ORIGINAL ARTICLE

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BLOODSUCKING INSECTS IN RURAL AREAS ADJACENT TO THE CORUMBÁ IV HYDROELECTRIC DAM RESERVOIR, SANTO ANTÔNIO DO DESCOBERTO, GOIÁS, BRAZIL

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ABSTRACT

Eutrophic reservoirs of hydroelectric dams may favor the proliferation of macrophytes and bloodsucking insects. Currently, macrophyte overgrowth has been observed in some stretches of the Corumbá IV hydroelectric dam (CIV) reservoir. The occurrence of bloodsucking insects was analyzed in rural areas adjacent to the CIV reservoir. In two periods (March and July/August) ten houses in the area with increased macrophyte proliferation (AG) and ten others in the area with low macrophyte proliferation (AP) were selected and sampled. Additionally, 100 macrophytes from each area were analyzed. A total of 35,788 insects were captured in light traps and 28% of them belonged to families of bloodsucking insects, especially Culicidae. The occurrence of culicids was different between the AG and AP areas ($p<0.05$). Mosquitoes were more frequent and abundant in the AG area. The larval survey showed that 100% of the houses visited had potential for mosquito breeding. Overall, 302 mosquito larvae were collected among macrophytes, mainly in the AG area. It is concluded that there is a higher frequency of mosquitoes in areas with increased macrophyte proliferation, but the CIV reservoir is not the only breeding source of mosquitoes in the studied areas.

KEY WORDS: Culicidae; *Eichhornia crassipes*; hydroelectric.

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RESUMO

Insetos hematófagos em áreas rurais adjacentes ao reservatório da usina hidrelétrica Corumbá IV, Santo Antônio do Descoberto, Goiás, Brasil.

Reservatórios de usinas hidrelétricas, quando eutrofizados, podem favorecer a proliferação de macrófitas e insetos hematófagos. Nos últimos anos, tem sido observado um crescimento excessivo de macrófitas em alguns trechos do reservatório da hidrelétrica Corumbá IV (CIV). O estudo objetivou analisar a ocorrência de insetos hematófagos em áreas rurais adjacentes ao reservatório da CIV. Foram selecionadas dez casas em área com grande proliferação de macrófitas (AG) e outras dez em área com baixa proliferação de macrófitas (AP), que foram amostradas em dois períodos (março e julho/agosto). Adicionalmente, analisaram-se 100 macrófitas em cada área. Foram capturados 35.788 insetos nas armadilhas luminosas e 28% deles pertenciam a famílias de insetos hematófagos, especialmente Culicidae. A ocorrência de culicídeos foi diferente entre as áreas AG e AP ($p<0,05$), uma vez que estes foram mais frequentes e abundantes na área AG. A pesquisa larvária mostrou que 100% das casas visitadas apresentaram potenciais criadouros de mosquitos. No total, 302 larvas de mosquitos foram coletadas nas macrófitas, sobretudo na área AG. Pode-se concluir que há maior frequência de culicídeos nas áreas com maior proliferação de macrófitas, porém o reservatório CIV não é o único criadouro de mosquitos nas áreas estudadas.

DESCRITORES: Culicidae; *Eichhornia crassipes*; hidrelétricas.

INTRODUCTION

Eutrophic reservoirs of hydroelectric dams may favor the proliferation of aquatic vegetation and bloodsucking insects. Macrophytes provide food resources for mosquitoes in the form of plant detritus and also promote the production of bacteria, algae, and protozoa which are also eaten by mosquitoes. In addition, these thick vegetation stands may reduce water flow, favoring the development of mosquito larvae (Rey et al., 2012).

In Brazil, some studies have analyzed the influence of aquatic macrophytes in the proliferation of bloodsucking insects such as horse flies, mosquitoes and black flies (Forattini, 2002; Poi De Neiff & Neiff, 1980). *Anopheles darlingi* Root, 1926 often occurs in the root filaments of *Eichhornia crassipes* (Forattini, 2002). According to Natal et al. (1991), the accumulation of *E. crassipes* provides a suitable habitat for the proliferation of *Culex quinquefasciatus* (Say, 1823) in the reservoir of the Edgard de Souza hydroelectric dam, located in the state of São Paulo. The larvae and pupae of mosquitoes of the genera *Mansonia* and *Coquillettidia* (Mansoniini tribe) are often found in the roots of aquatic vegetation, where they use their siphons to puncture macrophytes to obtain oxygen (Forattini, 2002). Moreover, Alencar et al. (2006) reported an increase in the *Mansonia titillans* (Walker, 1848) population caused by the neglected proliferation of *Eichhornia* sp. in a lake inside the campus of the Federal University of Mato Grosso do Sul.

Currently, overgrowth of macrophytes has been observed in some stretches of the Corumbá IV hydroelectric dam (CIV) reservoir, located in the state of Goiás, Brazil. These areas are polluted with sewage coming from the Descoberto River,

one of the tributaries from the reservoir; the sewage has favored the proliferation of *E. crassipes* in the CIV (Caesb, 2013a; 2013b). This scenario was identified in the municipality of Santo Antônio do Descoberto and it indicated the need for monitoring of the bloodsucking insects in this rural county.

The present study aimed to analyze the occurrence of bloodsucking insects in rural areas of Santo Antônio do Descoberto adjacent to the CIV reservoir. The study was designed to answer the following questions: 1. Which are the families of bloodsucking insects found in rural houses of Santo Antônio do Descoberto? 2. Are bloodsucking insects more common during a rainy month? 3. Is the occurrence of bloodsucking insects higher in areas with increased macrophyte proliferation? 4. Are the bloodsucking insects proliferating in macrophytes present in eutrophic areas of the reservoir? 5. Are there other potential breeding sites for bloodsucking insects in the rural area of the municipality of Santo Antônio do Descoberto?

MATERIAL AND METHODS

Study area

The municipality of Santo Antônio do Descoberto is located in the state of Goiás (UTM 793875, 8235767) within the Brazilian Cerrado. The estimated population is 61,791 inhabitants in an area of 938.309 km² (IBGE, 2010). The rainfall is unevenly distributed over the year, with a dry season from May to September and a rainy season between October and April (Klink & Machado, 2005). The study was conducted in the rural area, adjacent to the CIV reservoir. The dam is located in Corumbá river and the reservoir extends into areas of the municipalities of Alexânia, Abadiânia, Corumbá de Goiás, Luziânia, Novo Gama, Santo Antônio do Descoberto e Silvânia. The CIV reservoir is about 9,000 ha of wild protected area and 783.7 km perimeter.

The Household Units (HUs) were selected with a minimum distance of 250 m between them to allow for an independent spatial analysis. This distance considers information on dispersion of some bloodsucking insects available in the literature (Briegel et al., 2001; Casanova et al., 2005). The georeferenced houses showed an average distance of 400 m to the bank of macrophytes. Moreover, presence of inhabitants of the houses and their permission to perform the survey were considered as criteria to select the HUs. Thus, there were ten houses selected in the area with increased macrophyte proliferation (AG) and ten others in the area with low macrophyte proliferation (AP) (Figure 1). In the AG area the macrophytes were very abundant and covered much of the reservoir surface, while in the AP area the macrophytes were located in a narrow strip on the margin of the reservoir. The houses were located in rural areas and they showed peridomiciliary environments with animal shelters (e.g., corrals, chicken coops and pig pens). The survey was conducted after the approval of the Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renováveis (authorization number 003660/2013).

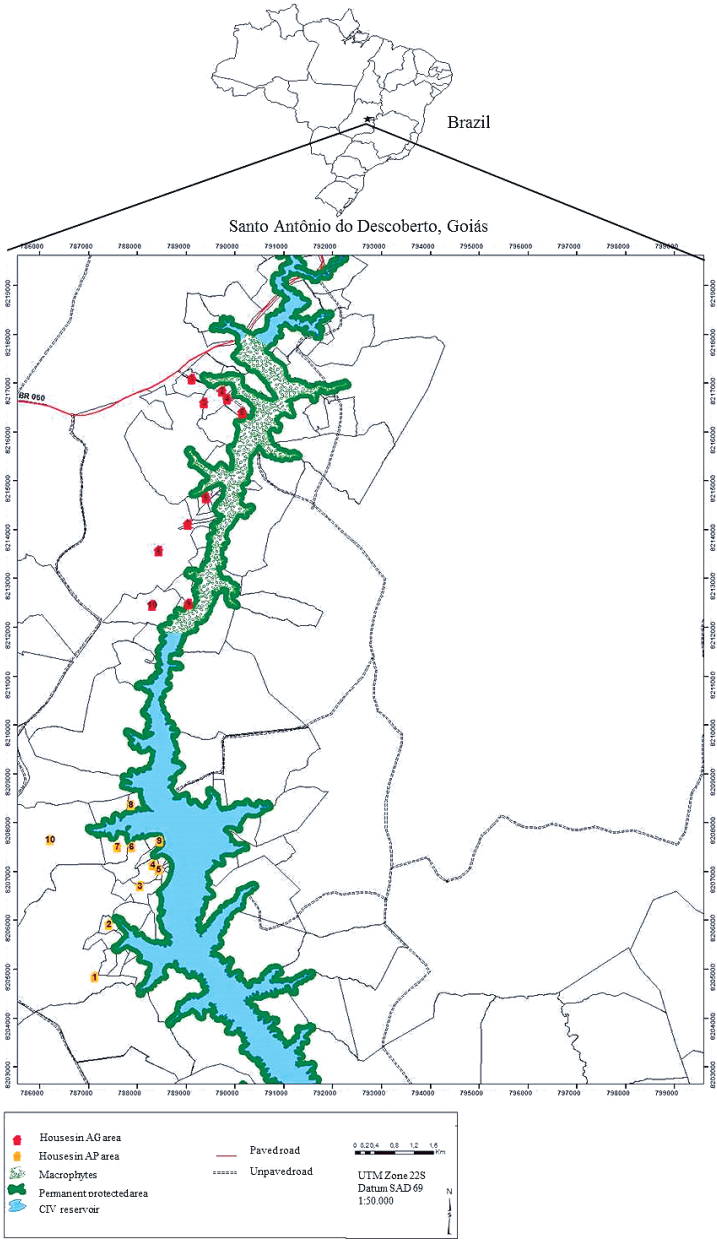

Figure 1. Location of the surveyed houses in a rural area of the municipality of Santo Antônio do Descoberto, Goiás, Brazil, 2013. Source: Corumbá Concessões S.A.

Entomological survey

Two surveys were conducted in 2013, one in March and the other in July/August. According to the Instituto Nacional de Meteorologia (INMET), 23 rainy days were recorded in March, with a total precipitation of 312 mm. Furthermore, the average temperature was 24 °C and the relative humidity was 81%. In July and August 2013, no rainy days were recorded, the average temperature was 22.8 ºC and the relative humidity was 46%. Insects were captured using HP light traps (Pugedo et al., 2005) and larval surveys carried out with standard techniques (Sucen, 1997). Briefly, the search for larvae was undertaken inside and outside houses, in all water deposits not properly sealed. The collection of larvae was carried out with a household sieve and was performed separately for each water deposit present in the house. The collected larvae were placed in vials containing 70% ethanol. In each HU, three to four HP traps were installed, one inside the house, and the others around it, nearby animal shelters and water deposits. The traps were placed daily from 4 to 6 p.m. and recovered the next day at 8 to 10 a.m., for three consecutive days. The capture effort was 200 HP trap-nights (100 in the AG area and 100 in the AP area) in each period, totaling 400 trap-nights and 6,400 hours of trapping.

To detect larvae in macrophytes 100 *E. crassipes* specimens were searched in each study area (50 macrophytes at each station/area), totaling 200 specimens. Macrophytes were collected using 100 L plastic bags. For the screening of specimens, the entire plastic bag's contents was placed in a white tray. Initially, the leaves of the macrophytes were inspected with the aid of forceps or a brush. After the inspection of the leaves, the roots were screened for insects by washing the macrophytes in the tray and filtering mosquito larvae with a household sieve. All larvae were removed to vials containing 70% ethanol. The families of adult and immature insects collected were identified based on Borror & Delong (1998).

Data analysis

The insect families' constancy during the sampling was assessed by the formula C%=(p/N).100, where p=the number of sampling occasions in which a specimen of each family was captured and N=the total number of captures. The families were then grouped into constancy categories, such as constant (C>50%), accessory (C>25-50%) and accidental (C<25%) (Silveira Neto et al., 1976). To determine the categories of dominance, the classification established by Friebe (1983) was applied using the formula D%=(i/t).100, where i=the total number of individuals in the family and t=the total number of individuals captured. Thus, the established categories were eudominant (D>10%), dominant (D>5-10%), subdominant (D 2-5%), eventual (D 1-2%) and rare (D<1%).

The Mann-Whitney test was used to analyze the abundance of mosquitoes in different months. In this analysis, we considered the abundance of mosquitoes in

the study as the dependent variable. The occurrence of mosquitoes in the AG and AP areas was compared using chi-square tests. In this analysis, only data from the traps around the houses was considered because some houses were observed with and others without screens on the windows and doors. The tests were performed in the Statistica® software, with significance set at 5%.

RESULTS

A total of 35,788 insects were captured in light traps, 28% of them belonged to families of bloodsucking insects, especially Culicidae. During March (rainy month) in the AG area, 14,551 insects were captured and bloodsucking insects accounted for 53% of all captured specimens. The number of insects was higher outside the houses (Table 1). On average, 70 mosquitoes were captured per trap (ranging from 0-560 mosquitoes). During July/August (dry months) 2,291 insects were captured, with 15% from bloodsucking insect families.

Table 1. Number of insects captured in light traps in the area with increased macrophyte proliferation (AG), in two periods, in the municipality of Santo Antônio do Descoberto, Goiás, Brazil, 2013.

	March					July/August				
	Intradomicile	Peridomicile	Total	Const.*	Dom.**	Intradomicile	Peridomicile	Total	Const.*	Dom.**
Bloodsucking insects										
Culicidae	547	7187	7734	C	E	127	201	328	A	D
Simuliidae	0	0	0	Ac	R	0	2	2	Ac	R
Phlebotominae	0	0	0	Ac	R	1	13	14	Ac	R
Non-bloodsucking insects										
Chironomidae	21	146	167	Ac	Ev	29	178	207	Ace	D
Others***	1274	5376	6650	C	E	240	1500	1740	C	E

*Const. (Constancy): C=Constant (C>50%) A=Accessory (C>25-50%); Ac=Accidental (C<25%).**Dom. (Dominance): E=Eudominant (D>10%); D=Dominant (D>5-10%); Ev=Eventual (D>1-2%); R=Rare (D<1%). The formulae used for these indicators are listed in the text. ***Coleoptera, Hemiptera, Lepidoptera, Diptera (non-Chironomidae), Hymenoptera.

During March in the AP area, 16,084 insects were captured and 9% of them belonged to bloodsucking insect families. The number of mosquitoes per trap was higher inside the houses, whereas non-bloodsucking insects were more abundant outside the houses (Table 2). In July/August 2,862 insects were captured and representation of bloodsucking insect families increased to 18%. The only family that showed dominance was Culicidae, which was captured mainly indoors (Table 2). The sand flies (Phlebotominae) were considered accidental and rare (Table 2).

During March, there was a greater abundance of mosquitoes outside houses in the AG area (Figure 2). Additionally, the number of mosquitoes per trap was statistically different between the areas (Mann Whitney; $Z=4.81$; $p<0.05$). In July/August there was no statistical difference between the number of mosquitoes

per trap from the two areas (Mann Whitney; Z=0.94; p=0.34), probably due to the smaller number of individuals captured during this period. Moreover, a significant difference in the frequency of positive traps for mosquitoes ($\chi 2$=4.2; p<0.05) was observed between the AG and AP areas.

Table 2. Number of insects captured in light traps in the area with low macrophyte proliferation (AP) in two periods, in the municipality of Santo Antônio do Descoberto, Goiás, Brazil, 2013.

	March					July/August				
	Intradomicile	Peridomicile	Total	Const.*	Dom.**	Intradomicile	Peridomicile	Total	Const.*	Dom.**
Bloodsucking insects										
Culicidae	474	870	1344	C	D	411	88	499	A	E
Simuliidae	1	0	1	Ac	R	0	0	0	Ac	R
Phlebotominae	11	26	37	Ac	R	9	11	20	Ac	R
Non-Bloodsucking insects										
Chironomidae	24	358	382	Ac	S	259	1512	1771	C	E
Others***	1995	12325	14320	C	E	51	521	572	C	E

*Const. (Constancy): C=Constant (C>50%) A=Accessory (C>25-50%); Ac=Accidental (C<25%).**Dom. (Dominance): E=Eudominant (D>10%); D=Dominant (D>5-10%); S=Subdominant (D>2-5%); Ev=Eventual (D>1-2%); R=Rare (D<1%). The formulae used for these indicators are listed in the text. ***Coleoptera, Hemiptera, Lepidoptera, Diptera (non-Chironomidae), Hymenoptera.

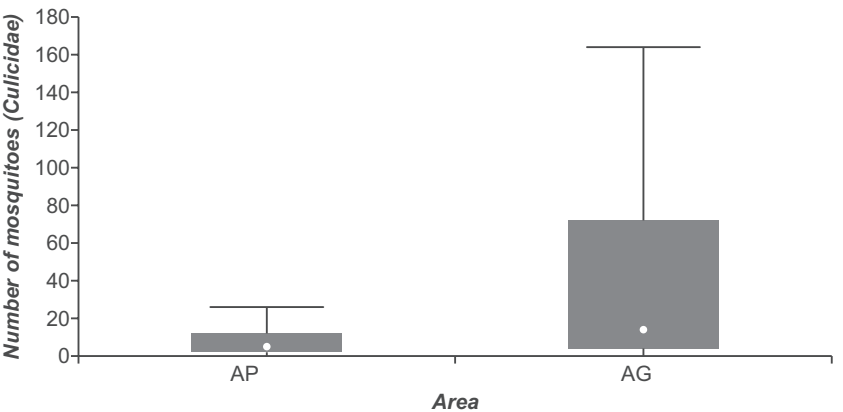

Figure 2. Number of mosquitoes captured in light traps located in peridomiciliary areas with low macrophyte proliferation (AP) and increased macrophyte proliferation (AG) during the rainy period. The box diagrams illustrate the median (central square), the values contained between 25 and 75% of cases (rectangles) and the maximum and minimum values found excluding the extreme values (vertical lines).

The larval survey showed that 100% of the houses had some type of reservoir that could serve as breeding sites for mosquitoes. During March, 200 water deposits were surveyed in the two areas (101 in the AP and 99 in the AG).

Unsealed water tanks, water fountains for animals, tires, trash and other types of potential breeding site were detected. 24 infested deposits (12%) of mosquito larvae were found. The frequency of larvae in potential breeding sites was higher in the AG (17%) compared to households in the area AP (7%). A total of 330 larvae were collected, the majority of them (72%) in the AG area. During July/August, an effort was made to visit the same water deposits surveyed during the rainy season, but many of them were no longer present or they were dry. Thus, only 42 water tanks were surveyed, of which four (9%) were infested by mosquito larvae.

Culicidae was classified as an accessory group in the macrophytes analyzed, showing a constancy of 39% and 41% in the rainy and dry months, respectively. In total, 302 mosquito larvae were collected in macrophytes, mainly in the AG area (n=259).

DISCUSSION

The frequency and abundance of bloodsucking insect families were higher during March (rainy month), which is in agreement with other studies in the Brazilian Cerrado (Lira-Vieira et al., 2013; Pinheiro et al., 2002; Silva et al., 2010). The high frequency of mosquitoes may be associated with large pools of water deposits rich in organic matter in rural areas of Santo Antônio do Descoberto, including many deposits outside houses and flooded areas with large amounts of macrophytes.

A higher number of mosquitoes were captured in the area with increased macrophyte proliferation. Culicids are considered pests by hindering the daily activities of residents living near water reservoirs (Alencar et al., 2006; Paula & Gomes, 2007). The influence of macrophytes on the occurrence of mosquitoes can be direct or indirect. Some culicid larvae (e.g. *Mansonia* species) depend directly on this resource for their development (Mulieri et al., 2005) and other species, (e.g. *Cx. quinquefasciatus*), develop better when there is more organic matter in the water, which might be facilitated by the presence of macrophytes as well as sewage and manure of other animals (Natal et al., 1991).

The low frequency of black flies (Simuliidae) must be related to the capture methods applied in the present study, since the species of this group are diurnal and usually restricted to areas near flowing water (Cunha, 2011). Sand flies were rare in the study areas. However, some were found well fed inside houses, illustrating the potential for *Leishmania* transmission to the people living there. In houses where these insects were detected, suitable breeding sites were observed for sand fly development (e.g. backyards with large shaded areas and with the presence of chickens and dogs) (Brasil, 2009). Epidemiological data from Santo Antônio do Descoberto between 2005-2012 shows that only one case of human visceral leishmaniasis was detected in 2006.

The results indicate that the CIV water reservoir is not the only source of mosquito larvae in the studied areas. The larval survey showed that 100% of the houses had some type of reservoir that could serve as a breeding site for mosquitoes. Even in the dry period we detected mosquito breeding sites associated with water reservoirs used by cattle and horses. Future studies should be performed to determine the species of mosquitoes, sand flies and black flies in rural areas of Santo Antônio do Descoberto. Specific entomological surveys for each group are recommended to determine the potential vectors and therefore the risk of pathogen transmission to residents. Moreover, other factors may influence the occurrence of bloodsucking insects in the studied areas (e.g. number of peridomiciliary animals, environmental management and control activities performed by households), which should be evaluated in future studies.

Larvae elimination should be an important measure of mosquito control to be implemented by local residents, with the support of county health agents and health education strategies. Removal of emergent vegetation is also a potential management strategy for the control of the mosquitoes (Grieco et al., 2005; Rey et al., 2012). Currently, this strategy has been applied in the municipality of Santo Antônio do Descoberto, where the Corumbá Concessões S.A. has removed the excess macrophytes for the production of organic fertilizer. The treatment of domestic sewage of Santo Antônio do Descoberto could also reduce the amount of organic matter in the reservoir and thus macrophyte proliferation. The combination of these control strategies together with the use of screens on the windows and doors of the houses adjacent to the reservoir could reduce contact between humans and bloodsucking insects in the area.

CONCLUSIONS

In the present study, three families of bloodsucking insects were found in rural houses of Santo Antônio do Descoberto, mainly Culicidae. The frequency and abundance of mosquitoes were higher during the rainy period and in areas with increased macrophyte proliferation. Finally, all houses surveyed had some type of reservoir that could serve as a breeding site for mosquitoes. It can be concluded that there is a higher frequency of mosquitoes in areas with increased macrophyte proliferation, but the CIV reservoir is not the only breeding source of mosquitoes in the studied areas.

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