ISSN 1996-3351

# Asian Journal of Biological Sciences

Knowledgia
SCIENTIFIC
A Place to Publish Outstanding Research

http://knowledgiascientific.com

OPEN ACCESS Asian Journal of Biological Sciences

ISSN 1996-3351
DOI: 10.3923/ajbs.2019.898.904

# Research Article
# Spatio-temporal Dynamics of Glossines, Tabanids and Stomoxyids in the Dodéo Plain, Adamawa, Cameroon

[1]Sieumeni Djonguep André, [2]Kohagne Tongue Lisette, [1]Abah Samuel, [2]Fako Hendji Christian, [3]Sevidzem Silas Lendzele, [4]Mamoudou Abdoulmoumini and [1]Nukenine Elias Nchiwan

[1]Faculty of Sciences, University of Ngaoundere, P.O. Box 454, Ngaoundere, Cameroon
[2]Association for the Fight Against Parasitoses, P.O. Box 13173, Yaounde, Cameroon
[3]Post Graduate School of Higher Institutes, Laboratory of Vector Ecology, P.O. Box 13354, Libreville, Gabon
[4]Department of Parasitology and Parasitological Diseases, School of Veterinary Medicine and Science, University of Ngaoundere, P.O. Box 455, Ngaoundere, Cameroon

## Abstract

**Background and Objective:** The Dodéo plain is a bovine trypanosomiasis foci, but no information exists on its vectors. The present survey aimed at studying the dynamics of vectors of trypanosomosis to fill the gap. **Materials and Methods:** Two sites were identified: an open grass savanna with the presence of a stream bordered by a gallery forest and the other consisted of trees and shrub savanna. In each site, a cattle pen was built and Nzi and Biconical traps pitched beside. Fly collection was carried out in four consecutive days of the collection months [October 2012 (end rainy season) to January 2013 (dry season)]. **Results:** Three genera of fly-vectors were captured with apparent trap densities: *Glossina* (0.25 f/td), *Tabanus* (1.09 f/td) and *Stomoxys* (5.59 f/td). Three species of tsetse flies (*Glossina morsitans*, *Glossina fusca* and *Glossina nashi*), three species of tabanids (*Tabanus taeniola*, *Tabanus biguttatus* and *Tabanus gratus*) and two species of stomoxyids (*Stomoxys calcitrans* and *Stomoxys niger niger*) were identified. Only *Tabanus* differed significantly with capture sites. Populations of all the three genera showed significant difference between months. **Conclusion:** Three species of glossines, three species of tabanids and two species of *Stomoxys* were identified as vectors of trypanosomosis in the Dodéo plain.

Key words: *Glossina*, *Tabanus*, *Stomoxys*, spatio-temporal dynamics

Citation: Sieumeni Djonguep André, Kohagne Tongue Lisette, Abah Samuel, Fako Hendji Christian, Sevidzem Silas Lendzele, Mamoudou Abdoulmoumini and Nukenine Elias Nchiwan, 2019. Spatio-temporal dynamics of glossines, tabanids and stomoxyids in the dodéo plain, adamawa, Cameroon. Asian J. Biol. Sci., 12: 898-904.

Corresponding Author: Sieumeni Djonguep André, Faculty of Sciences, University of Ngaoundere, P.O. Box 454, Ngaoundere, Cameroon
Tel: +237 697386362



Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

In most African countries, animal production in general and cattle breeding are the main activities of several populations[1,2], as they represent an important sector that cannot be ignored in poverty reduction and economic growth. The development of this sector faces several constraints and one of them is bovine trypanosomosis which remains in the veterinary field, one of the major pathological constraints for the development of livestock in sub-saharan Africa[3]. It hampers animal production[4] in nearly 7-8 million km$^2$, which nevertheless offers strong fodder and agricultural potential. One quarter of the economic losses due to all animal diseases in Africa south of the Sahara are attributed to trypanosomosis[5].

In Cameroon, the Adamawa region, which accounts for one-third of the national herd population, is not free from bovine trypanosomosis[2]. The appearance of tsetse flies (*Glossina morsitans* sub *morsitans*, *Glossina tachinoides*, etc.) on the Adamawa plateau occurred[6] in the 1950s. To fight against this disease, the Special Mission for the Eradication of Glossines (MSEG) was created in 1974 for this purpose. The tsetse control unit carried out a massive aerial spraying with insecticides since 1976, which allowed the freeing-up of up to 32 000 km$^2$ of pasture land[2]. After the 1994 tsetse eradication activities, the Adamawa plateau was sub-divided into three zones notably infested zone, non-infested and buffer by the MSEG to ease intervention activities. However, the Faro and Deo where the locality of Dodéo was situated, consisted of a pasture area with highest glossines infestation[7,8] as well as trypanosomosis infection rate (61.1%)[2]. The major sources of tsetse and other vectors re-infestation of the Dodéo plain were the two parks (Gashaka and Faro) that bordered it. The present study seeks to provide current information on the fauna of the vectors of bovine trypanosomosis in the infested zone of Dodéo, more than 20 years after the tsetse eradication campaign by focusing on their abundance and population dynamics.

## MATERIALS AND METHODS

**Study area:** The entomological prospection was carried out in the Dodéo basin, located 60 km from the Mayo Baléo district in the Faro and Deo division of the Adamawa region (Fig. 1). The Faro and Deo division was located between Latitude 7° and 8° North and between Longitude 12° and 13° East, surface area[9] of 11,000 km$^2$ and shared boundary with Nigeria (250 km). It was bordered to the north by the Faro game reserve, to the south by Djérem and Mayo-Banyo, to the east by Vina and to the west by the Nigerian forest reserve

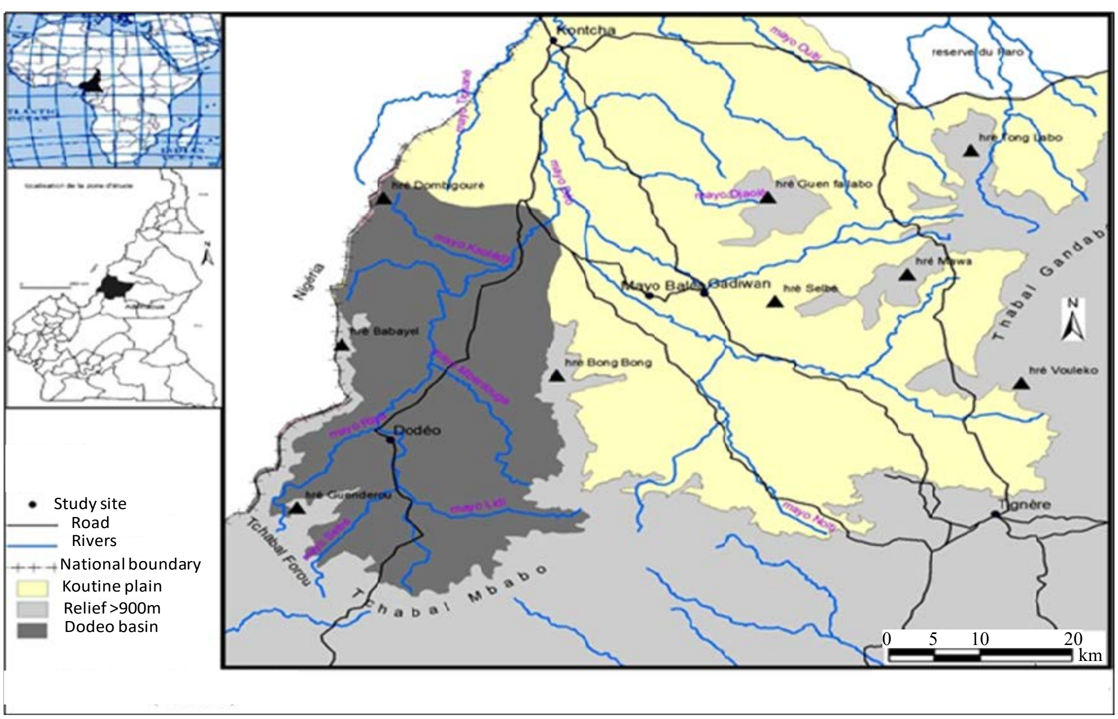


Fig. 1: Location of the study area
Source: Special mission for the eradication of glossines, 2015

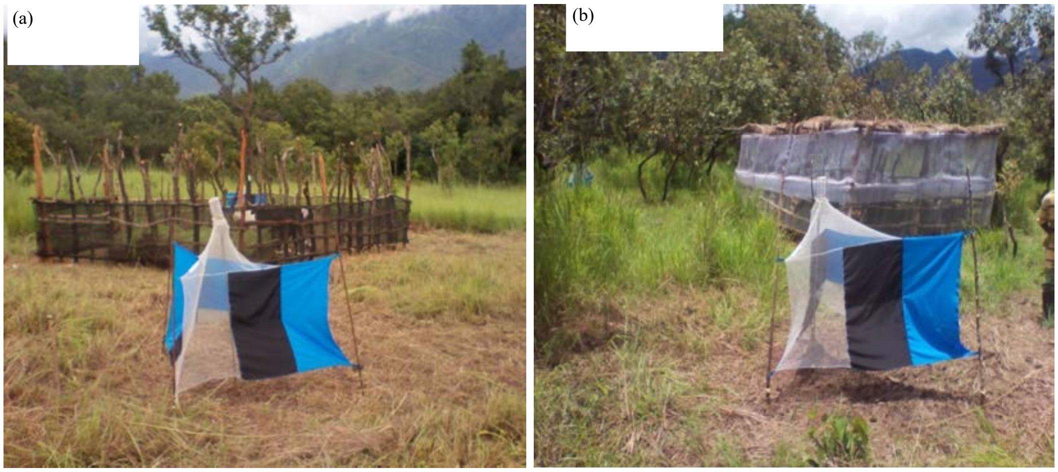


Fig. 2(a-b): Display of trapsin the sampling sites

(Gashaka). It was characterized by two seasons: a dry season from November-March (marked by intense pastoral activity with herds from the Adamawa Plateau and neighboring Nigeria that spent the transhumance period) and a rainy season from April-October. The climate was of mild Sudanese-Guinean type in the mountainous areas and Sudano-Sahelian in the plain areas, with an average annual temperature of 28°C and average rainfall[10] of about 1200 mm year$^{-1}$. The vegetation cover consisted of a shrub, grass savanna punctuated by gallery forests and dominated by *Daniellia oliveri* and *Lophira lanceolata*[11]. There was a herbaceous part with *Hyparrhenia* and *Panicum* conditioned by anthropogenic factors (grazing, bush fires and clearing), edaphic and climatic. Agriculture and livestock breeding are the important activities of the indigenes of the region.

**Entomological prospection:** The study was carried out from October 2012 (late rainy season) to January 2013 (dry season). Two sites, 1 km from each other were considered for trapping with characteristics: site 1 (low vegetation cover, closer to a stream and bordered by a gallery forest) and site 2 (tree and shrub savanna). In each site, a pen was constructed and cattle kept inside (Fig. 2a, b). At the four corners of the pen (5 m apart), two Nzi traps[12] and two Biconical traps[13] all georeferenced (GPS) were diagonally pitched North West-South East and North East-South West. Hematophagous flies were captured for 4 consecutive days per month. Traps were set and activated on the eve of catch days before 10 am and removed after the 4th collection day. Collection of fly-vectors was between 9 am and 11 am.

**Fly identification:** Daily identification of the flies was carried out at the laboratory of the special mission for the eradication of glossines (MSEG) under a binocular microscope, according to the morphological criteria defined by Pollock[14] for tsetse flies and by Desquesnes *et al.*[15] for stomoxyids and tabanids.

**Data analysis:** Abundance data was transformed by the square root formula and then subjected to the analysis of variance (one-way ANOVA) using a statistical software that enabled the execution of statistical tests. The Student-Newman-Keuls test was used to compare trap apparent densities (level of significance p<0.05) and the Student's test was used to compare populations of different vectors between sites and traps. The abundance of captured flies was defined by trap apparent density (ADT), which represented the number of specimens of each species caught per trap and day:

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

## RESULTS

**Genus composition:** Three genera were identified notably *Stomoxys* that was most abundant with a mean catch density of 5.59±0.56, followed by *Tabanus* (1.09±0.25) and by the genus *Glossina* (0.25±0.00) (Table 1).

**Species composition:** The genus *Glossina* comprised of three species: *Glossina nashi* (56%), *Glossina morsitans* (40%) and

Table 1: Fly-vectors composition (October, 2012 to January, 2013)

| Fly-vectors | Number | ADT (f/t/d) | Proportion (%) |
|---|---|---|---|
| *Glossina morsitans* | 13 | 0.10±0.10 | 40.00 |
| *Glossina fusca* | 1 | 0.01±0.01 | 4.00 |
| *Glossina nashi* | 18 | 0.14±0.04 | 56.00 |
| Total *Glossina* spp. | 32 | 0.25±0.05 | 100.00 |
| *Tabanus* spp. | 114 | 0.89±0.23 | 81.65 |
| *Tabanus taeniola* | 13 | 0.10±0.03 | 9.18 |
| *Tabanus biguttatus* | 6 | 0.05±0.02 | 4.59 |
| *Tabanus gratus* | 6 | 0.05±0.02 | 4.59 |
| Total *Tabanus* spp. | 139 | 1.09±0.25 | 100.00 |
| *Stomoxys* spp. | 712 | 5.56±0.55 | 99.47 |
| *Stomoxys niger* | 1 | 0.01±0.01 | 0.18 |
| *Stomoxys calcitrans* | 2 | 0.02±0.01 | 0.36 |
| Total *Stomoxys* spp. | 715 | 5.59±0.56 | 100.00 |
| By catches | 2352 | 18.38±2.26 | 100.00 |

ADT(f/t/d): Trap apparent density (fly per trap per day)

Table 2: Fly-vectors composition with site (October 2012-January, 2013)

| Fly-vectors | Site 1 | Site 2 | t-value | P |
|---|---|---|---|---|
| *Glossina morsitans* | 0.12±0.04 | 0.08±0.04 | 0.80 | ns |
| *Glossina fusca* | 1.56e-02±1.562e-02 | 0.00±0.00 | 1.00 | ns |
| *Glossina nashi* | 0.16±0.07 | 0.12±0.047 | 0.37 | ns |
| Total *Glossina* spp. | 0.30±0.08 | 0.20±0.060 | 0.94 | ns |
| *Tabanus* spp. | 1.43±0.43 | 0.34±0.12 | 2.46 | * |
| *Tabanus taeniola* | 0.12±0.05 | 0.08±0.04 | 0.80 | ns |
| *Tabanus biguttatus* | 0.07±0.04 | 0.03±0.03 | 0.63 | ns |
| *Tabanus gratus* | 0.07±0.04 | 0.03±0.02 | 0.71 | ns |
| Total *Tabanus* spp. | 1.69±0.46 | 0.48±0.14 | 2.50 | * |
| *Stomoxys* spp. | 6.19±0.82 | 4.93±0.74 | 1.12 | ns |
| *Stomoxys niger* | 1.57e-02±1.56e-02 | 0.00±0.00 | 1.00 | ns |
| *Stomoxys calcitrans* | 0.00±0.00 | 3.12e-02±2.19e-02 | 1.42 | ns |
| Total *Stomoxys* spp. | 4.75±0.637 | 6.42±0.90 | 1.51 | ns |
| Others | 18.93±3.17 | 17.81±3.24 | 0.24 | ns |

Density±standard error, ns: Non significant = $p>0.05$, *$p<0.05$

*Glossina fusca* (4%). For tabanids, three species were identified: *Tabanus taeniola*, *Tabanus biguttatus* and *Tabanus gratus*. Of the stomoxyids collected, *Stomoxys niger* and *Stomoxys calcitrans* were identified (Table 1).

### Vector collection with site

**Genus composition with site:** The overall density of *Glossina* and *Tabanus* differed statistically ($p<0.05$) with sites. Tabanids were statistically significantly higher in site 1 (low-wood savanna vegetation, near a stream bordered by a gallery forest) with ADT of 1.69 tabanids/trap/day as compared to site 2 (woody savanna and shrub). *Stomoxys* was most abundant in site 1 (6.19 stomoxyids/trap/day) and site 2 (4.93 stomoxyids/trap/day) whereas, the genus *Glossina* was rare in both sites (Table 2).

**Collection based on trap-type:** There was a statistical significant difference ($p<0.05$, $t = 2.91$) in the abundance of glossines caught with traps, where the Nzi trap (0.20±0.060) caught more glossines than its Biconical (0.10±0.039) counterpart. The genus *Tabanus* was highly caught using the Nzi trap (2.12±0.456) than the Biconical (0.04±0.026) with a statistical significant difference ($p<0.001$, $t = 4.54$) (Table 3).

**Monthly dynamics of collected flies:** The maximum abundance was observed during the month of November and minimum in January. The genus *Stomoxys* was the most frequent during prospection months and the genus *Glossina* was rare (Fig. 3). Tsetse fly densities were significantly higher in October and November than in other months. Tabanids were significantly higher in November, but stomoxyids were significantly lower in January (Fig. 3).

The monthly distribution of glossines revealed that *Glossina nashi* showed a statistically significant difference in its abundance as compared to others in the month of October (Fig. 4a). It was interesting to know that all the *Glossina* spp. (*Glossina morsitans, Glossina fusca* and *Glossina nashi*) reported in this study occurred only in October. But in November, December and January only two species (*Glossina morsitans* and *Glossina nashi*) were represented

Table 3: Fly-vectors composition with respect to trap-types (October, 2012 to January, 2013)

| Fly-vectors | Biconical trap | Nzi trap | t-value | P |
|---|---|---|---|---|
| *Glossina morsitans* | 0.04±0.026 | 0.15±0.050 | 1.90 | ns |
| *Glossina fusca* | 0.00±0.00 | 1.57e-02±1.562e-02 | 1.00 | ns |
| *Glossina nashi* | 0.06±0.030 | 0.21±0.075 | 1.92 | ns |
| Total *Glossina* spp. | 0.10±0.039 | 0.20±0.060 | 2.91 | * |
| *Tabanus* spp. | 0.00±0.00 | 1.79e00±4.263e-01 | 4.17 | *** |
| *Tabanus taeniola* | 0.00±0.00 | 2.03e-01±5.536e-01 | 3.66 | *** |
| *Tabanus biguttatus* | 0.00±0.00 | 9.37e-02±4.838e-02 | 1.93 | ns |
| *Tabanus gratus* | 0.04±0.026 | 0.04±0.034 | 0.00 | ns |
| Total *Tabanus* spp. | 0.04±0.026 | 2.12±0.456 | 4.54 | *** |
| *Stomoxys* spp. | 6.82±0.949 | 4.29±0.537 | 2.31 | * |
| *Stomoxys niger* | 1.56e-02±1.562e-02 | 0.00±0.00 | 1.00 | ns |
| *Stomoxys calcitrans* | 0.01±0.015 | 0.10±0.15 | 0.00 | ns |
| Total *Stomoxys* spp. | 5.39±0.732 | 5.78±0.840 | 0.35 | ns |
| Others | 8.82±1.443 | 27.92±3.95 | 4.54 | *** |

Density±standard error, ns: Non significant = p>0.05,*p<0.05, **p<0.01, ***p<0.001, t: Student t- test, P: Probability level

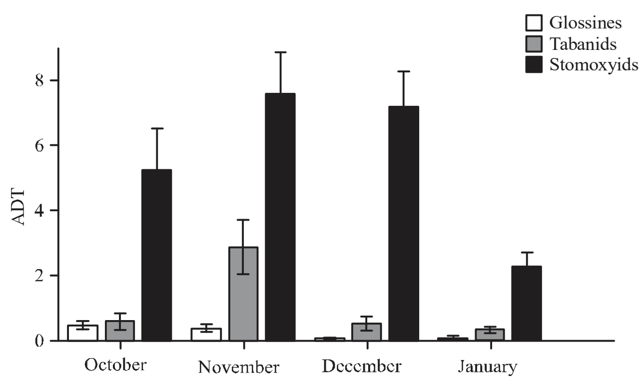


Fig. 3: ADT of different genera caught (October, 2012 to January, 2013)

(Fig. 4a). The *Tabanus* spp. showed a statistically significant difference in abundance, when compared to other *Tabanus* in October, November and December (Fig. 4b). For stomoxyids, it was interesting to observe that highest species occurrence was in October and dwindled across the other collection months (Fig. 4c).

## DISCUSSION

The results obtained in this study constitute vital in formation on animal trypanosomosis vectors in Dodéo in the Faro and Deo division. It confirmed the presence of tsetse flies, but above all, the presence of mechanical vectors whose high density relative to tsetse flies indicates their contribution to the mechanical transmission of trypanosomes in the Faro and Deo division[15,16]. The Nzi trap was more effective in the capture of tabanids[17,18] and savanna tsetse than biconical trap.

The low record of flies with sites can be explained by the relative short prospection period, limited number of sites (two sites) and survey period. In November, the dry season began with the absence of rains necessary for the emergence of adults and intense heat that inhibited the activity of flies. These results are like those obtained by Mavoungou *et al.*[19,20] in Gabon, that showed that rainfall provoked the emergence of hematophagous Diptera. Similarly, the phenomenon of transhumance observed in Dodéo from December with herds previously treated with insecticides could explain why an overall low catch was recorded.

The non-significant difference in the abundance with sites can be explained by the small distance between the sites. Indeed, according to Bailey *et al.*[21] and Bouyer[22], flies can travel for several kilometers in search of food and more favorable conditions. This ubiquitous distribution could be explained by the presence of a fixed food source (cattle in pens) in each site.

Tabanids were significantly more abundant in site 1. This could be explained by an ecological preference due to its location closer to gallery forest and a watercourse that provided suitable environmental conditions (temperature and relative humidity) for their activity and survival. Acapovi *et al.*[17] reported the high occurrence of tabanids in gallery forest in a similar study in Ivory Coast. This difference could be explained by the differences in landscape. Indeed, site 2 consisted of trees, that limited the illumination of the site as well as the visibility of the traps therefore, hindering their effectiveness[23].

Some species were present and dominant in both sites like *G. nashi*, *G. morsitans* and *T. taeniola*. Their presence in both sites could be explained by the ecological and behavioral adaptation of these species. Ovazza *et al.*[24] and Acapovi *et al.*[17] showed that *T. taeniola* was a species found in all biotopes. The presence of certain species such as *G. fusca* in one site (site 1) was thought to be due to an ecological preference. However, Sevidzem *et al.*[8] showed their preference for wetlands in the Faro and Deo division.

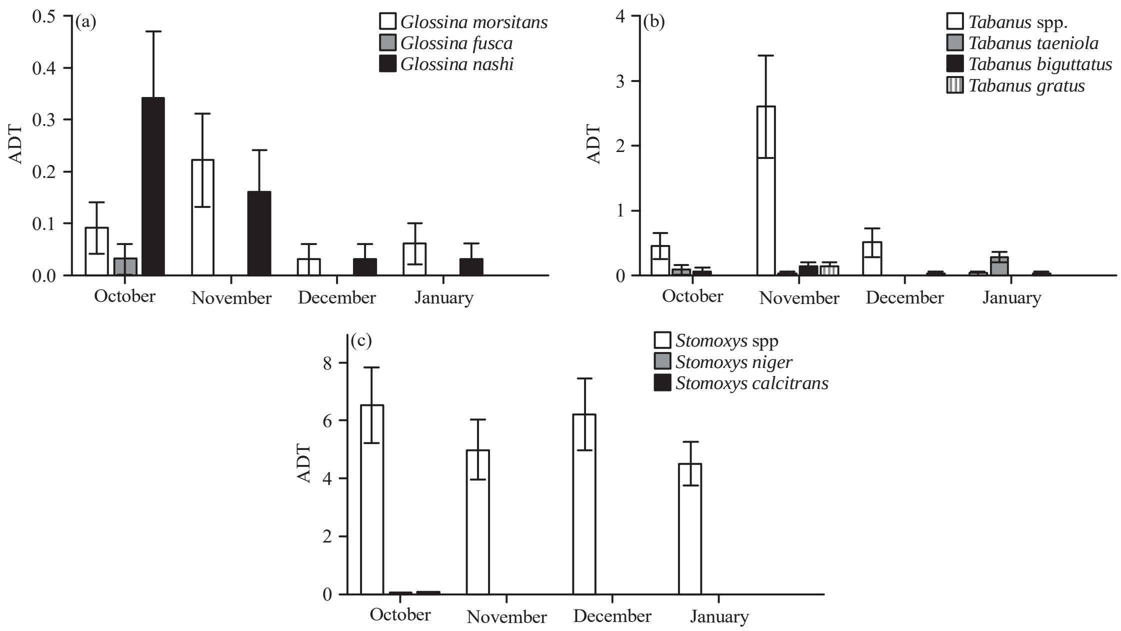


Fig. 4(a-c): Number (ADT±standard error) of different species: (a) *Glossina*, (b) *Tabanus* and (c) *Stomoxys* (October, 2012-January, 2013)

The maximum catch was observed during the month of November (early dry season). This peak catch in November could be related to the recent cessation of rainfall that created favorable climatic conditions for the emergence of adults (relatively high temperature, humidity and absence of precipitation). The tsetse fly-catch turnover was significantly high in October and November (late rainy season and early dry season) and low during the dry season. These results were like those obtained by Arthur *et al.*[25] in south-Cameroon, where they showed that a very low hygrometry stressed tsetse flies and limited their activity.

## CONCLUSION

This inventory recorded different vectors (biological and mechanical) of bovine trypanosomosis in Dodéo and their spatio-temporal dynamics. In total, three genera of vectors of trypanosomosis namely *Glossina*, *Tabanus* and *Stomoxys* were recorded and 8 species identified. Only members of the genus *Tabanus* differed significantly with sites. The abundance of these genera witnessed significant monthly fluctuations with high representation during the month of November. Given these results and the important pastoral potential of Dodéo, vector control should be put in place in this locality.

## ACKNOWLEDGMENT

Authors thank the indigenes of Dodéo for providing field assistance in the transportation of traps and personnels.

## SIGNIFICANCE STATEMENT

This study discovered *Glossina nashi* and *Glossina fusca* which are important vectors of human and bovine trypanosomosis. Also, the mechanical vectors of bovine trypanosomosis such as *Tabanus* (*T. taeniola*, *T. biguttatus* and *T. gratus*) and *Stomoxys* (*S. niger niger* and *S. calcitrans*) were identified. Their distribution differed with site, season and trap-types. This study will help the researchers to uncover the critical areas in the epizootiology of bovine trypanosomosis, that many researchers were not able to explore. Thus a new theory on the mechanical transmission of bovine trypanosomosis and control may be arrived at.

## REFERENCES

1. FAO., 1985. Yearly productivity: Author's calculations. Animal Health and Production No. 25, Food and Agriculture Organization of the United Nations, Rome, Italy.

2. Tanenbe, C., H. Gambo, A.G. Musongong, O. Boris and M.D. Achukwi, 2010. Prevalence of bovine trypanosomosis in the Faro and Deo and Vina divisions in Cameroon: Outcome of 20 years of tsetse control. Rev. Elev. Med. Vet. Pay. Trop., 63: 63-69.
3. Mounioko, F., G.D. Maganga, J.F. Mavoungou, C.R.Z. Koumba and A.A. Koumba *et al*., 2018. Molecular screening of *Trypanosoma* spp. in *Glossina*, *Stomoxys* and Tabanids in the Moukalaba Doudou National Park (South-West, Gabon). World, 6: 52-61.
4. Smith, D.H., J. Pepin and A.H. Stich, 1998. Human African trypanosomiasis: An emerging public health crisis. Br. Med. Bull., 54: 341-355.
5. De Jaan, C. and S. Bekure, 1991. Animal health services in Sub-Saharan Africa: Initial experience and new approaches. Technical Paper No. 134, World Bank, Washington DC, USA.
6. Hurault, J., 1993. The experience of Banyo and Tibati witnessed as a result of tse-tse fly invasion (1990-1991). Report of the Special Mission for Tse-Tse Eradication, Cameroon.
7. Tongue, L.K., G.L. Acapovi-Yao, D. Kaba, S. Abah and E.N. Nchiwan, 2015. Updating tsetse distribution: Presence of *Austenina subgenus* group in Northern-Cameroon. J. Basic Applied Res. Int., 7: 66-72.
8. Sevidzem, S.L., A. Mamoudou, A.F. Woudamyata and P.A. Zoli, 2015. Contribution to the knowledge of ecodiversity and density of tsetse (Glossinidae) and other biting flies (Tabanidae and Stomoxyinae) in the fly controlled-infested livestock/wild life interface of the Adamawa plateau-Cameroon. J. Entomol. Zool. Stud., 3: 329-333.
9. Achukwi, M.D., J. Gillingwater, A.M.N. Nloga and G. Simo, 2013. Lack of evidence for sufficiently isolated populations of *Glossina morsitans submorsitans* on the Adamawa Plateau of Cameroon following geometric morphometric analysis. Adv. Entomol., 1: 1-7.
10. Mamoudou, A., A. Zoli, C. Tanenbe, J.P. Andrikaye and Bourdanne *et al*., 2006. Assessment of the resistance of cattle trypanosomes to diminazene aceturate and isometamidium chloride on the adamawa plateau in Cameroon using a field test and a test in mice. Rev. Elev. Med. Vet. Pay. Trop., 59: 11-16.
11. Rippstein, G., 1985. Study of the vegetation of Adamawa. Evolution, Conservation, Regeneration and Amelioration of A Pastured Ecosystem, Maisons-Alfort, France, Cirad-REMVT, pp: 74.
12. Lendzele, S.S., M. Abdoulmoumini and A.Y.G. Lydie, 2017. Spatial repartition of tabanids (Diptera: Tabanidae) in different ecological zones of North Cameroon. Biodivers. Int. J.., Vol. 1. 10.15406/bij.2017.01.00010.
13. Challier, A. and C. Laveissiere, 1973. A new trap for catching *Glossina*: Description and field trials. Cahiers ORSTOM, 11: 251-262.
14. Pollock, J.N., 1992. Training Manual for Testse Control Personnel, Volume 1: Tsetse Biology, Systematics and Distribution, Techniques. United Nations for Food and Agricultural Organisation, Rome, Italy, pp : 1-310.
15. Desquesnes, M., M.L. Dia, G.L. Acapovi and W. Yoni, 2005. Mechanical Vectors of Animal Trypanosomosis. Centre International de Recherche-Développement sur l'Elevage en zone Subhumide (CIRDES), France, pp: 1-67.
16. Desquesnes, M., 2004. Livestock Trypanosomoses and their Vectors in Latin America. OIE, Paris, France, ISBN: 9789290446347, Pages: 174.
17. Acapovi, G.L., Y. Yao, E. N'Goran, M.L. Dia and M. Desquesnes, 2001. Relative abundance of tabanids in the Savanna regions of Cote d'Ivoire. Rev. Elev. Med. Vet. Pay. Trop., 54: 109-114.
18. Zinga, K.R.C., Y.G.L. Acapovi, J.F. Mavoungou, K.L. Tongue, O.A.M. Nguema, O.P.K. Obame and M. Shango, 2013. Influence of season on the ecodistribution of glossines, tabanids and stomoxyids in Baï of Momba Makokou, Gabon. Agron. Afr., 25: 149-158.
19. Mavoungou, J.F., P. Jay-Robert, J. Gilles, E.A. Atsame and G. Duvallet, 2008. Ecology of stomoxys flies (Diptera: Muscidae) in Gabon. I. First survey in different ecological areas. Parasite, 15: 27-34.
20. Mavoungou, J.F., N. Picard, L.T. Kohagne, B. M'Batchi, J. Gilles and G. Duvallet, 2013. Spatio-temporal variation of biting flies, *Stomoxys* spp. (Diptera: Muscidae), along a man-made disturbance gradient, from primary forest to the city of Makokou (North-East, Gabon). Med. Vet. Entomol., 27: 339-345.
21. Bailey, D.L., T.L. Whitfield and B.J. Smittle, 1979. Flight and dispersal of the stable fly. J. Econ. Entomol., 66: 410-411.
22. Bouyer, J., 2009. Tse-tse, intelligent flies?-2nd part. Insects, 153: 23-24.
23. Mavoungou, J.F., B. Makanga, Y.G. Acapovi, M. Desquesnes and B. M'Batchi, 2012. [Abundance and species diversity of tabanids (Diptera) in the biosphere reserve Ipassa-Makokou (Gabon) during the rainy season]. Parasite, 19: 165-171.
24. Ovazza, M., A. Rickenbach and M. Valade, 1959. Tabanids of the bobo-dioulasso (Haute volta) region-distribution and annual pattern; some systematic notes. Bull. Soc. Pathol. Exot., 52: 679-698.
25. Arthur, M.M.J., T.J. Claude, M.J. Anselme and E. Jean-Pierre, 2011. [Trial on a small scale on the fight against *Glossina palpalis palpalis* (Robineau-Desvoidy, 1830) with Vavoua traps impregnated with insecticides in the forest zone of South-Cameroon]. J. Applied Biosci., 45: 3000-3007.