato Grosso. In the municipality of Várzea Grande/Mato Grosso, reports on this species were recorded by SILVA et al. (2008) who found immature forms of this species in water boxes in association with larvae of *Aedes albopictus* (Skuse). CARREIRA-ALVES (2001) in the city of Rio de Janeiro/Brazil; found larvae of *An. argyritarsis* and pupa of *An. aquasalis*, in deactivated artificial containers found in open sky.

FORATTINI et al. (1998), in a research carried out in São Paulo/Brazil, found this type of synanthropy, where two larvae of *An. argyritarsis* were identified, together with immatures of *Ae. albopictus* and *Culex quinquefasciatus* (Say). This information corroborates and contributes to show the high plasticity of this arthropod in adapting to new environments that are not ideal for development and growth mainly sites devoid of emergent vegetation, which are the first choice sites for these anophelines.

Previous studies have confirmed that *An. argyritarsis*, a vector specimen of *Plasmodium vivax* transmission (FARAN & LINTHICUM 1981); although in relation to this species. FORATTINI (2002) reports in his studies that the vector capacity of *An. argyritarsis* has been the subject of questioning, fact attributed to possible misidentifications. This species, although it can be found in houses, is not truly domiciled and shows great indifference to

human blood (FORATTINI 2002).

In relation to the collection periods from 2014 to 2016, there was a higher index in the first year (2014), where 1,735 (36.3%) were recorded, followed by the year (2015), where there were 1,589 (33, 3%) and finally the year 2016, where 1,449 (30.4%) were registered (Table 1). In the region of gold mining in Nova Guarita, researchers from Mato Grosso (MACIEL & OLIVEIRA 2014) collected 481 specimens of the genus. In 2008, in the municipality of Colniza/Mato Grosso (MACIEL & MISSAWA 2012) collected 3,160 high-density specimens in May of that year.

We can still check the records of RIBEIRO et al. (2013) who obtained 2,762 specimens from seven different species of *Anopheles*, evaluating the nictemeral distribution in the area of influence of the Manso hydroelectric station. In 2015, Martins et al. found the first records of *An. darlingi* in a hydroelectric station in Minas Gerais/Brazil, and the impacts generated by these reservoirs. These researchers found *An. darlingi* species as the most prevalent species, and these results are in accordance with the results found in this study, showing that this species of Anophelines, the representative with the highest prevalence index in the Midwest of Brazil.

In Mato Grosso State, the records of the species captured through different collection techniques (human bait, mosquito trap and Shannon trap) performed by MISSAWA et al. (2011) demonstrate the importance of this genus in the center-west region of the country, citing: *An. darlingi*, *An. benarrochi*, *Anopheles (Anopheles) mediopunctatus* (Theobald), *Anopheles (Nyssorhynchus) nigritarsis* (Chagas), *An. oswaldoi*, *Anopheles (Anopheles) peryassui* (Dyar et Knab), *Anopheles (Nyssorhynchus) rangeli* (Gabald, Covo-gar et Lopez), and *An. triannulatus*, as captured species.

In Goiás/Brazil, MANOEL et al. (2010) found a variety of Anophelines species that presented the highest diversity in the studied municipalities were *An. argyritarsis* and *An. darlingi*, however these researchers found a higher density in *Anopheles (Nyssorhynchus) evansae* (Brethes). We can observe the rich of species that may be present in the different niches of the Central West region of Brazil. In contrast to the techniques used in the study by these researchers, it can be observed in this study that the technique of human bait was superior in the capture of the winged specimens, 4,161 (87.2%) in relation to the Shannon technique 612 (12.8%), (Table 2), showing opposite values to those found by MISSAWA et al. (2011).

The collection period occurred from 17:00 at 23:00 h *An. darlingi* was the most prevalent species in Shannon trap and human bait, present at all collection times and in all years of capture. In human bait *An. darlingi* and *An. argyritarsis*, 87.4% of the captured insects were added together. TEODORO et al. (1995) evaluating Culicidae diversity in the Paraná river/Brazil, detected the presence of *An. triannulatus* and *An. albitarsis*

Table 2. Number and percentage of anophelines species captured according to harvesting techniques in the years 2014, 2015 and 2016, in Coxipó do Ouro district, Cuiabá/MT – Brazil.

Species Captured	Human isca		Shannon		Total	
	(N)	%	(N)	%	(N)	%
<i>An. (Nys.) albitarsis</i>	82	2,8	62	16,2	144	3,0
<i>An. (Nys.) argyritarsis</i>	192	6,5	75	19,6	267	5,6
<i>An. (Nys.) benarrochi</i>	42	1,4	25	6,5	67	1,4
<i>An. (Nys.) darlingi</i>	3555	120,9	350	91,6	3905	81,8
<i>An. (Nys.) minor</i>	91	3,1	20	5,2	111	2,3
<i>An. (Nys.) oswaldoi</i>	35	1,2	18	4,7	53	1,1
<i>An. (Nys.) triannulatus</i>	164	5,6	62	16,2	226	4,7
Total	4161	142	612	160	4773	100

in Shannon trap. *An. Triannulatus* in Shannon trap (2,741) followed by human bait (788).

In the Shannon trap, the most active h of the prevailing species (*An. darlingi*) in this study were between 18:00 at 22:00 h, in human bait *An. argyritarsis* had a higher density of 22:00 at 23:00 h, while *A. triannulatus* Neiva & Pinto and *An. minor* Lima prevailed from 17:00 at 19:00 h, while *An. benarrochi*, *An. oswaldoi*, and *An. albitarsis* were detected at 17:00 at 18:00 h. The performance of *An. albitarsis* and *An. argyritarsis* was recorded from 22:00 to 23:00 h (Figure 2).

When analyzing the activity period of the dominant species *An. darlingi* in the research area of the Coxipó do Ouro/Mato Grosso district, we can observe that this species was active mainly in the initial collection times from 17:00 at 18:00 h with number of specimens collected and again a second peak of hematophageal activity at 21:00 at 22:00 h. When we compare this information with the results obtained by MISSAWA *et al.* (2011), these researchers showed in their casuistic proximity of the hematophageal activity of this species that had its initial peak from 18:00 at 19:00 h and then resuming its frequency at a second peak from 22:00 to 23:00 h.

Other researchers in their series reported values close to those found in this study. RIBEIRO *et al.* (2013) found a high prevalence in the period from 18:00 at 19:00 h of *An. darlingi*, using human bait technique in the period 2005-2006. MACIEL & OLIVEIRA (2014) collected 481 specimens of the genus with peak of greater activity from 18:00 at 21:00 h.

When we compare the results obtained in studies in Mato Grosso by MACIEL & MISSAWA (2012) we can observe a similarity in the schedules obtained in this study and conclude that this vector species showed to be very active first from 18:00 at 19:00 h resuming the secondary peak of their food activities at 21:00 at 22:00 h. TADEI & DUTARY-TATCHER (2000) report that the highest activity period of *An. darlingi* occurs during the first three h of the escotophase, varying from 17:00 at 21:00 h. This report is in accordance with this work. However, these arguments can be compared with the records of RUND *et al.* (2013) that observed the rhythmic patterns of *Anopheles gambiae* Giles and found that the olfactory organs of these

arthropods feel the odors of humans in the pre-twilight and twilight periods being more attracted hematophagy at night.

The vector species *An. darlingi*, has a preferential feeding activity at twilight times, being this variation to be differentiated by determining factors, such as temperature and season of the year. FORATTINI *et al.* (1993) and FORATTINI 2002 argue in their results that these variations of the rhythm in the nytemeral cycle of *An. darlingi* are indicative of the existence of diverse populations and, consequently, of different behavior. However, in a similar cycle observed in Aripuanã/Mato Grosso/Brazil, CHARLWOOD & WILKES (1979) verified that the twilight peaks are predominantly composed of nulliparous females. As different researchers have registered different preferential activity schedules in their cases (TADEI & DUTARY-TATCHER 2000; VOORHAM 2000; SANTOS *et al.* 2005).

The natural history of this subfamily of mosquitoes has received the attention of researchers from various parts of the world (SINKA *et al.*, 2011; SINKA *et al.*, 2012). These studies have led to a process of knowledge of their biological characteristics in order to discover their vulnerabilities to more easily monitor and combat them (FORATTINI 2002). Currently, vectors serve as a tool for growing studies. The study of Anophelinae species in a region where malaria is endemic is important for the targeting of control measures, especially since the same species in the same place can change their habits over time, mainly due to environmental changes.

The data obtained in the present study indicate that the ecological changes followed by the human occupation observed in the research should be considered. This study showed that changes in the environment, whether they are in urban areas, prospectors or rural areas. This finding raises the discussion about the need to understand the importance of social and population characteristics, such as mobility, that affect the population dynamics of species transmitting pathogens, possibly contributing to the increase of disease transmission, among them malaria.

The populations of *Anopheles*, which are located in the study area, are due to the locations of water from these environments, some species demonstrate the ability to

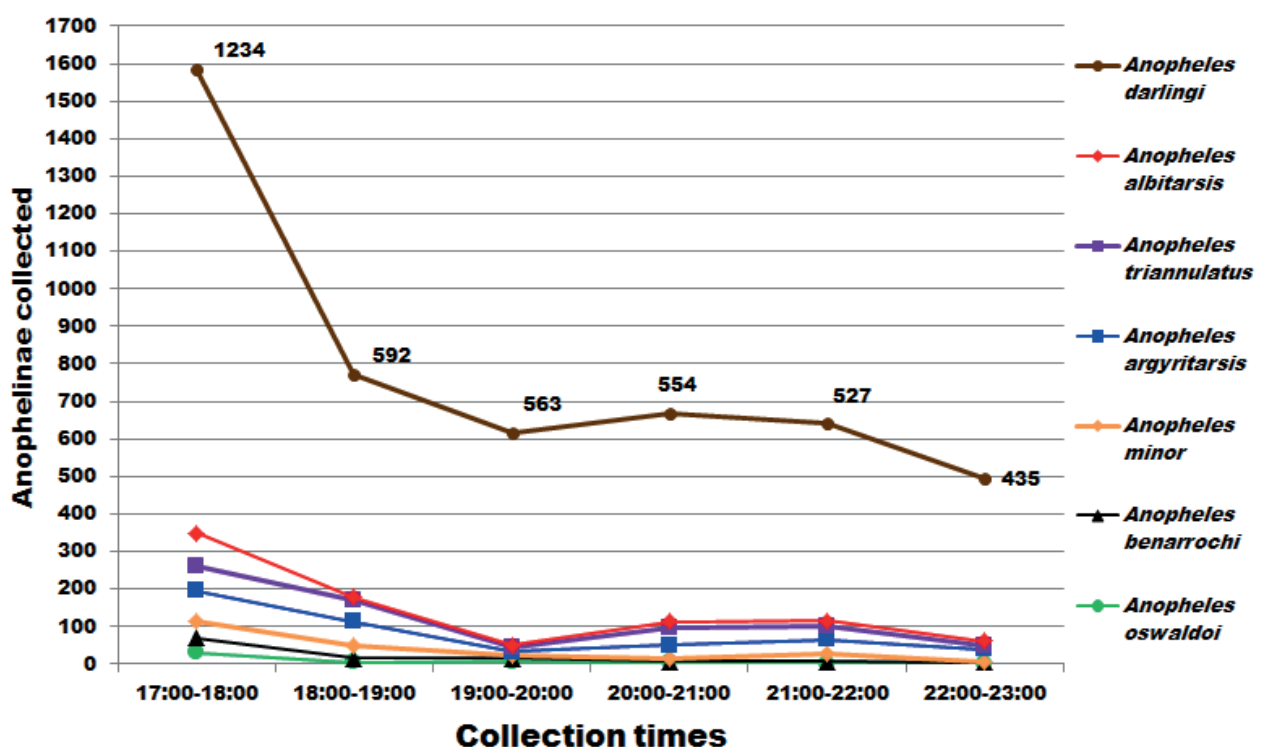


Figure 2. Activity schedule of the Anophelinae captured in the District of Coxipó do Ouro, Cuiabá district, State of Mato Grosso, Brazil, during the period of 2014, 2015 and 2016, especially the prevalent species *Anopheles darlingi*.

undergo variations in their biology and to adapt to different environmental conditions.

The high degree of synanthropism of species of the genus *Anopheles*, prevalent *An. darlingi*, is a species considered important in the epidemiology of malaria in the region, point to the need to monitor these species in environments preserved, anthropized and modified by man.

ACKNOWLEDGEMENT

Financial support for this study were provided by FAPEMAT - Research Foundation in the State of Mato Grosso [Foundation for the Support of Science of the State of Mato Grosso].

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

REFERENCES

- Amuzu H, MD Wilson & DA Boakye, 2010, Studies of *Anopheles gambiae* s.l (Diptera: Culicidae) exhibiting different vectorial capacities in lymphatic filariasis transmission in the Gomoa district, Ghana. *Parasit Vectors*, 3: 85-90. DOI: <https://doi.org/10.1186/1756-3305-3-85>
- Aramburú, GJ, AC Ramal & R Witzig, 1999. Malaria re-emergence in the Peruvian Amazon region. *Emerging Infectious Diseases*, 5: 209-215. DOI: <https://doi.org/10.3201/eid0502.990204>
- Benarroch, El, 1931. Studies of malaria in Venezuela. *American Journal of Epidemiology*, 14: 690-693. DOI: <https://doi.org/10.1093/oxfordjournals.aje.a117797>
- Brasil, 2011. Instituto Brasileiro de Geografia e Estatística. Available in: <<http://www.ibge.gov.br/home/>>. [Accessed on: ii.2019].
- Brasil, 2017. Ministério da Saúde. Guia de Vigilância em Saúde. Volume único. 2ª. Ed. Available in: <<http://portalarquivos.saude.gov.br/images/pdf/2017/outubro/06/Volume-Único-2017.pdf>>. [Accessed on: iv.2019].
- Brasil, 2018. Instituto Nacional de Pesquisas Espaciais. Coordenação Geral de Observação da Terra. Projeto Monitoramento Cerrado. TerraBrasilis. Available in: <<http://terrabrasilis.dpi.inpe.br>>. [Accessed on: 11.iv.2019].
- Brasil, 2019. Ministério da Saúde. Portal da Saúde. Available in: <<http://portalms.saude.gov.br/saude-de-a-z/malaria>>. Acesso em Abril 2019.
- Brasil, P, MG Zalis, A Pina-Costa, AM Siqueira, C Bianco Jr, S Silva, ALL Areas, M Pelajo-Machado, DAM Alvarenga, ACFS Santelli, HG Albuquerque, P Cravo, FVS Abreu, CL Peterka, GM Zanini, MCS Mutis, A Pissinatti, R Lourenço-de-Oliveira, CFA Brito, MF Ferreira-da-Cruz, R Culleton & CT Daniel-Ribeiro, 2017. Outbreak of human malaria caused by *Plasmodium simium* in the Atlantic Forest in Rio de Janeiro: a molecular epidemiological investigation. *The Lancet Global Health*, 5: e1038-e1046. DOI: [https://doi.org/10.1016/S2214-109X\(17\)30333-9](https://doi.org/10.1016/S2214-109X(17)30333-9)
- Carreira-Alves, JR, 2001. Encontro de anofelinos do subgênero *Nyssorhynchus* em recipientes artificiais, Maricá, RJ, Brasil. *Revista de Saúde Pública*, 35: 407-408. DOI: <https://doi.org/10.1590/S0034-89102001000400012>
- Charlwood, J.D & TJ Wilkes, 1979. Studies on the age-composition of samples of *Anopheles darlingi* Root (Diptera: Culicidae) in Brazil. *Bulletin of Entomological Research*, 69: 37-42. DOI: <https://doi.org/10.1371/journal.pone.0130773>
- Collucci, E & MAM Sallum, 2006. Records of *Anopheles (Nyssorhynchus)* (Diptera, Culicidae) in artificial containers in Ribeirão Preto City, State of São Paulo, Brazil. *Revista Brasileira de Entomologia*, 50: 431-432. <https://doi.org/10.1590/S0085-56262006000300015>
- Consoli, RAEB & RL Oliveira 1994. Principais mosquitos de importância sanitária no Brasil. Edição 1. Rio de Janeiro: Fiocruz:
- Dantas ESO, DP Leite-Jr JD Souza RR Carmo FG Silvestre & PPP Maltempi, 2016. Genetic Identification of Necrophagous Insect Species (Diptera) of Forensic Importance Sampled from Swine Carcasses in Mato Grosso, Midwestern Brazil. *Journal of Forensic Research*, 7: 1000323. DOI: <https://doi.org/10.4172/2157-7145.1000323>
- De Alvarenga, DA, A De Pina-Costa, TN De Souza, A Pissinatti, MG Zalis, MC Suaréz-Mutis, R Lourenço-de-Oliveira, P Brasil, CT Daniela-Ribeiro, CF De Brito, 2015. Simian malaria in the Brazilian Atlantic forest: first description of natural infection of capuchin monkeys (Cebinae subfamily) by *Plasmodium simium*. *Malaria Journal*, 14: 81-90. DOI: <https://doi.org/10.1186/s12936-015-0606-6>
- Deane, LM, OR Causey & MP Deane, 1947. Chave ilustrada para a identificação de 35 espécies de anofelinos das regiões nordestina e amazônica do Brasil pelos caracteres da fêmea com notas sobre os transmissores de Malária (Diptera, Culicidae). *Memórias do Instituto Oswaldo Cruz*, 71-102.
- Faran, ME & KJ Linthicum, 1981. A handbook of the Amazonian species of *Anopheles (Nyssorhynchus)* (Diptera: Culicidae). *Mosquitos Systematics*, 13: 1-81.
- Forattini OP, I Kakitani GRAM Marques & M Brito, 1998. Formas imaturas de anofelíneos em recipientes artificiais. *Revista de Saúde Pública*, 32: 189-191, DOI: <https://doi.org/10.1590/s0034-89101998000200015>
- Forattini, OP, 2002. *Culicidologia Médica*. Vol. 2. São Paulo: EDUSP.
- Forattini, OP, I Kakitani, E Massad & D Marucci, 1993. Studies on mosquitoes (Diptera: Culicidae) and anthropic environment: 4 - Survey of resting adults and synanthropic behaviour in South-Eastern, Brazil. *Revista de Saúde Pública*, 27: 199-207. DOI: <https://doi.org/10.1590/S0034-89101993000600002>
- Harbach, RE, 2020. Inventário Taxonômico de Mosquitos. Available in: <<http://mosquito-taxonomic-inventory.info/valid-especies-list>>. [Accessed on: 10.iv.2020].
- Hiwat, H & G Bretas, 2011. Ecology of *Anopheles darlingi* Root with respect to vector importance: a review. *Parasites & Vectors*, 4: 177. DOI: <https://doi.org/10.1186/1756-3305-4-177>
- John, B, 2008. *Mosquito Ecology – Field Sampling Methods*. 3a. Ed. Mosq. Ecol. Springer. Available in: <<http://www.springer.com/life+sciences/entomology/book/978-1-4020-6665-8>>. [Accessed on: iv.2019].
- Kiszewski, A, A Mellinger, A Spielman, P Malaney, SE Sachs & J Sachs, 2004. A global index representing the stability of malaria transmission. *The American Journal of Tropical Medicine and Hygiene*, 70: 486-498. DOI: <https://doi.org/10.4269/ajtmh.2004.70.486>
- Lalremruata, A, M Magris, S Vivas-Martínez, MM Koehler, M Esen, P Kempaiah, S Jeyaraj, DJ Perkisn, B Mordmüller & WG Metzger, 2015. Infecção natural de *Plasmodium brasilianum* em humanos: homem e macaco compartilham quartas parasitas da malária na Amazônia venezuelana. *EBioMedicine*, 2: 1186-1192. DOI: <https://doi.org/10.1016/j.ebiom.2015.07.033>
- Lane, J, 1953. *Neotropical Culicidae I*. University São Paulo, São Paulo. 1953; 1: 550.
- Maciel, GBML & EC Oliveira, 2014. Perfil Entomológico e Epidemiológico da malária em região garimpeira no norte do Mato Grosso. *Epidemiologia e Serviços de Saúde*, 23: 355-360. DOI: <https://doi.org/10.5123/S1679-49742014000200017>
- Maciel, GBML & NA Missawa, 2012. Description of fauna of the genus *Anopheles* (Culicidae, Anophelinae) in malaria endemic area in the Municipality of Colniza, State of Mato Grosso, Brazil. *Epidemiologia e Serviços de Saúde*, 21: 141-148. DOI: <https://doi.org/10.5123/S1679->

- 49742012000100014
 Manoel, ER, HH Garcia da Silva & I Garcia da Silva, 2010. Espécies de Anopheles (Diptera, Culicidae) em Municípios com risco Autoctonia de Malária no Estado de Goiás. Revista de Patologia Tropical, 39: 137-144. DOI: <https://doi.org/10.5216/rpt.v39i2.10732>
- Marcondes, CB, J Alencar, VQ Balbino & AE Guimarães, 2007. Description of three practical and inexpensive devices for the collection of mosquitoes and other small insects. Journal of the American Mosquito Control Association, 23: 84-6. DOI: [https://doi.org/10.2987/8756-971x\(2007\)23\[84:dotpai\]2.0.co;2](https://doi.org/10.2987/8756-971x(2007)23[84:dotpai]2.0.co;2)
- Martins, R, GF Monteiro, FM Costa & Y Antonini, 2015. First Record of Anopheles darlingi Root (Diptera, Culicidae) in the Volta Grande Environmental Reserve, Conceição das Alagoas Municipality, Minas Gerais, Brazil. EntomoBrasilis, 8: 82-84. DOI: <https://doi.org/10.12741/ebrasilis.v8i1.474>
- Mato Grosso, 2016. Saúde divulga dados de malária no estado. Secretaria de Estado de Saúde. Governo do Estado de Mato Grosso. Available in: <http://www.mt.gov.br/4402598-saude-divulga-dados-de-malaria-no-estado>. [Accessed on: iv.2019].
- Medlock, JM, KR Snow & S Leach, 2005. Potential transmission of West Nile virus in the British Isles: an ecological review of candidate mosquito bridge vectors. Medical and Veterinary Entomology, 19: 2-21. <https://doi.org/10.1111/j.0269-283X.2005.00547.x>
- Missawa, NA, ALM Ribeiro, GBML Moreira & P Zeilhofer, 2011. Comparison of capture methods for the diagnosis of adult anopheline populations from State of Mato Grosso, Brazil. Revista da Sociedade Brasileira de Medicina Tropical, 44: 555-560. <https://doi.org/10.1590/S0037-86822011005000053>
- Moreno, M, S Bickersmith, W Harlow, J Hildebrandt, SN McKeon, TF Silva-do-Nascimento, JR Loaiza, F Ruiz, R Lourenço-de-Oliveira, MAM Sallum, ES Bergo, GN Fritz, RC Wilkerson, YM Linton, MJ Dantur Juri, Y Rangel, MM Póvoa, LA Gutiérrez-Builes, MM Correa & JE Con, 2013. Phylogeography of the neotropical *Anopheles triannulatus* complex (Diptera: Culicidae) supports deep structure and complex patterns. Parasites & Vectors, 6: 47. DOI: <https://doi.org/10.1186/1756-3305-6-47>
- Parente, AT, ED Souza & JBM Ribeiro, 2012. A ocorrência de malária em quatro municípios do estado do Pará, de 1988 a 2005, e sua relação com o desmatamento. Acta Amazonica, 42: 41-48. DOI: <https://doi.org/10.1590/s0044-59672012000100005>
- Perelman, P, WE Johnson, C Roos, HN Seuànez, JE Harovath, MAM Moreira, B Kessing, J Pontius, M Roelke, Y Rumpfer, MPC Schneider, A Silva, SUJ O'Brien & JA Pecon-Slaterry, 2011. Molecular phylogeny of living primates. Plos Genetics, 7: 1-17. <https://doi.org/10.1371/journal.pgen.1001342>
- Reidenbach KR, S Cook, MA Bertone, RE Harbach, BM Wiegman & NJ Besansky, 2009. Phylogenetic analysis and temporal diversification of mosquitoes (Diptera: Culicidae) based on nuclear genes and morphology. BMC Evolutionary Biology, 9: 298. DOI: <https://doi.org/10.1186/1471-2148-9-298>
- Ribeiro, ALM, NA Missawa & P Zeilhofer, 2007. Distribution of phlebotomine sandflies (Diptera: Psychodidae) of medical importance in Mato Grosso State, Brazil. Revista do Instituto de Medicina Tropical de São Paulo, 49: 317-321. DOI: <https://doi.org/10.1590/S0036-46652007000500008>
- Ribeiro, ALM, RD Miyazaki, JSV Rodrigues & JH Campelo Júnior, 2013. Parity and influence of abiotic factors on Anopheles in the Manso dam, State of Mato Grosso, Brazil. Revista da Sociedade Brasileira de Medicina Tropical, 46: 498-501. DOI: <https://doi.org/10.1590/0037-8682-1354-2013>
- Rund, SSC, NA Bonar, MN Champion, JP Ghazi, CM Houk & MT Leming, 2013. Daily rhythms in antennal protein and olfactory sensitivity in the malaria mosquito *Anopheles gambiae*. Scientific Reports, 3: 2494. <https://doi.org/10.1038/srep02494>
- Santos RLC, IMC Sucupira, RNL Lacerda, AS Fayal & MM Póvoa, 2005. Levantamento entomológico e infectividade durante epidemia de malária no município de Anajás, Estado do Pará, Brasil. Revista da Sociedade Brasileira de Medicina Tropical, 38: 202-204. DOI: <https://doi.org/10.1590/s0037-86822005000200018>
- Silva, JS, AM Acel, AE Guimarães & J Alencar, 2008. *Anopheles (Nyssorhynchus) argyritarsis* larvae found in artificial breeding sites in the State of Mato Grosso. Revista da Sociedade Brasileira de Medicina Tropical, 41: 313-314. DOI: <https://doi.org/10.1590/S0037-86822008000300019>
- Sinka, ME, MJ Bangas, S Manguin, Y Rubio-Palis, T Charonviriyaphap & M Coetzee, 2012. A global map of dominant malaria vectors. Parasites & Vectors, 5: 69. DOI: <https://doi.org/10.1186/1756-3305-5-69>
- Sinka, ME, Y Rubio-Palis, S Manguin, AP Patil, WH Temperley & PW Gething, 2011. The dominant Anopheles vectors of human malaria in the Americas: occurrence data, distribution maps and bionomic précis. Parasites & Vectors, 4: 210. DOI: <https://doi.org/10.1186/1756-3305-3-72>
- Tadei, WP & B Dutary-Thatcher, 2000. Malaria vectors in the Brazilian Amazon *Anopheles* of the subgenus *Nyssorhynchus*. Revista do Instituto de Medicina Tropical de São Paulo, 42: 87-94. DOI: <https://doi.org/10.1590/S0036-46652000000200005>
- Tadei, WP, IB Rodrigues, JMM Santos, MS Rafael, RA Passos, FM Costa, & AEM Oliveira, 2007. Entomologia e controle de vetores: o Papel da entomologia no controle da Malária. X Reunião Nacional de Pesquisa em Malária, 22-26.
- Teodoro, U, ALF Guilherme, AL Lozovei, VLS Filho, Y Fudushigue, RP Spinosa, MEMC Ferreira, OC Barbosa & EM Lima, 1995. Culicidae of Itaipu lake, Paraná River, southern Brazil. Revista de Saúde Pública, 29: 6-14. DOI: <https://doi.org/10.1590/S0034-89101995000100003>
- Voorham, J, 2000. Intra-population plasticity of *Anopheles darlingi's* (Diptera, Culicidae) biting activity patterns in the state of Amapá, Brazil. Revista de Saúde Pública, 36: 75-80. DOI: <https://doi.org/10.1590/S0034-89102002000100012>
- WHO, 2013. World Health Organization. Malaria entomology and vector control. Training Module on Malaria Control. Guide for tutors. Available in: <https://www.who.int/malaria/publications/atoz/9789241506014/en>. [Accessed on: ii.2019].
- Zavortink, TJ, 1927. Mosquito Studies (Diptera, Culicidae) XXVIII. The New World species formerly placed in *Aedes* (Finlaya). Contributions of the American Entomological Institute, 8: 1-206.

Suggestion citation:

Jacobina, ACM, JD Bandeira, FAL Santos, ESO Dantas & DP Leite-Jr, 2020. Entomological profile and new registers of the genera *Anopheles* (Diptera, Culicidae) in a Brazilian rural community of the District of Coxipó do Ouro, Cuiabá, Mato Grosso. EntomoBrasilis, 13: e0848.

Available in: doi: [10.12741/ebrasilis.v13.e0848](https://doi.org/10.12741/ebrasilis.v13.e0848)

