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## Seasonal comparison of vavoua, biconical and NGU traps for monitoring of *Glossina* (Diptera: Glossinidae) and *Tabanids* (Diptera: Tabanidae) in The Gambia

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### Abstract

This work shows the effective trapping method used in catching *Glossinidae* and *Tabanidae* species and their distribution in The Gambia. One hundred and eight-six traps were used in this study comprising of 62 Biconical traps, 62 NGU traps and 62 Vavoua traps for 50 trapping days. These traps were baited with at least 4 months old cow urine and acetone and they were deployed at a distance of 100 m apart. A total number of 517 flies belonging to the genus *Tabanidae* and *Glossinidae* were captured. This included: *Atylotus. agrestis* (55%), *Tabanus sourcouf* (0.4%), *Tabanus par* (1.2%) and *T. taeniatus* (1.4%), *Glossina morsitan submorsitan* (26%) and *Glossina palpalis gambiensis* (16%). However, *Atylotus agrestis* and *Glossina palpalis gambiensis* were the species that were mostly caught in this study. The present study also shows that, Lower River Region was the region with the highest number of *Tabanidae* species caught (85 catches, mean=20.7 and SD=16.76) while Central River Region-North also had the highest catch of *Glossinidae* species (52 catches, Mean= 14 and Sd=6.98). Late rainy season (October 2020) and late dry season (April 2020) were the seasons in which the highest number of *Tabanidae* and *Glossinidae* species were caught respectively. This study clearly demonstrated that, Biconical trap is the most effective trap that can be used to control the population of both *Glossinidae* and *Tabanidae* species in The Gambia.

**Keywords:** Biconical, Glossinidae, NGU traps, Tabanidae, Vavoua

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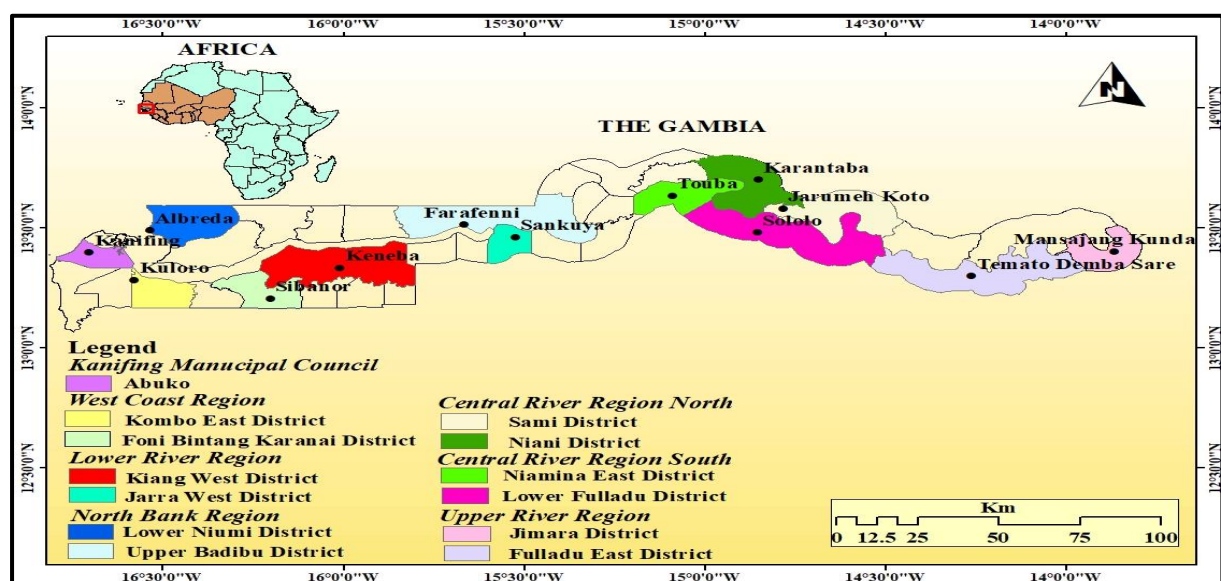
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## INTRODUCTION

The aim of this study was to determine the most effective trap for trapping Glossinidae and Tabanidae and to show their distribution in The Gambia. Tsetse flies belong to the order Diptera and suborder Brachycera. They are similar to Muscoidea, from which they differ mainly by the adaptation of their mouthparts to blood sucking (Solano *et al.*, 2010). Their single genus (*Glossina*) includes three subgenera and 31 species and subspecies. These subgenera are subgenus are; *Nemorhina* (also known as the *Palpalis* group), subgenus *Glossina Sensu lato* (*Morsitans* group) and subgenus *Austenina* (*Fusca* group). Tabanids also known as horse flies, deer flies, and march flies. They are piercing flies of the family Tabanidae and Order Diptera because they are true flies (Crooft *et al.*, 2017). They are of both medical and veterinary importance because the females of most species are blood feeders that can transmit several pathogens to a host as they feed on animals and humans (Sevidzem and Mavoungou, 2019). Pathogens transmitted by Tabanidae include bacteria, protozoa, helminths and viruses (Baldacchino *et al.*, 2014; Keita *et al.*, 2020). They are classified in the families of *Athericidae*, *Pelecorhynchidae* and *Oreoleptidae* in the superfamily *Tabanoidea* and along with *Rhagioidea* constitute the infra-order *Tabanomorpha* (Kerr, 2010; Morita *et al.*, 2016). Tsetse flies and tabanids are all known to transmit trypanosomes which causes African Trypanosomiasis in humans (Human African Trypanosomiasis) and animals (Animal African

Trypanosomiasis). The disease has undesirable effects on the hosts as it causes low productivity, leading to mortality when untreated. In livestock, some of the losses caused by the disease include abortion, low milk yield and death (Malele *et al.*, 2016). Traps essentially function through visual stimuli. In the field, the visual stimuli can be significantly obstructed by vegetation, mainly for forest species. In such instances, attraction of flies to traps is boosted through the use of odour attractants. Three groups of natural odours have been used so far from the host animals: those found in urine (e.g., phenols), breath (e.g., acetone) and skin secretions e.g., octenols (Kuzoe and Schofield, 2004). The response of tsetse, tabanids flies to particular odours differs amongst species (Kuzoe and Schofield, 2004). Vavoua trap has been seen to be very effective in catching tabanids in Cameroon (Lendzele *et al.*, 2017; Abdoulmoumini *et al.*, 2020) in Thailand by (Tunnakundacha *et al.*, 2017), NGU trap was also documented as the best trap for catching *Glossinidae* in Tanzania (Malele *et al.*, 2016) and Biconical traps has also been documented to be among the best traps for trapping tsetse flies (Kuzoe and Schofield, 2004). However, the comparative performance of several traps against the tsetse flies and tabanids species has never been documented before in The Gambia.

## MATERIALS AND METHODS



**Fig. 1: The study area in The Gambia (shown in colour)**

## Study area

A village or a constituency was chosen in all the administrative regions of The Gambia namely: Banjul (BJL), Kanifing Municipal Council (KMC), West Coast Region (WCR), Lower River Region (LRR), North Bank Region (NBR), Central River Region-South (CRR-S), Central River Region North (CRR-N) and Upper River Region (URR) (Figure 1). In each of the villages or constituency, two trapping sites were conveniently picked in such a way that each was either a Rivera habitat or a Savannah habitat, and this decision was based on the most likely preferred habitable area of these specie, since they are to live in either Rivera and Savanna habitat.

## Riverian ecosystem

The riverain sites in this study includes Banjul (Bond road), KMC (Steam corner), WCR (Kalagi), LRR (Soma), NBR (Farafenni), CRR-

N (Sinchu jenung), CRR-S (Kudang) and URR (Mansajang kunda). These habitats are mainly made up of swampy or wet land vegetation. The animals that may be found in this habitat includes birds, hippos, reptiles and aquatic organism. However, part of this area is usually used for rice cultivation and a drinking place for cattle. Tsetse fly's specie mostly found. includes *Glossina palpalis gambiensis*

## Savanah ecosystem

The savannah study areas include, Banjul (mile 2), KMC (Abuko nature reserve), WCR (Tanji), LRR (Kuli Kunda), NBR (Fass), CRR-N (Sami mandina), CRR-S (Yorro Berre Kunda) and URR (Mankamang kunda). These habitats are characterized by woodland vegetation. The wild animals found at include hyena, antelopes, rodents, snakes, birds, wild pigs and cattle rearing. *Glossina morsitan submorsitan* are known as savannah living species.

## Traps used in this study



**Fig. 2:** Traps used in seasonal monitoring in this study: (A) and (B) Biconical trap, (C) and (D) NGU trap, (E) and (F) Vavoua trap

A line transect survey was carried out using three traps, namely the Biconical trap as shown Fig. 2 (A) and Fig. 2 (B), NGU see Fig. 2 (C) & Fig. 2 (D) and Vavoua trap see Fig. 2 (E) & (F) in each of the villages selected for this survey. NGU and Vavoua traps used in this survey were made locally, using regular white mosquito net, phthalogen blue and black fabric. The Biconical trap was also made up of similar fabric but was obtained from the West Africa Livestock Center (WALIC) entomology unit. The traps were set for four seasons namely; Late Rainy (LR), Early Dry (ED), Late Dry (LD) and Early Rainy (ER) in all the eight administrative regions in The Gambia. Traps were set up at 0600 hour and cages were collected daily at 1800 hour (Tunnakundacha *et al.*, 2017). A total of 6 traps was used in each trapping village per region in a single season. Therefore, for the four seasons of sampling in this study across eight regions in The Gambia, a total of 186 traps comprising of equal number of traps were used in 50 trapping days. Each trap type was located at least 100 meters apart (Lendzele *et al.*, 2017). At each trap, the grasses were cut to the ground level and the legs of the trap were greased to avoid ants consuming caught flies. Each trap was baited using an attractant made from three to four months old cow urine and acetone, (Hargrove, 2003; Nnko *et al.*, 2016). Besides, aged urine is more attractive to tsetse and tabanids flies than fresh urine due to the development of both phenols and ammonia as the urine ages (Mihok and Lange, 2012). Flies were kept in a separate Eppendorf tube with 70% ethanol at room temperature until when needed for DNA extraction.

### Data analysis

Statistical Package for the Social Sciences software (version 25; SPSS Inc.; Chicago, IL, USA) and Excel Microsoft package was used to perform all the statistical analysis. Tables were used to show the distribution of all the flies caught in each site. One-way analysis of variance was used to analyze trap catches (number of flies collected per trap) in the field (Tunnakundacha *et al.*, 2017). The homogeneity of the variance and normal distribution of the variables were assessed with the tests of Levene. Means were compared using Duncan's multiple range test. Paired samples t test was done to compare means of the various traps with the catches in the region. An alpha value of 0.05 was used for all statistical tests. The abundance was determined by the Trap Apparent Density (TAD):

$$TAD = \frac{\text{No. of flies caught}}{\text{No. of traps} \times \text{No of trapping days}}$$

### Ethical statement

This study was approved by the Ethics Committee of the Ministry of Higher Education Science Research and Technology, The Gambia with the reference number AFG 85/272/01.

## RESULTS

### Identification and distribution of the species caught per region in The Gambia

Identification of the tabanids were carried out, based on morphological characteristics using published keys summarized by (Baldacchino *et al.*, 2012) and for Tsetse flies (Kuzoe and Schofield, 2004). The results were compared for relative efficiency in trapping different *Glossina palpalis* species and Tabanid species see Fig. 3A and 3B.

### The different *Tabanidae* and *Glossinidae* species identified and their distribution in The Gambia

A total of 517 flies were sampled in this study. This is comprised of 297 *Tabanidae* species and 220 *Glossinidae* species. The following species of *Tabanidae* and *Glossinidae* species were identified in this study:

Genus: *Tabanus* Linnaeus, 1758

a. *Tabanus* par. Walker, 1854

This species see Fig 3 (A) was only found LRR and CRR-S.

b. *Atylotus agrestis* Wiedemann 1828

This species was the most abundant in this study see Fig 3 (B) and 3 (C). It was highly sampled in LRR and CRR-S but was also common in all the other regions.

c. *Tabanus taeniatus* Macquart 1834

This species was only found CRR-S, CRR-N and LRR see Fig. (3D)

d. *Tabanus suffis* Jeanicke, 1567

It was only found in LRR and URR

Genus: *Glossinadae*

a. *Glossina morsitan submorsitan*

This specie was most abundant in LRR and CRR-S but were also common in all the other regions (Fig 3 E).

b. *Glossina palpalis gambiensis*

It was only absent in URR, KMC and BJL see Fig 3 (F). However, it was also abundant in CRR-S. The number of tabanids captured in this study were 297 (56%) and Tsetse flies 220(44%) (Tables 1 and 2). Based on the frequency of Glossinidae specie and Tabanidae species in this study, LRR had the highest TAD=0.44 and BJL had the lowest TAD=0.04 of Tabanidae species, as for the Glossinidae population surveyed, CRR-N had the highest TAD of 0.29 and BJL recorded the lowest TAD=0.05 (Table 3). All the sampling period shows

that, there was a statistical significance of all the trapping seasons in this study (Table 4).

**Seasonal catch of Glossinidae and Tabanidae per season**

Late rainy season (October 2020) had the highest number of *Tabanidae* species caught 96(32%) and late dry (April 2020) had the highest number of Glossinidae specie caught 73 (33.2%) in this study (Table 5).

**Performance of the various traps**

Biconical trap was the most effective in catching both *Tabanus* species 235(79%) and *Glossina* species 143(65%) among the traps used in this study (Tsable 6). Student t test result shows that, there was statistical significance between the traps and the region in which the trapping was done (Table 7).



**Fig. 3** Shows (A) *Tabanus par*, (B) and (C) *Atylotus agrestis*, (D) *Tabanus taenatus*, (E) *Glossina morsitans submorsitan* and (F) *Glossina palpalis gambiensis*

Table 1: Number of species of Glossinidae and Tabanidae caught per region in The Gambia

Species	LRR	CRR-N	CRR-S	URR	WCD	NBR	KMC	BJL	N	%
<i>Atylotus agrestis</i> Wiedemann 1828	79	64	42	19	39	25	10	4	282	95
<i>Tabanus taeniatus</i> Macquart 1834	0	5	1	1	0	0	0	0	7	2
<i>Tabanus sufis</i> Jeanicke, 1567	1	1	0	0	0	0	0	0	2	1
<i>Tabanus par</i> Walker, 1854	5	1	0	0	0	0	0	0	6	2
Total	85(29%)	71(24)	43(15%)	20(7%)	39(13%)	25(8%)	10 (3%)	4(1%)	297(57%)	
TAD	0.44	0.37	0.22	0.21	0.20	0.13	0.5	0.04		
<i>Glossina morsitan submorsitan</i>	47	20	14	16	5	9	19	5	135	61
<i>Glossina palpalis gambiensis</i>	6	36	17	0	13	13	0	0	85	39
Total	53	56	31	16	18	22	19	5	220	517
	(24%)	(26%)	(14%)	(7%)	(8%)	(10%)	(9%)	(2%)	(43%)	
TAD	0.28	0.29	0.16	0.17	0.09	0.11	0.1	0.05		

Table 2: Catches of *Tabanus* species per region in The Gambia

Region	Season	Number of Trap	Total catch	Mean	Sd	Total Catch
LRR	Late rainy	6	17	20.7	16.76	85
	Early dry	6	44			
	Late dry	6	18			
	Early rainy	6	4			
CRR-S	Late rainy	6	26	10.75	11.41	43
	Early dry	6	2			
	Late dry	6	13			
	Early rainy	6	2			
CRR-N	Late Rainy	6	25	17.75	7.72	71
	Early Dry	6	18			
	Late Dry	6	21			
	Early Rainy	6	7			
URR	Late rainy	6	5	17.5	4.97	20
	Early Dry	6	2			
	Late Dry	6	12			
	Early Rainy	6	1			
WCR	Late rainy	6	11	8.75	6.95	39
	Early Dry	6	4			
	Late Dry	6	19			
	Early Rainy	6	5			
NBR	Late rainy	6	7	4.75	4.11	25
	Early Dry	6	6			
	Late Dry	6	8			
	Early Rainy	6	1			
KMC	Late rainy	6	2	2.25	1.5	10
	Early Dry	6	4			
	Late Dry	6	1			
	Early Rainy	6	3			
BJL	Late rainy	6	1	1.0	1.0	4
	Early Dry	6	2			
	Late Dry	6	1			
	Early Rainy	6	0			

Key: LRR (Lower River Region), CRR-S (Central River Region- South), CRR-N (Central River Region-North), URR (Upper River Region), WCR (West Coast Region), NBR (North Bank Region), KMC (Kanifing Municipal council), BJL (Banjul).

## DISCUSSION

We used existing morphological keys to identify four *Tabanus* and *Atylotus* species in this research. *Atylotus agrestis*, *Tabanus taeniatus*, *Tabanus sufis*, and *Tabanus par* were among the 297 Tabanidae that were caught. Our findings matched those of Raymond *et al.*, 1980, who also sampled *A. agrestis*, *T. par*, *T. Sufis*, and *T. taeniolar* in Keneba village in the Lower River Region of The Gambia. This study's findings are comparable to those of Keita *et al.*, 2020, who used morphological methods to identify 143 *Tabanus* species in Casamance, Senegal. This study site is fewer than 9 kilometers from one of the current study's sites. *Atylotus agrestis* was found across The Gambia, in all seasons and in

all regions in the country. This species was discovered in both savannah and riverine ecosystems. It's possible that their large feeding range and wide range of temperature tolerance explains their habitat preference.

In this study, *Tabanus taeniatus* was found in the savannah or woodland areas of CRR-N (Sami Mandina village), CRR-S (Yorro Berre Kunda), and URR (Mankamang Kunde village). This could be due to the abundance of vegetation and the large cattle population found in these villages. *T. Sufis* was exclusively found in the LRR (Kuli kunda) and CRR-S riverain areas (Kundang village). *T. par* was only found in the LRR's woodland areas (Kuli Kunda village). *Tabanus. par* was also reported by Raymond *et al.*, 1980,

at Keneba village LRR, a few kilometers from Kuli kunda village. This species' affinity for this region could potentially be due to the vegetation and existence of a host.

*Glossina morsitan submorsitan* has been found in all savannah ecosystems across The Gambia. This finding differs from earlier research conducted between 1989 and 1990. *Glossina morsitan submorsitan* was not found in the southern regions of The Gambia, according to previous research conducted by (Rawlings *et al.*, 1993; Kargbo and Kuye, 2020). However, their presence in the southern part of The Gambia could be due to the changes in the climate

conditions of those settlements. *Glossina palpalis gambiensis* was also found in all of the study's riverian environments. Moreover, the findings of this study are consistent with those of Rawlings *et al.*, 1993. They discovered *G. p. gambiensis* in evergreen forest and woodland near the shore, as well as riparian habitats along the river Gambia and its main tributaries (Rawlings *et al.*, 1993). Different bio-geographical locations and humidity levels may have led to the occurrence of different species/genera of tabanids in different geographical places, resulting in the diversity of *Tabanida* and *Glossina* species caught (Lydie *et al.*, 2017).

Table 3: Catches Tsetse fly species per region in The Gambia

Region	Season	Number of Trap	Total catch	Mean	Sd	Total Catch
LRR	Late rainy	6	5	13.25	9.29	53
	Early dry	6	6			
	Late dry	6	18			
CRR-N	Early rainy	6	24	14	6.98	56
	Late rainy	6	24			
	Early dry	6	13			
CRR-S	Late dry	6	8	7.75	5.19	31
	Early rainy	6	11			
	Late Rainy	6	4			
URR	Early Dry	6	3	4	5.66	16
	Late Dry	6	14			
	Early Rainy	6	10			
WCR	Late rainy	6	0	4.5	1.73	18
	Early Dry	6	0			
	Late Dry	6	12			
NBR	Early Rainy	6	4	5.5	3	22
	Late rainy	6	8			
	Early Dry	6	4			
KMC	Late Dry	6	8	4.75	0.5	19
	Early Rainy	6	2			
	Late rainy	6	5			
BJL	Early Dry	6	5	1.25	0.5	5
	Late Dry	6	5			
	Early Rainy	6	4			
	Late rainy	6	1	1.25	0.5	5
	Early Dry	6	1			
	Late Dry	6	2			
	Early Rainy	6	1			

Key: LRR (Lower River Region), CRR-S (Central River Region- South), CRR-N (Central River Region-North, URR (Upper River Region), WCR (West Coast Region), NBR (North Bank Region), KMC (Kanifing Municipal council), BJL (Banjul).



Table 4: Analysis of variance for homogeneity of variances of the various catch during the season based on their mean

Season of sampling	Test of Homogeneity of Variances			
	Levene Statistic	df1	df2	P value
October	88.79	1	149	0.000*
December	4.03	1	109	0.047*
April	37.46	2	164	0.000*
July	9.57	1	85	0.003*

Table 5: Species of Tabanidae and Glossinidae caught per season

Species	Late rainy season	Early dry season	Late dry season	Early rainy season	Total	%
<i>Atylotus agrestis</i> Wiedemann 1828	90	78	90	24	282	95
<i>Tabanus taeniatus</i> Macquart 1834	3	1	2	1	7	2
<i>Tabanus sufis</i> Jeanicke, 1567	1	1	0	0	2	1
<i>Tabanus par.</i> Walker, 1854	2	2	2	0	6	2
Total	96(32%)	82(28%)	94(32%)	25(8%)	297	
TAD	0.15	0.13	0.15	0.04		
<i>Glossina morsitan submorsitan</i>	22	12	57	44	135	61
<i>Glossina palpalis gambiensis</i>	34	17	16	18	85	39
Total	56(26%)	29(13%)	73(33%)	62(28%)	220	
TAD	0.09	0.09	0.05	0.1		

Table 6: Number of species of Tabanidae and Glossinidae caught per traps

Species	Biconical	NGU	Vavoua
<i>Atylotus agrestis</i>	220	38	24
<i>Tabanus taeniatus</i>	7	0	0
<i>Tabanus surcouf</i>	2	0	0
<i>Tabanus par</i>	6	0	0
Total	235(79%)	38(13%)	24(8%)
<i>Glossina morsitan submorsitan</i>	92	24	19
<i>Glossina palpalis gambiensis</i>	51	12	22
Total	143(65%)	36(16%)	41(19%)

Table 7: Paired t test between the traps and the regions of trapping

Paired Samples Test								
Paired Differences								
Variable	Mean	Std. Deviation	Std. Error	95% Confidence level			df	P value
				Lower	Upper	t		
Biconical - Region	-1.80	1.60	0.09	-1.98	-1.62	-19.65	303	<0.001
NGU – Region	0.49	0.50	0.06	0.37	0.60	8.32	73	<0.001
Vavoua – Region	0.63	0.49	0.06	0.51	0.75	10.46	64	<0.001

On the basis of trap performance, Biconical traps caught the most Tabanidae species (235(79%), followed by NGU 24(38%). The Biconical trap grabbed the most Glossinidae species, 143 (65%), while the Vavoua trap

caught the second most, 41 (19%). However, our findings indicate that Biconical traps outperform NGU and Vavoua. This work, on the other hand, contradicts the findings of (Lendzele and François, 2019), who found out

that the Biconical trap was less effective than the NGU trap in catching Tabanidae specie in the Adamawa region of Cameroon. Lendzele et al., (2017), also found out that the Vavoua trap was more effective in trapping Tabanidae specie in Northern Cameroon and in Tanzania. Malele *et al.*, 2016 reported that, the NGU trap was more efficient in trapping *Glossina* species. The biconical trap was the only trap that could catch both Tabanidae and Glossinidae species in practically all of the trapping sites used in this investigation. During the early rainy season in Banjul, all of the traps fail to catch at least one Tabanidae species. Furthermore, in LRR during the early dry season and in URR during the late rainy season and early dry season, all traps failed to capture a *Glossina* specie.

## CONCLUSION

This work shows that, the Biconical trap is the most efficient and effective trap that can be used to sample both Tabanidae and Glossinidae species in The Gambia. Additionally, it also indicates that Biconical trap could be used in the controlling of Tabanidae and Glossinidae specie in the country. Since *Dipterans* where both caught in all the administrative regions of The Gambia, their presence however could pose the greatest risk to animals and humans in contracting *Vesicular stomatitis* virus, Swine fever virus, Anthrax, Rabbit fever, *Anaplasmosis*, Lyme disease (Black-legged), *Besnoitia besnoiti*, *Haemoproteus metchnikovi* and *Trypanosomiasis*. Moreover, since late rainy season (October) and late dry season (April) were the seasons in with the highest catches of *Tabanidae* and *Glossinidae* species in The Gambia, control measures of flies could be specifically targeted during this period. However, other studies can focus on the molecular identification of the origin blood meal of these vectors in other to control the epidemiology of haemoparasites confirmed in them. we also recommend that, other studies to focus on niche suitability modeling of *Glossinidae* and *Tabanidae* specie under the changing climatic conditions in The Gambia.

## Conflict of Interest

The authors declare that there are no conflicts of interest

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