



Abundance and Diurnal Activity Rhythm of *Stomoxys* spp. in a Wildlife-human Interface in Makokou (North East-Gabon)

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AOJM, SSL, ZKCR, MF and JFM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AOJM, SSL and MF managed the analyses of the study. Authors ZKCR, RMN, KAA, MF, AYGL, MB and SSL managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJRIZ/2019/v2i230064

Editor(s):

(1) Dr. Cesar Augusto Pospissil Garbossa, Professor, Department of Animal Nutrition and Production, School of Veterinary Medicine and Animal Science, University of São Paulo (USP), Brazil.

Reviewers:

(1) Gerard Duvallet, University Paul-Valery, France.

(2) Egbe Ben Besong, University of Buea, Cameroon.

Complete Peer review History: <http://www.sdiarticle3.com/review-history/49159>

Original Research Article

Received 06 March 2019

Accepted 13 May 2019

Published 15 July 2019

ABSTRACT

The aim of the study was to determine the abundance and diurnal activity rhythm of Stomoxyinae at the Ivindo National park and its environs, 14 Vavoua traps were set-up during the rainy season (25th Sept-5th Oct and 21st Oct-9th Nov 2018), in two habitats: the forest, a part of the Ivindo National Park (INP) and village-Town. In the Village-Town habitat, 62141 *Stomoxys* were caught and regrouped under five species notably 36502 *S. omega* (58.74%), 24045 *S. n. niger* (38.69%),

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1312 *S. xanthomelas* (2.11%), 265 *S. n. bilineatus* (0.43%) and 17 *S. calcitrans* (0.03%). At the INP, 4645 *Stomoxys* were caught and regrouped under four species notably 2364 *S. n. niger* (50.89%), 2153 *S. omega* (46.35%), 114 *S. xanthomelas* (2.45%) and 14 *S. n. bilineatus* (0.30%). *Stomoxys* were more abundant in the village (517.84 s/t/d) as compared to the INP (44.24 s/t/d). There was a statistically significant difference ($P < 0.05$) in apparent density of *Stomoxys* in the prospected biotopes. *Stomoxys* spp. showed a unimodal activity pattern in Village-Town environments and forest sites of the INP. The diurnal activity trend of *Stomoxys* spp. was sex dependent. This base line data will be used in *Stomoxys* spp. management in the environs of the INP.

Keywords: *Stomoxys*; Vavoua traps; biotope; Gabon.

1. INTRODUCTION

The knowledge on the occurrence of blood sucking dipterous insects such as *Stomoxys* in wildlife-human interface is essential because of their medical and veterinary importance [1,2]. About 18 species of *Stomoxys* are known worldwide and 13 of them reside in the Afro-zoogeographical region [3]. They are close to house fly in size but differ in that male and female are blood sucking [3]. They are vectors of some dangerous infectious agents like viruses, bacteria, protozoans and helminths [4,5]. The study of Sevidzem et al. [6] showed the existence of Stomoxyinae at a wildlife-livestock interface in the Adamawa plateau of Cameroon.

In Gabon (a neighbouring country to Cameroon), the knowledge of *Stomoxys* in the wildlife-human interface of Makokou is scanty [7,8,9,10] especially on the diurnal activity rhythm of this group with respect to sex. There is need to update on the knowledge of Stomoxyinae in the area because they represent a risk for the human and animal population through their direct nuisance (precludes outdoor activities such as ecotourism, etc..) and by their vectoral role. Moreover, the best approach in the valorization of the national parks of Gabon in terms of ecotourism involves knowledge on the abundance and activity rhythm of different species of vectors and the pathogens they harbor [11]. This knowledge is useful in developing control strategies for these insects.

To collect data on the abundance of *Stomoxys*, a cross-sectional entomological prospection was carried out in the rainy season in two different habitats that characterize the biosphere reserve of the Ivindo National Park (INP). The objective of this survey was to determine the apparent density and diurnal activity rhythm of *Stomoxys* in the forest of the INP and Village-town.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in Makokou, located in the Ogooué-Ivindo province in North-East Gabon. Trapping was carried out at the Institute of Research for Tropical Ecology (IRET) of Ipassa (0° 51'N; 12° 79'E) and its environs (0° 52'N; 12° 82'E) (Fig. 1), elevated at an altitude of 500 m [12]. The area is constituted of the Ivindo National Park (INP) with a surface area of 3000km² and 12 km away from the city of Makokou. The climate is of the equatorial and humid type with alternating rainy and dry seasons. The mean annual rainfall is 1600 to 1800mm while the mean annual temperatures are close to 24°C. The annual and daily thermal amplitudes are weak [13] and the main water body in the area is river Ivindo. The entomological prospection was carried out during the rainy season (25th Sept-5th Oct and 21st Oct-9th Nov 2018). The forest fauna of Gabon is rich and diversified and the Makokou region holds a significant share with one of the highest listed fauna in Gabon. It consists of 128 species of mammals, 424 species of birds, 65 species of reptiles, 47 species of amphibians among others [13].

2.2 Capture of *Stomoxys*

Trapping was carried out using 14 Vavoua traps [14]. The Vavoua traps have been reported to be efficient in the collection of muscids especially *Stomoxys* [15]. Traps were set along a transect of about 17 km, following the anthropogenic gradient from the secondary forest in the INP (non-anthropized environment), to village and Makokou town (highly anthropized environment). The trapping duration was 30 days. The 14 traps were divided into the two study areas, at a ratio of 7 traps per milieu. Trapping effort was: 14

traps × 30 days = 420 traps days. The traps were activated in the morning at 8 am and emptied at 6 pm. All trap cages were tagged with the trap number and date and returned to the laboratory. They were then placed in a freezer for 15 minutes to kill the insect prior to identification. Identification was carried out using the dissecting microscope (LABOMED®, France) of the field station laboratory of IRET-Ipassa in Makokou.

2.3 Daily Activity Rhythm

The diurnal activity pattern of *Stomoxys* in the study area was carried out for three days consecutively in the two habitats during prospection days. The follow-up diurnal time ranges for this trial was 8-10H, 10-12H, 12-14H, 14-16H and 16-18H. Three Vavoua traps in each site (i.e. N=6) were monitored for *Stomoxys* spp. activity. Trap-tags consisted of date, location and time interval.

2.4 Fly Identification

Stomoxys spp. identification was carried out using the identification key of Zumpt [3]. The sex of stable flies was determined using the Frontal Index (FI) [16] as such:

$$\text{Frontal Index} = \frac{\text{Interocular space}}{\text{Ocular length}}$$

The measurements were made using a full fly on the dorsal side with the aid of a binocular microscope. The measured values were compared with those from four populations by Garros et al. [17] and Masméatathip et al. [16].

The abundance was defined by the Apparent Density per Trap (ADT) known as the number of stomoxiines caught per trap and day:

$$\text{ADT} = \frac{\text{Number of Stomoxys flies captured}}{\text{Number of traps} \times \text{Number of trapping days}}$$

2.5 Data Analysis

The statistical analysis was carried out using the SPSS statistical package of version 20. The one-way ANOVA on ranks was used to compare the ADT of Stomoxyinae in the two prospection biotopes. The Kruskal Wallis test by ranks was used to compare the ADT of *Stomoxys* spp. across prospected sites. The level significance was $P < 0.05$.

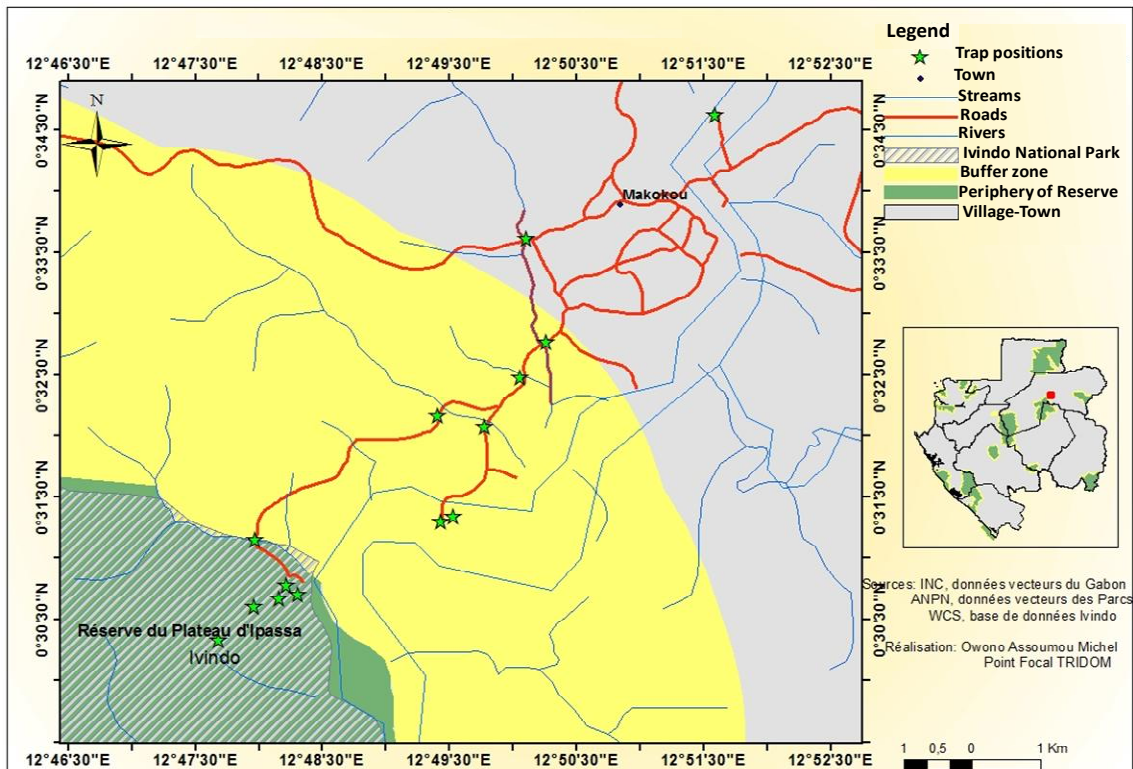


Fig. 1. Map of the study area showing trap positions (green stars)

3. RESULTS

3.1 *Stomoxys* Species Composition in the Prospected Milieu

The Stomoxyinae fauna in the forest of the INP and its environs consisted of five species in the Village-Town milieu and four species in INP. Their population was dominated by females. The dominant species in the Village-Town milieu was *S. omega* while that at the INP was *S. n. niger*. *S. calcitrans* was only encountered at the Village-

Town milieu and was absent at the INP (Table 1).

3.2 Abundance of *Stomoxys* spp. in the Prospected Milieu

The overall Stomoxyinae per trap and day was higher in the Village-Town (517.8 stomoxyines/trap/day) environment as compared to forest (44.24 s/t/d) with a statistically significant difference ($P < 0.05$) (Fig. 2).

Table 1. *Stomoxys* spp. composition with respect to sex in the prospected milieu

SN	Site	Species	Male	Female	Number	Percentage
1	Village-Town (N=5)	<i>Stomoxys omega</i>	15087	21415	36502	58.74
2		<i>Stomoxys niger niger</i>	6103	17942	24045	38.69
3		<i>Stomoxys xanthomelas</i>	347	965	1312	2.11
4		<i>Stomoxys niger bilineatus</i>	80	185	265	0.43
5		<i>Stomoxys calcitrans</i>	3	14	17	0.03
Total in Village-Town			21620	40521	62141	100
6	INP (N=4)	<i>Stomoxys niger niger</i>	920	1444	2364	50.89
7		<i>Stomoxys omega</i>	893	1260	2153	46.35
8		<i>Stomoxys xanthomelas</i>	40	74	114	2.45
9		<i>Stomoxys niger bilineatus</i>	7	7	14	0.3
Total in INP			1860	2785	4645	100

SN: Serial Number

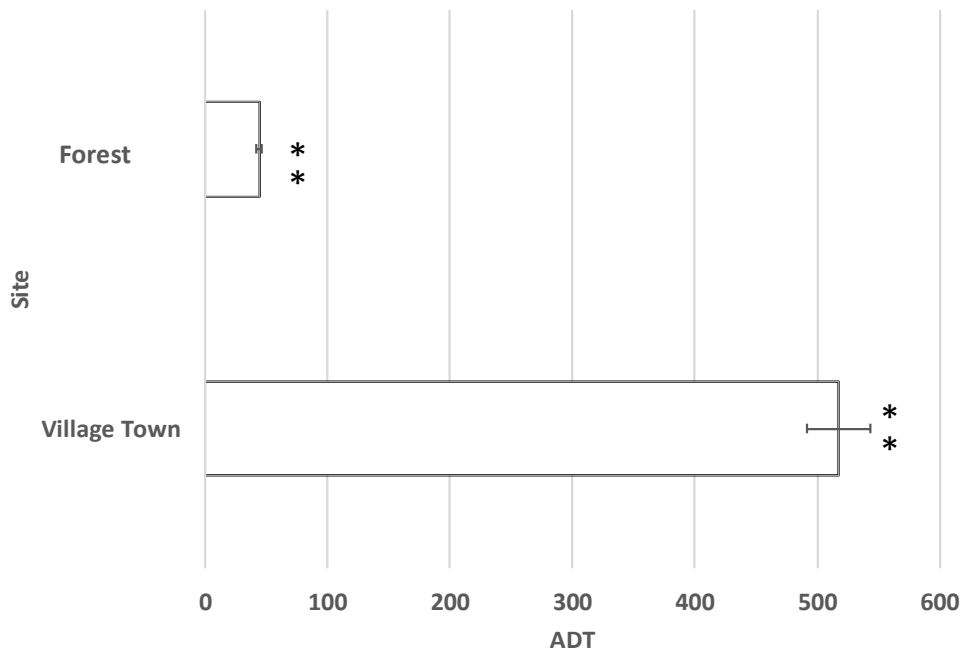


Fig. 2. The overall Stomoxyinae ADT with respect to prospection sites
 ** Statistically significant difference ($P < 0.05$), INP: forest sites of the Ivindo National Park

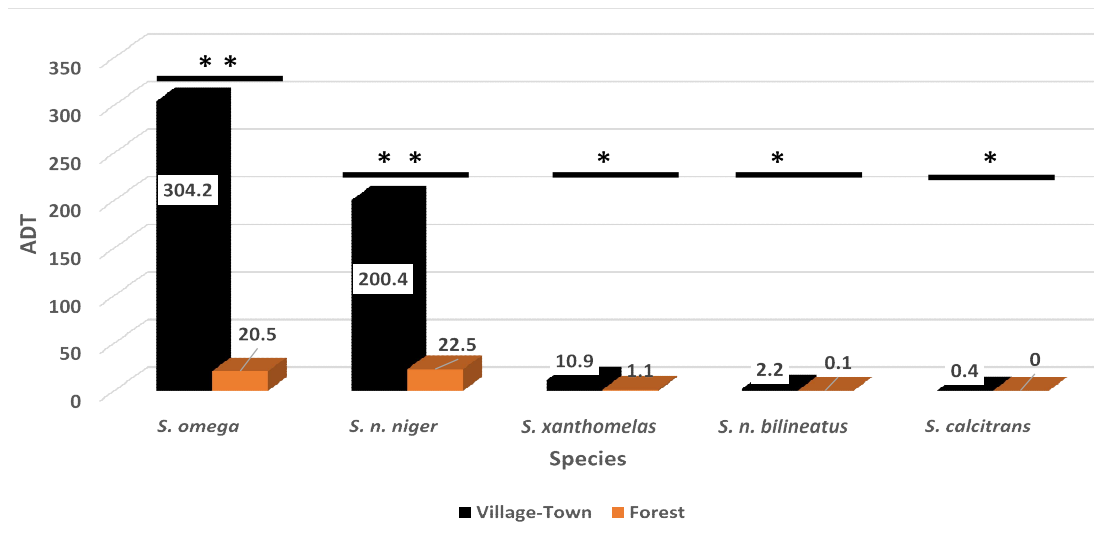


Fig. 3. The ADT of *Stomoxys* with respect to prospection milieu
 ** Statistically significant difference ($p < 0.05$); * no statistically significant difference ($p > 0.05$)

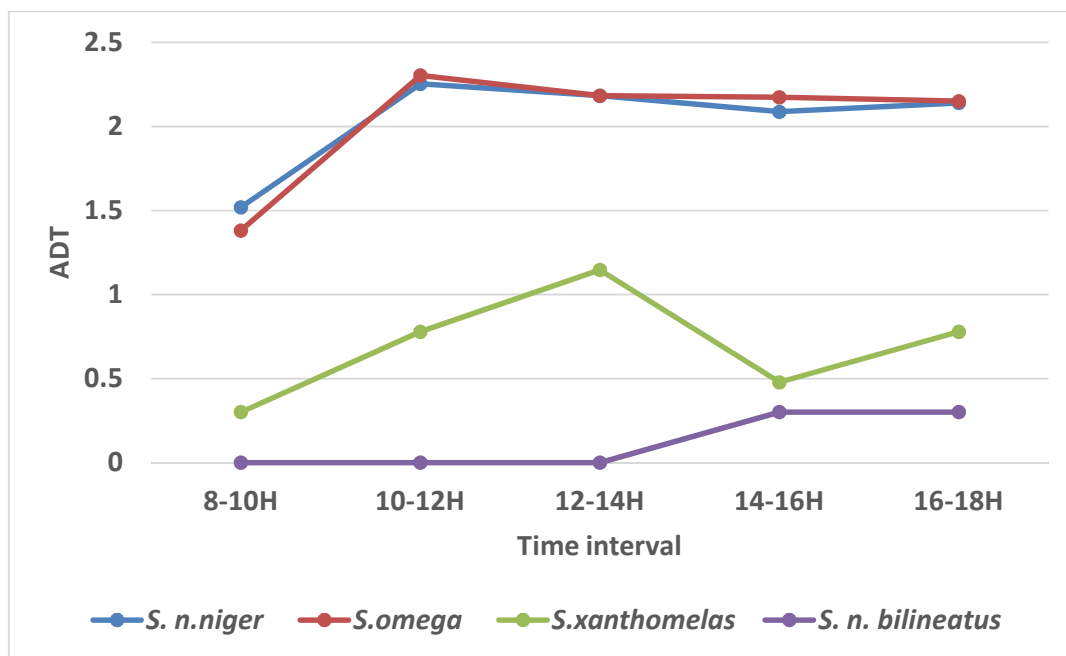


Fig. 4. Diurnal activity rhythm of male *Stomoxys* spp. in the forest

In the Village-Town milieu (anthropized sites), *S. n. niger* and *Stomoxys omega* were the most abundant species with ADT greater than 20. In the Village-Town milieu, *S. omega* and *S. n. niger* were the most abundant species with ADT greater than 200; while *S. xanthomelas* and *S. n. bilineatus* presented ADTs greater than 2. While *Stomoxys calcitrans* was rarely caught (Fig. 3). At the INP, *S. xanthomelas* was very poorly captured with apparent density barely greater

than one. Similarly, *S. n. bilineatus* was rarely captured with ADT of less than one (Fig. 3). There was a statistically significant difference ($P < 0.05$) in the distribution of *S. omega* and *S. n. niger* across prospected biotopes. However, there was no statistically significant difference ($P > 0.05$) in the distribution of *S. xanthomelas*, *S. n. bilineatus* and *S. calcitrans* across sampled sites.

3.3 Diurnal Activity Rhythm of Male *Stomoxys* in the Forest Sites

In the forest, the diurnal activity trend of male *Stomoxys* spp. showed that *S. n. niger* and *S. omega* had peak abundance between 10H-12H; while *S. xanthomelas* and *S. n. bilineatus* had peak abundance between 12H-14H and 14H-16H respectively (Fig. 4).

3.4 Diurnal Activity Rhythm of Female *Stomoxys* in the Forest Sites

In the forest, the diurnal activity pattern of female *Stomoxys* spp. revealed that *S. n. niger*, *S. omega* and *S. xanthomelas* had peak between 10H-12H; while *S. n. bilineatus* had peak abundance between 14H-16H (Fig. 5).

3.5 Diurnal Activity Rhythm of Male *Stomoxys* in the Anthropized Sites

In the anthropized milieu, the daily activity of the male *Stomoxys* spp. was unimodal with abundance peaks between 14H-16H (Fig. 6).

3.6 Diurnal Activity Rhythm of Female *Stomoxys* in the Anthropized Sites

The diurnal activity trend of female *Stomoxys* spp. in the anthropized sites showed peak abundance between 14h-16H (Fig. 7).

4. DISCUSSION

Plenty of Stomoxyinae were collected during the prospection period in the two biotopes. The abundance gotten in this study was higher than that obtained by Mounioko et al. [18]. This difference could be related to the trapping effort. Five species of the genus *Stomoxys* spp. were identified in our survey, i.e. 71.43% of *Stomoxys* spp. of Gabon [19]. This result was lower than the number captured by Mavoungou et al. [7]. This difference could be linked to the limited number of sites prospected. In the present study, two environments were surveyed notably: INP and Village-Town, whereas the study of Mavoungou et al. [7] in Makokou was in three sites (primary forest, secondary forest and the village). The 5 species of *Stomoxys* captured in the present study was present in the list of 6 species identified by Dibakou et al. [20] at the Moukalaba-Doudou National Park (MDNP) in Gabon. *S. calcitrans* was only captured in the Village-Town trapping points and was absent at

the INP. This absence of *S. calcitrans* in the forest of the INP could be linked to the unfavorable environmental factors for their development and survival, the short prospection period and the trap-type used.

The species composition of *Stomoxys* according to sex showed that females were more abundant than males. This result was like that of Solórzano et al. [21]. In fact, female dominance could be explained by the fact that females were more active and more attracted to blue or black tissue traps during search for blood meal host, resting as well as breeding sites [22,23,24].

Stomoxys spp. were abundant in the forest than in the man-made environment. This observation corroborates with that of Mounioko et al. [18]. This similitude can be explained by a high distribution of wild animals in the surveyed environment which are blood meal host for *Stomoxys* spp. [25]. Thus, the study of Mavoungou et al. [19] showed that manure from wild droppings and domestic waste favoured the development of the various *Stomoxys* spp.

The overall ADT of *Stomoxys* spp. was higher in Village-Town than in the forest of the INP. This result was like that of Mounioko et al. [18] at the MDNP. This similarity could be due to the high degree of anthropization as previously reported by Mavoungou et al. [19] and Zumpt [3] that highly inhabited environments favoured the proliferation of *Stomoxys*. Also, the landscape of the Village-Town environment that generated the micro-habitats favorable for the development of *Stomoxys* spp. consisted of low tree cover that allowed high degree and duration of luminosity in this environment as compared to the sites in INP. Consequently, increasing the visibility of traps to flies, hence increasing their efficacy.

The peak activity of *Stomoxys* spp. was unimodal in the Village-Town and the forest of the INP. This result is like that of Mavoungou et al. [26] and Phasuk et al. [27]. These observations could be related to environmental conditions (humidity, host temperatures, etc.). The present survey focused on Stomoxyinae fauna of the forest of the INP and its environs. However, information on other important hematophagous dipterous groups like glossines and tabanids is underway in order to provide baseline information for their control in this important touristic site of the country.

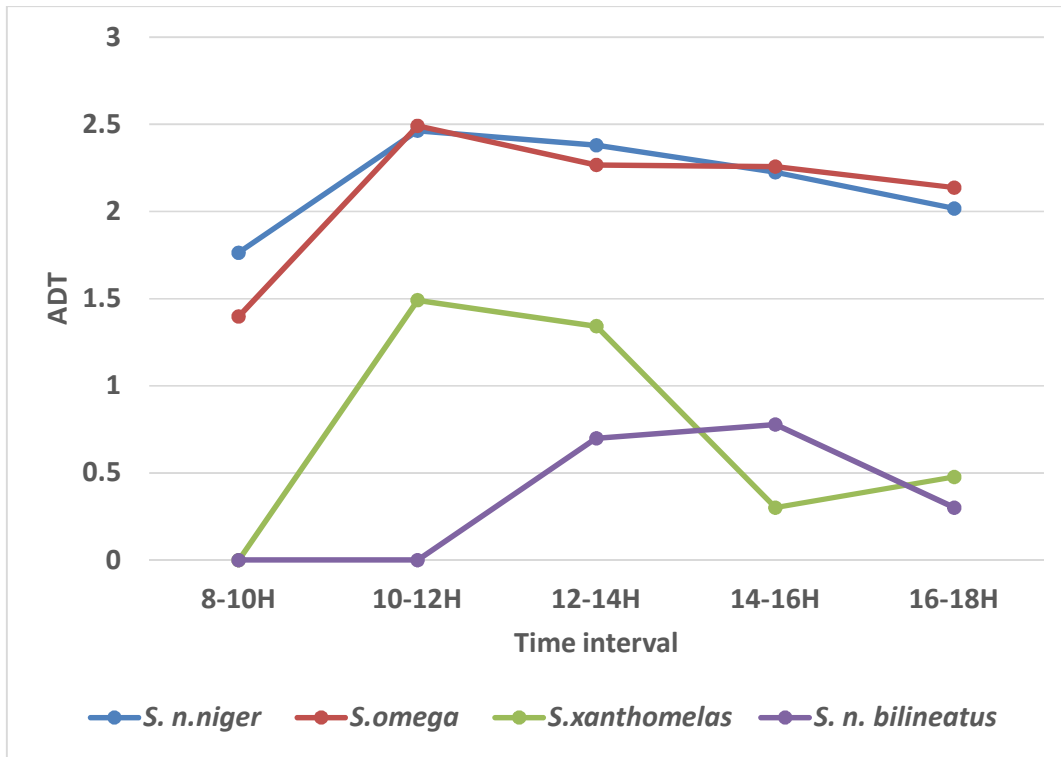


Fig. 5. Diurnal activity rhythm of female *Stomoxys* spp. in the forest

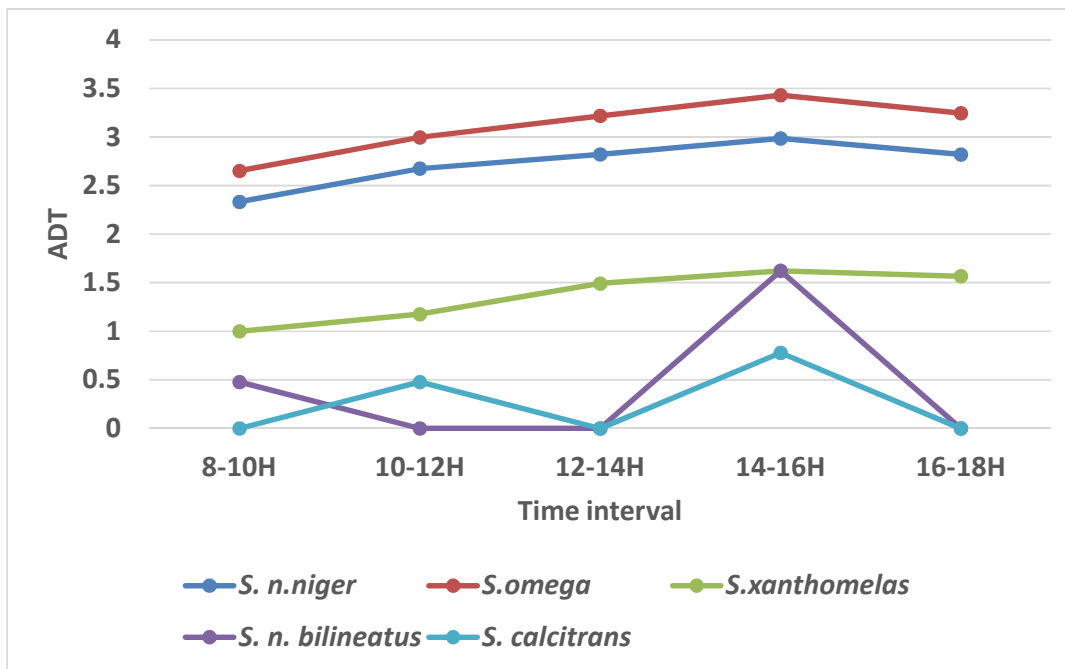


Fig. 6. Diurnal activity rhythm of male *Stomoxys* spp. in the anthropized milieu

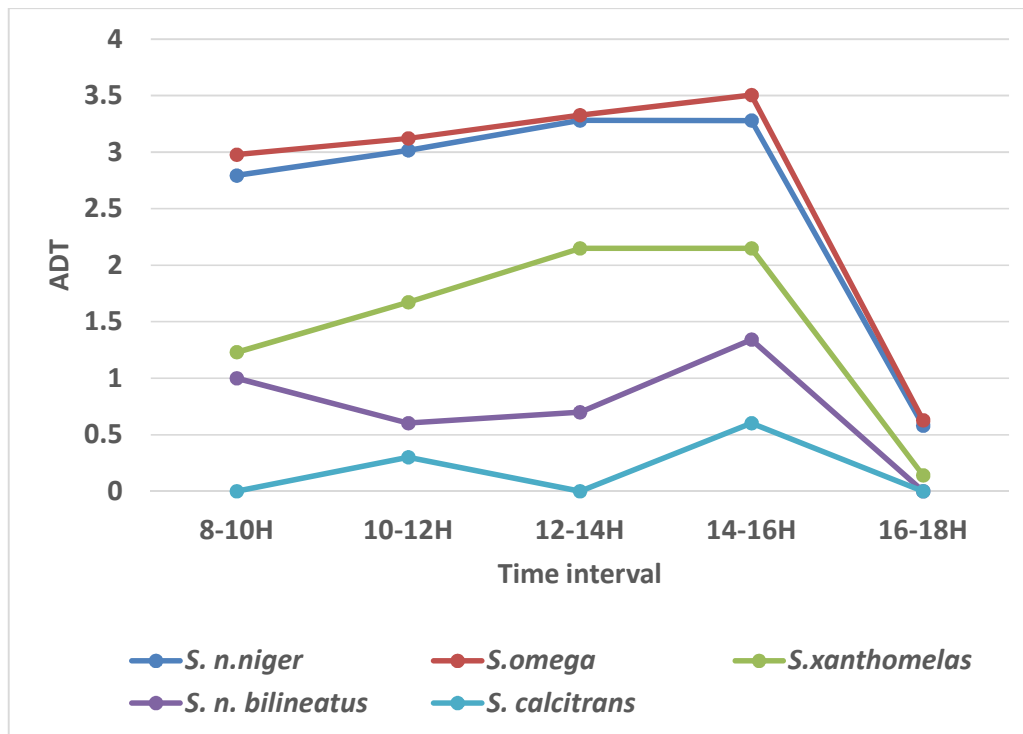


Fig. 7. Diurnal activity rhythm of female *Stomoxys* spp. in the anthropized milieu

5. CONCLUSION

Stomoxys spp. were highly encountered in the wildlife human interface. A total of 5 species of *Stomoxys* were identified in the anthropized environment (*Stomoxys niger niger*, *Stomoxys omega*, *Stomoxys calcitrans*, *Stomoxys xanthomelas* and *Stomoxys niger bilineatus*) and 4 species in forest (*S. n. niger*, *S. omega*, *S. xanthomelas*, and *S. n. bilineatus*) with *S. n. niger* more dominant at the INP environments while *S. omega* was dominant in the Village-Town. *S. calcitrans* was only found in the Village-Town trapping sites but was absent at the INP forest. *Stomoxys* were more abundant in the Village-Town ecosystem as compared to the INP. *Stomoxys* spp. showed a unimodal activity peak in the prospected microenvironments.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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