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RESEARCH ARTICLE

AN UPDATE ON THE DISTRIBUTION OF GLOSSINA DIPTERA: GLOSSINIDAE) AT PROTECTED RESERVE 2012-2019), BURKINA FASO

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ABSTRACT

Tsetse flies Diptera: Glossinidae) are the biological vectors of the trypanosomes responsible sleeping sickness in humans and African animal trypanosomiasis AAT) in domestic animals in sub-Saharan Africa. Ecological factors, climate change and habitat fragmentation affect distribution in tsetse flies. but little information is available in the conserved areas. The objective of our study is to update information on the distribution and density of tsetse flies in the protected area of Folonzo, in the southwest of Burkina Faso. For the sampling and monitoring of tsetse flies, the transect method was used. Each transect consisted of 5 biconical traps set from the bank of the stream to the savannah. The total of 25 traps 5 transects) were collected every 24 hours and for 5 days per season. The overall density of the 4 tsetse species initially encountered *G. tachinoides*; *G. palpalis gambiensis*, *G. morsitanssubmorsitans* and *G. medicorum*) in 2012, was reduced by 87.11% in 2019, $p<0.001$) .However, no capture of *G. m. submorsitans* was only observed in 2019. The influence of the season effect on tsetse density has not been verified. This study shows that tsetse populations in conservation areas are also affected by the impact of climate change and human pressure. These pressures can lead to extinction *G. m. submorsitans*) , scarcity *G. tachinoides*) and the resilience *G. p. gambiensis*) of some species. Knowledge of tsetse distribution is an important component in understanding the dynamics of trypanosome transmission in order to effectively control AAT.

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INTRODUCTION

Human African Trypanosomiasis HAT or sleeping sickness) and African Animal Trypanosomiasis AAT) are deadly parasitic diseases specific to sub-Saharan Africa. These neglected tropical diseases are caused by protozoa of the genus Trypanosoma transmitted by tsetse flies tsetse fly) of the genus Glossina. The medical and economic impact of African trypanosomiasis transmitted by tsetse flies is considerable for affected countries Kabayo, 2002; Alsan, 2015) .One of the strategies to control these trypanosomoses is to interrupt the chain of transmission by eliminating the vector and preventing new infections Laveissière & Penchenier, 2005) .Vector control tools traps and tiny target impregnated with insecticide, etc.) are available and showed their effectiveness during control campaigns Rayaissé *et al.*, 2010; Mahamat *et al.*, 2017; Rayaisse *et al.*, 2020) .

However, the implementation of these control and planning actions is limited by the dynamics of the spatio-temporal distribution of vector populations, induced by certain environmental factors biotic and abiotic) Allou *et al.*, 2009) . Habitat type, water availability, seasonal climate variations and hosts availability, determine tsetse distribution, abundance and transmission of trypanosomiasis Chikowore *et al.*, 2017; Gashururu *et al.*, 2021). Although the impact of climate change CC) on the epidemiology of trypanosomiasis remains a matter of speculation, the various scenarios predict many changes in tsetse fly distribution McDermott *et al.*, 2002; Nnko *et al.*, 2021) . Tsetse diversity and abundance would be negatively affected. McDermott et al 2002) demonstrated that CCs would impact AAT in semi-arid and sub-humid areas of West Africa by 2050. In West Africa, recent studies showed that these CCs and demographic changes would drive the northern limit of tsetse to the south Courtin *et al.*, 2009, 2010) In Burkina Faso, during the last ten years, the slackening of the surveillance of protected areas has led to profound changes in the environment: poaching, presence of domestic animals, deforestation, etc... Salou *et al.*, 2012; Rayaissé *et al.*, 2015) .In the protected area of Folonzo, for example, a locality in the department of Niangoloko, located in southwestern Burkina Faso, changes in the distribution of tsetse species linked mainly to anthropogenic factors have been reported Rayaissé *et al.*, 2009; Rouamba *et al.*, 2009) .Four tsetse species were reported in 2012 Salou *et al.*, 2012; Rayaissé *et al.*, 2015) , *Glossina G.*) *tachinoides* the dominant species with 80% of the total catch) and *G. palpalis gambiensis*; both belonging to the Palpalis group, then *G. morsitanssubmorsitans* Morsitans group) and *G. medicorum* Fusca group) . Several faunal species are encountered, antelopes, warthogs, hippos, monitor lizards and reptiles crocodiles and snakes) Salou *et al.*, 2012; Rayaissé *et al.*, 2015) .These wild animals in the reserve were the main food hosts for tsetse. A recent study in this locality showed that landscape changes would lead to a reduction in the diversity of tsetse species encountered Fauret *et al.*, 2015) . *G. morsitanssubmorsitans* is progressively decreasing in this protected area. However, this observation has been verified particularly in the non-protected areas Fauret *et al.*, 2015; Mweempwa *et al.*, 2015) . This study aims to update information on the abundance, diversity, and seasonal variation of tsetse fly populations in the Comoé-Léraba Reserve between 2012 and 2019. This information is important for the implementation of a tsetse and AAT control strategy in southwest Burkina Faso.

MATERIALS AND METHODS

Study area: Entomological surveys were conducted in the Comoé-Léraba classified forest and partial wildlife reserve near the locality of Folonzo ~09° 54′ N, 04° 36′ W) , located in the department of Niangoloko in southwest Burkina Faso.The reserve occupies an area of 124,510 hectares and is characterized in part by abundant vegetation forest galleries, wooded and grassy savannahs) and diversified Rayaissé *et al.*, 2015) .Gallery forests have also been established along the Comoé River, which is the main water course in the area. Several fauna species are encountered in the conservation area: antelopes, warthogs *Phacochaerusaethiopicus*) , hippopotamuses *Hippopotamus amphibius*) , monitor lizards *Varanusniloticus*) and other reptiles crocodiles and snakes) , which are the main feeding hosts of the tsetse Rouamba *et al.*, 2009; Salou *et al.*, 2012) .

Entomological Surveys: In 2012, two entomological surveys were conducted in the dry season January 2012) and wet season May 2012) . These same surveys were repeated at the same sites as the first study, in January 2019 for the dry season and June 2019 for the wet season. For estimation of tsetse densities, the transect method described by Rayaissé et *al.* 2015) was used. This method consisted of deploying 25 biconical traps Challier & Laveissière, 1973) georeferenced with a GPS Global Positioning System) .Five radial transects were formed, from the bank of the Comoé River to the savannah forest. The distance between two adjacent transects was estimated to be about 1.5 to 2 km. Each transect consisted of 5 biconical traps from the river bank to the savanna. Adjacent trapswere 200-300 m apart Figure 1) . Tsetse flies were captured for 5 consecutive days during each season. Daily collections were made and tsetse flies were counted by species and sex. The abundance of tsetse flies was estimated by the apparent density per trap per day ADT) using the formula: ADT= N/ P*D)

N= number of tsetse flies captured

P= number of traps

D= number of days of capture

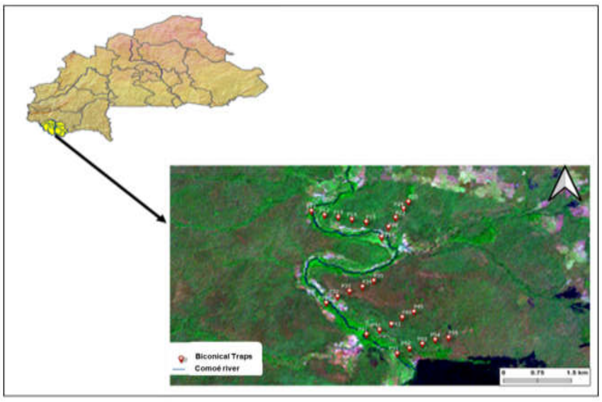

Figure 1. Disposition of the 5 transects along the Comoé River.For each transect, the 5 biconical traps were set from the river bank to the savanna and the interval between two traps varied between 200-300 m

Statistical analysis: The Generalized Linear Model was used GLM) . Species, season and period of capture were the explicative variables; then the number of tsetse captured was the quantitative variable. The capture means were submitted to an analysis of variance ANOVA) using R software version 4.0.2 R-Development-core-team, 2010) . For all of our analyses, the maximum value of the significance level retained was 0.05.

RESULTS

Entomologicalsurveys : A total of 3241 tsetse flies were captured during the entomological surveys, distributed into 2870 individuals in 2012 ADT= 5.74 tsetse flies/trap/day) and 371 individuals in 2019 ADT= 0.74 tsetse flies/trap/day) , a reduction of 87.11%. Results showed a significant reduction in overall tsetse densities between 2012 and 2019, with ADTs of 5.74 tsetse/trap/day and 0.74 tsetse/trap/day respectively, $p < 0.001$) . The proportions for tsetse species composition were: 7.28% for *G. palpalis gambiensis*, 77.60% for *G. tachinoides*, 13.88% for *G. morsitanssubmorsitans* and 1.24% for *G. medicorum* Table1) .

Table 1. Number of tsetse fly captured by species, sex, and period 2012 and 2019)

Species	Sex	Number of tsetse captured		
		2012	2019	Total
G. palpalisgambiensis	M	76	64	
	F	71	25	
	Total	147	89	236
G. tachinoides	M	1115	155	
	F	1120	125	
	Total	2235	280	2515
G. morsitanssubmorsitans	M	188	0	
	F	262	0	
	Total	450	0	450
G. medicorum	M	21	1	
	F	17	1	
	Total	38	2	40
			Total	3241

Tsetse population distribution from 2012 to 1019: Analysis of tsetse species diversity in the study area shows the presence of four tsetse species in 2012 versus three species in 2019. *Glossina m.submorsitans* was not captured in 2019. The analysis shows a predominance of *G. tachinoides* regardless of the survey year Table 3) . The total number of tsetse flies captured in 2012 was 2870 versus 371 in 2019.

Thus, the results showed a significant reduction in overall tsetse fly population from 5.74 in 2012 to 0.74 in 2019 $p < 0.001$) . A significant $p < 0.001$) decrease in *G. tachinoides* population was also evidenced nevertheless this species remains dominant in the study area. However, the ADTs of the two resilient species, *G. palpalis gambiensis* and *G. medicorum*, reminded relatively stable, 0.57 vs. 0.34 $p = 0.196$) and 0.07 vs. 0.02 $p = 0.06$) respectively Table 2 and Figure 2) .

Table 2. Evolution of the specific density of tsetse between 2012 and 2019 in the Comoé-Léraba reserve

Species	Sex	Captures means 2012	Captures means 2019	*P-value*
G. palpalisgambiensis	M	0.328	0.272	0.596
	F	0.24	0.072	0.088
	Total	0.568	0.344	0.196
G. tachinoides	M	4.88	0.856	0.001**
	F	5.912	0.808	0.002**
	Total	10.792	1.664	0.001**
G. morsitanssubmorsitans	M	0.864	0	0.0001***
	F	1.184	0	0.0001***
	Total	2.048	0	0.0001 ***
G. medicorum	M	0.008	0.008	1
	F	0.064	0.008	0.0495 *
	Total	0.072	0.016	0.0666

Significance of codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '1. M: male; F: female

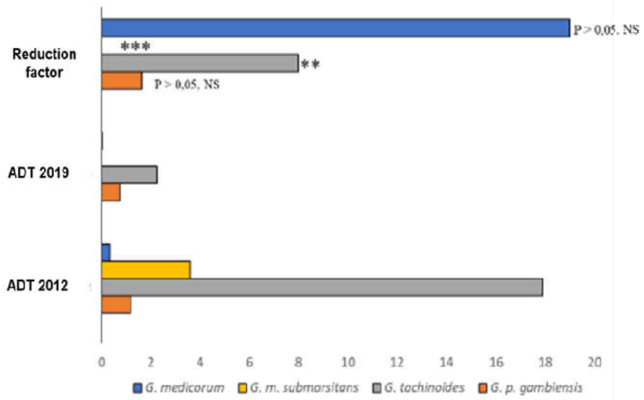

Figure 2. Apparent densities and reduction factors of the tsetse population from 2012 to 2019

Seasonal variation in catches: Between 2012 and 2019, catches were higher in the wet season than in the dry season. For each period of catch, the ADTs did not show significant seasonal fluctuations. Indeed, in 2012 the differences in catches between the dry season and the rainy season, were not significant for the 4 species present that are *G. p. gambiensis*, *G. tachinoides*; *G. m. submorsitans* and *G. medicorum* Table 3) . In 2019, the results were similar to those observed in 2012 Table 4) .

DISCUSSION

According to the results obtained, the abundance and diversity of tsetse have declined significantly over time in the Folonzo Protected Area. This progressive decline in tsetse densities is not affecting all four sympatric species. In fact, two existential situations were observed. These are the inadaptation of certain tsetse species with the result that the population is progressively reduced *G. tachinoides*) or eliminated *G. m. submorsitans*) . In addition to this situation and despite environmental constraints, some species showed a resilience capacity, in particular *G. p. gambiensis* and *G. medicorum*. Reduction in tsetse fly densities and species composition have been previously reported Fauret *et al.*, 2015; Rayaissé *et al.*, 2015) .

This was most often established in degraded areas whose main causes were due to the degradation of the vegetation cover the tsetse fly habitat) to agricultural activities and the disappearance of wild animals, a source of blood meal. In our study, tsetse fly habitat did not degrade between 2012 and 2019. The vegetation cover appears to be still preserved as there is no cultivation activity in the reserve. This study showed a profound mutation in the abundance and diversity of tsetse flies. As an example, the dominant species *G. tachinoides* present in 2012 was replaced by *G. p. gambiensis* in 2019. For the first time, this study also showed the disappearance of *G. m.submorsitans* in the protected area. This absence of the species was clearly confirmed by several field missions conducted in the same area until February 2021 Salou, Personal Communication) .

In our case, trophic preference would be the main factor that drives the dynamics of abundance and diversity of species. Indeed, some authors had suggested that the maintenance of the species *G. m. submorsitans* would be linked to the presence of wild feeding hosts as a source of blood meal Courtin *et al.*, 2009; Rayaissé *et al.*, 2015) . The rarity of wild animals due to poaching and especially the introduction of domestic animals cattle and sheep) into the reserve by pastoralists in quest of better pasture for their livestock, have certainly modified the diet of tsetse. This change in diet may affect the presence and density of tsetse species to different degrees. *G. tachinoides* and *G. p. gambiensis*, riparian species, known to be opportunistic Clausen *et al.*, 1998) , would have the ability to adapt their diet to the available food hosts domestic and wild host species) Weitz, 1963) .But this capacity of adaptation within this group would be variable according to the species, which explains the maintenance of *G. p. gambiensis* and the decrease in density of *G. tachinoides*.

This difference could be explained by the hypothesis of Challier Challier, 1973) on trophic impregnation, which states that "the first host on which a tsetse fly feeds would then increase the probability that it will feed again on a host of the same species". *G. tachinoides*, accustomed to feeding on wild hosts, would tend to become loyal as suggested by some authors for other species Channumsin *et al.*, 2021; Makhulu *et al.*, 2021) ,but the massive introduction of livestock in the reserve would have perturbed its feeding behavior and consequently its life history trait. For *G. p. gambiensis*, its ability to adapt is clearly proven. In a decade, this species has become the main vector of trypanosomiasis in the anthropized areas of West Africa.

Table 3. A tsetse apparent density of tests ADT) by species and season in 2012

Species	Dry season 2012)			Wetseason 2012)		Total ADT 2012)
	Abundance n; %)	ADT		Abundance n; %)	ADT	
G. p. gambiensis	76 6.41)	0.608		71 4.21)	0.568	1.176
G. tachinoides	886 74.77)	7.088		1349 80.06)	10.792	17.88
G. m. submorsitans	194 16.37)	1.552		256 15.2)	2.048	3.6
G. medicorum	29 2.45)	0.232		9 0.53)	0.072	0.304

Tableau 4. Apparent density of tsetse ADT) by species and season in *2019*

Species	Dry season 2019)		Wetseason 2019)		Total ADT 2019)
	Abundance n; %)	ADT	Abundance n; %)	ADT	
G. p. gambiensis	46 38.98)	0.368	43 17)	0.344	0.712
G. tachinoides	72 61.02)	0.576	208 82.21)	1.664	2.24
G. m. submorsitans	0	0	0	0	0
G. medicorum	0	0	2 0.79)	0.016	0.016

This study also confirms its resilience to other species in sympatry in the conserved area. In addition, this resilience could have epidemiological significance because this vector could be a link between the sylvatic and domestic cycles of animal trypanosomes in the locality Makhulu *et al.*, 2021) .The occurrence of *G. m. submorsitans* had been reported in this protected area Bouyer *et al.*, 2005; Rayaissé *et al.*, 2015) , but for the first time we observed that the species disappeared. The unsuitability of the feeding behavior of *G. m. submorsitans* in relation to domestic hosts, would therefore be the main factor of its extinction. Its acquired trophic preference for wild animals, which have become rare, has strongly contributed to the decline and disappearance of its population.Seasonal variations in population densities showed the abundance of tsetse in the wet season compared to the dry season although the difference was not significant. This result was observed in Rwanda in *G. pallidipes* and *G. morsitanscentralis* Gashururu *et al.*, 2021) , in *G. pallidipes* and *G. fucipes* in Ethiopia Eyasu *et al.*, 2021) . This result could be explained by the captures made at the beginning of the rainy season, which coincided with the growth phase in the tsetse population dynamics. However, contrary observations have been made on dry season abundance in Côte d'Ivoire Djohan *et al.*, 2015) and Cameroon Abah *et al.*, 2019) .

CONCLUSION

These spatio-temporal changes also affected tsetse fly populations in the conserved areas and may result in the emergence of a resilient species *G. p. gambiensis*) capable of transmitting sylvatic trypanosome species circulating in the protected area in addition to the main known animal species. This situation could have consequences on the epidemiology of trypanosomiasis, especially since not all trypanosome species have been identified in the protected area Salou, personal communication) . Thus, the combined effects of hosts, vegetation, and climate affect the abundance and distribution of flies.

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