Spatial distribution of tsetse flies in some areas within western, eastern and northern regions of Ghana

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Abstract

Accurate identification of tsetse fly endemic-foci using spatially explicit maps could be important in the strategic control of tsetse flies. This survey presents spatially explicit maps of tsetse flies in some tsetse fly-endemic areas in the Western, Eastern and Northern Regions of Ghana. Field samplings for tsetse flies using randomly positioned unbaited-biconical traps were carried out from August to October 2016 in New-Juaben (6°10′29′′N, 0°18′57′′W), Jomoro (5°1′52′′N, 2°41′5′′W), West Gonja (9°15′35′′N, 1°51′25′′W) and West Mamprusi (10°17′19′′N, 0°38′56′′W) Districts of Ghana. Tsetse flies were present in all districts except in West Mamprusi. Overall, three species were collected: *Glossina palpalis, G. tachinoides* and *G. morsitans submorsitans. Glossina palpalis* were the most widely distributed, being present in three districts (West Gonja, New-Juaben and Jomoro). However, *G. tachinoides* and *G. m. submorsitans* were present only in West Gonja, in the Mole Game Reserve Area. It is expected that these data would be useful in the planning, execution and monitoring of tsetse fly control programmes in the sampled areas. However, there is need to cover wider areas which would enhance an update of the national tsetse fly map.

Keywords: Tsetse fly; map; control; Ghana.

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Introduction

African Animal Trypanosomosis (AAT) is a disease of livestock and wild animals caused by pathogenic trypanosomes and transmitted cyclically by tsetse flies. The disease is present in an area of approximately 10 million km^2 in sub-Saharan Africa where it is endemic in 37 countries with over 70 million livestock at risk of infection (Bauer *et al* 2011). Annual agricultural losses due to AAT are estimated at 4 billion US dollars (Kuzoe and Schofield, 2004). Across Ghana's land mass, the spatial distribution of tsetse is over 60% (Alhassan *et al* 2004).

In view of the economic consequences of AAT and recent upsurge of the disease after long period of relaxation of control activities, efforts by the Pan African Tsetse and Trypanosomosis Eradication Campaign (PATTEC) programme towards the eradication of the disease (Kuzoe and Schofield, 2004) are a welcomed development. In order to consolidate the activities of PATTEC, locating areas where tsetse flies are present could be a basic important step (Cecchi *et al* 2014).

Tsetse maps are evidence-based decision-making tools needed in identification of tsetse-endemic areas which could be useful in designing, monitoring and evaluating tsetse control programmes (Cecchi and Mattioli, 2009; Cecchi and Gilbert, 2011). Furthermore, spatially-explicit tsetse maps could assist in understanding possible effects of environmental factors on tsetse fly distribution as well as predict suitable tsetse habitats (Moore and Messina, 2010). Tsetse fly surveillance efforts could lead to identifying mechanical vectors in the disease epidemiology over an area which might be critical in the strategic control of the disease (Ahmed *et al* 2016; Thumbi *et al* 2010).

Despite the importance of tsetse fly surveillance, survey efforts are sparse in Ghana even though recently PATTEC is planning to determine the spatial distribution of tsetse flies across the country (Yahaya Adam, 2016, personal communication). However spatial information on tsetse species are often unknown at the district level in areas where AAT is reportedly endemic (TTCU, 1997; Nakayima *et al* 2012; Apaatah, 2014). Also, climate change may have influenced the presence/absence of tsetse flies as well as the species type in some locations overtime (McDermott *et al* 2002). Thus, this study sought to identify species of tsetse flies in the surveyed areas with spatial map to show and describe the apparent fly density, that would add to the pool of available tsetse fly data on tsetse fly belts for future comprehensive delineation and update of national tsetse fly distribution map for Ghana.

Materials and methods

Study areas

Tsetse fly sampling activities were carried out in four AAT-endemic districts of Ghana: namely West Mamprusi, West Gonja, Jomoro and New-Juaben (Table 1). West Mamprusi and West Gonja Districts are in the Northern Region, while Jomoro and New-Juaben Districts are in the Western and Eastern Regions, respectively (Figure 1). The Northern Region is in the guinea savannah, the Western Region in the tropical rainforest zone, while the Eastern Region is semi-deciduous forest zones. The Northern, Western and Eastern Regions have mean annual rainfalls of 1,000 mm, 2,200 mm and 1,500 mm respectively. All the sampling areas had habitats suitable for tsetse flies and are subjected to moderate anthropogenic activities except the Mole National Game Reserve in the West Gonja District.

Table 1. Elevation and coordinate description of sampling sites within each district in the three Eastern, Western and Northern regions.

Region	District	Sampling sites	Coordinates		Elevation (m)
			Latitude (N)	Longitude (W)	
Eastern	New-Juaben	Suhyen Mpaem	6°9'49"	0°19'27"	186
		Akwadum Mpaem	6°8'11"	0°21'49"	179
		Asuogya	6°10'2"	0°17'34"	204
		Asuogya stream	6°9'59"	0°17'35"	195
		Kofikrom	6°10'29"	0°18'57"	190
		Thomson village	6°9'46"	0°17'43"	192
		Yaw Kumi	6°9'56"	0°17'35"	202
Western	Jomoro	Ahwake	5°1'52"	2°41'5"	3
		Allowule Junction	5°2'17"	2°42'10"	20
		Nawulley	5°2'17"	2°43'27"	25
		Nyame Kwame	5°2'44"	2°42'44"	32
		Nyanke	5°3'14"N,	2°42'4"	7
Northern	West Gonja	Mole Game Reserve	9°15'35"	1°51'25"	138
		Mongnori	9°17'49"	1°46'20"	125
	West Mamprusi	Moatani	10°17'31"	0°39'39"	138
		Kparigu	10°17'19"	0°38'56"	140
		Bugyia	10°14'19"	0°43'15"	127

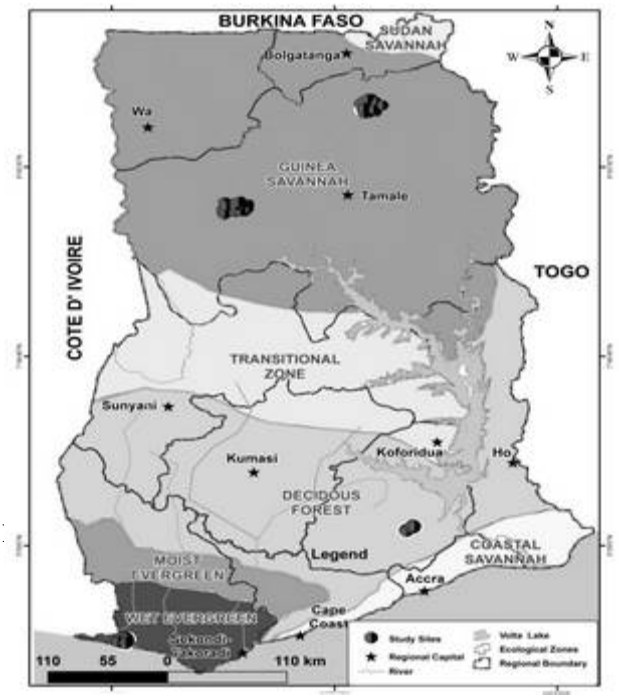

Figure 1. Map of Ghana showing study areas.

Tsetse fly sampling

Sampling activities were conducted from August to October 2016 across 17 sites; 7 sites (Kofikrom, Asuogya, Asuogya stream, Shuyem Mpaem, Akwadum Mpaem, Thomson Village and Yaw Kumi) in the Eastern Region and 5 each in the Western (Nyanke, Nawulley, Nyame Kwame, Allowule Junction, Ahwake) and Northern (Bugyia, Moatani and Kparigu in West Mamprusi and; Mole Game Reserve and Mongori in West Gonja) Regions. Tsetse flies were sampled using 64 randomly positioned unbaited-biconical traps; 20 traps each in West Mamprusi and West Gonja Districts, and 12 traps each in New-Juaben and Jomoro districts. Average distances between traps were: 0.18± 0.22 km, 0.18 ± 0.22 km, 0.34 ± 0.86 km, 0.49 ± 1.38 km and 0.03 ± 0.05 km in West Mamprusi, West Gonja, Jomoro and New-Juaben Districts, respectively. Coordinate data of trap locations were taken using the Geographic Position System and then further processed using ArcGIS (version 10.4). Trapped tsetse flies were harvested after 24 hours and then identified using morphological feature (FAO, 1982).

Results

Of the four districts sampled, tsetse flies were caught in only three: West Gonja, Jomoro and New-Juaben. A total of 1,729 (517 ♂, 1,212 ♀) tsetse flies were trapped: 54 *Glossina palpalis*, 719 *G. tachinoides* and 8 *G. morsitans submorsitans* in West Gonja; 110 *G. palpalis* in New-Juaben and 838 *G. palpalis* in Jomoro (Table 2). No tsetse fly was caught in the West Mamprusi District and in 2 sites (Suhyem Mpaem and Asuogya Stream) in the New-Juaben District. Tsetse flies were present at all sites in the Western Region. One species *Glossina palpalis* was present in all the 3 districts (West Gonja, Jomoro and New-Juaben) while *G. tachinoides* and *G. m. submorsitans* were restricted to the West Gonja District (Table 2).

Table 2. Species, numbers and apparent densities of tsetse flies collected during sampling in New Juaben, Jomoro and West Gonja Districts of Ghana (August to October, 2016).

Region/ District	Sampling sites (elevation, coordinates)	Total No. of tsetse flies	*G. palpalis*	*G. tachinoides*	*G. m. submor-sitans*	Apparent density (flies/trap/ day)
			♂/♀	♂/♀	♂/♀	
Eastern New-Juaben	**Suhyen Mpaem**	0	0/0	0/0	0/0	0
	Akwadum Mpaem	4	0/4	0/0	0/0	**0**.5
	Asuogya	22	9/13	0/0	0/0	1.16
	Asuogya stream	0	0/0	0/0	0/0	0
	Kofikrom	68	24/44	0/0	0/0	2.34
	Thomson village	15	9/6	0/0	0/0	1.5
	Yaw Kumi	1	1/0	0/0	0/0	0.5
Western Jomoro	**Ahwake**	436	159/277	0/0	0/0	31.14
	Allowule Junction	234	109/125	0/0	0/0	16.71
	Nawulley	21	8/13	0/0	0/0	5.25
	Nyame Kwame	52	15/37	0/0	0/0	6.5
	Nyanke	95	20/75	0/0	0/0	11.88
Northern West Gonja	**Mole Game Reserve**	409	1/4	56/340	3/5	25.56
	Mongnori	372	14/35	89/234	0/0	12.4
West Mamprusi	**Moatani**	0	0/0	0/0	0/0	0
	Kparigu	0	0/0	0/0	0/0	0
	Bugyia	0	0/0	0/0	0/0	0

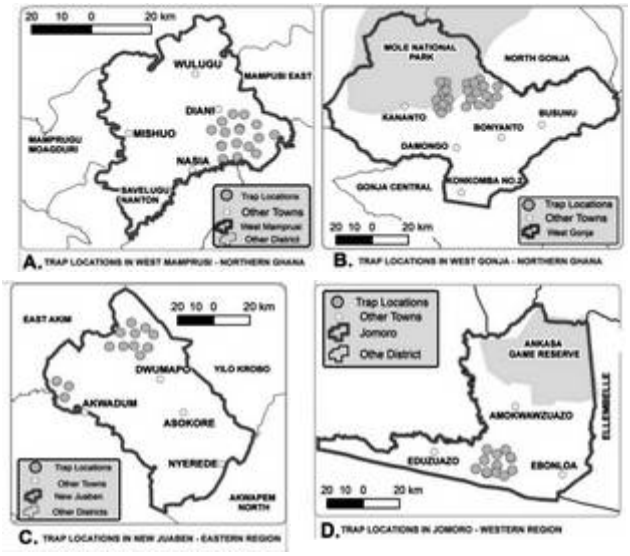

Figure 2. Maps (A-D) showing locations of traps used in sampling for tsetse flies in West Mamprusi, West Gonja, New Juaben and Jomoro Districts of Ghana between August and October, 2016.

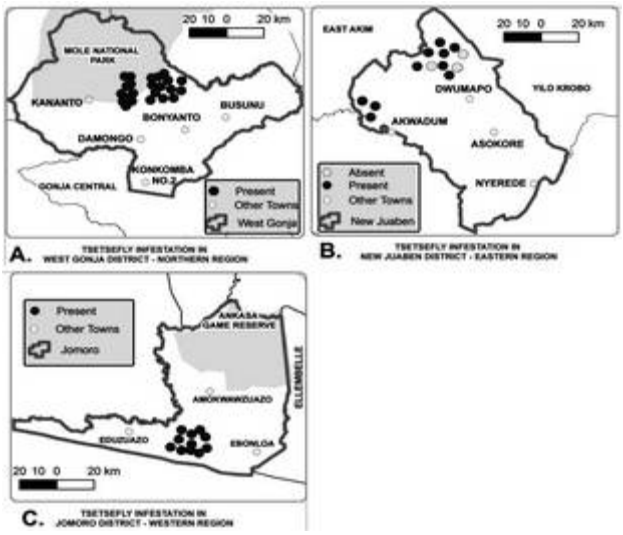

Figure 3. Maps (A-C) showing presence and absence of tsetse flies in West Gonja, New Juaben and Jomoro Districts of Ghana between August and October, 2016.

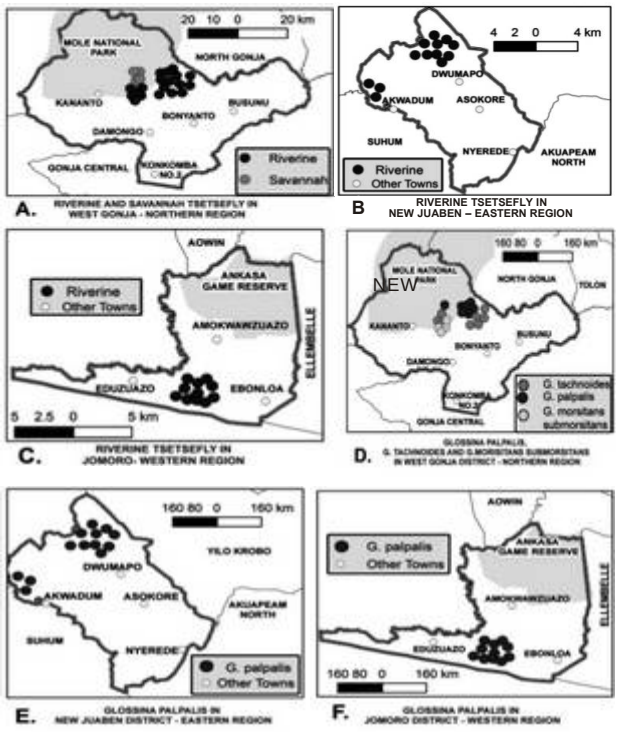

Figure 4. Maps (A-F) showing ecotypes and species of tsetse flies sampled from West Gonja, New Juaben and Jomoro Districts of Ghana between August and October, 2016.

Apparent mean fly density (flies/trap/day) was highest in Jomoro (17.45 ±9.36 f/t/d), followed by West Gonja (16.98 ±6.58 f/t/d) and least in New-Juaben (1.53 ±0.8 f/t/d). Maps generated from the survey are shown in Figures 2-4.

Discussion

A study to determine tsetse flies distribution was undertaken in New-Juaben, Jomoro, West Gonja and West Mamprusi Districts of Ghana. In this survey, tsetse flies were present in all sampling areas except West Mamprusi. In West Mamprusi District, being an AAT-endemic area, there were no tsetse fly catches and this was unexpected. It was known that sometimes there may be no record of tsetse fly presence in an area during a particular season and this does not totally suggest absence of tsetse flies in that area (Cecchi *et al* 2015). It could be on account of the season (wet season) of sampling. Similar results were reported in previous sampling exercise carried out in same period of the year as well as in an ecologically comparative area in northern Togo (Burkhard Bauer, personal communication).

Previous studies in Ghana indicate the presence of the three known ecotype groups (riverine, savannah and forest) of tsetse flies (Mahama *et al* 2003). In this study, no species of the forest-group was recorded. It is possible that the group was absent from the sampled areas and/or maintains limited distribution in the country. But this has to be investigated further in future studies. *G. longipalpis, G. palpalis, G. tachinoides* and *G. m. submorsitans* are economically important species reportedly endemic in Ghana (Mahama *et al* 2003). However, *G. longipalpis* was not caught in this survey. We suspect that the absence of *G. longipalpis* was possibly because the transitional zone where the species was previously reported was not included in our areas of sampling.

While *G. palpalis* was the only species recorded in the Western and Eastern Regions, it however co-existed with *G. tachinoides* in the Northern Region. The co-existence of both riverine species had been previously reported (Mahama *et al* 2003) where the density of *G. palpalis* was sparse compared to *G. tachnoides* along moderately exposed riparian vegetation. Our observation and that made by Mahama *et al* (2003) on higher density of *G. tachinoides* over *G. palpalis* are similar and may be due to the ability of the former to better adapt to environmental changes than the latter (de La Rocque *et al* 2001; Bouyer *et al* 2005; Rayaisse *et al* 2015).

Glossina m. submorsitans is a member of the savannah ecotype of tsetse flies that are often seen in the dry, canopied woodland but absent from ecologically disturbed areas. The species is usually present within protected areas having rich diversity and high abundance of mammalian hosts (Mamoudou *et al* 2008). The occurrence of *G. m. submorsitans* only within the Mole Game Reserve in the Northern Region is therefore typical of the ecological behavior of this species and consistent with results from past surveys in Ghana (Mahama *et al* 2003; Dräger, 2010) and elsewhere (Rawlings *et al* 1993). Field samplings for tsetse flies conducted outside protected areas in the Upper East (Yahaya *et al* 2012) and Northern (Mahama *et al* 2005) regions did not indicate the presence of *G. m. submorsitans*. Similarly, *G. m. submorsitans* were not trapped in the Western and Eastern Regions, and this could suggest the restricted distribution of *G. m. submorsitans* to protected areas in the savannah belt of Ghana.

Besides seasonal meteorological influences (Desta *et al* 2013), history of control activities could impact on tsetse fly density. Tsetse control activities were carried out in the Eastern Region (>3 years) prior to the study and this has significantly accounted for the low tsetse density in the area. In fact, no catch was made in Suhyem Mpaem, one of the sampling areas where insecticide-treated nets used in control of tsetse flies are still on ground. Previously, in this region, insecticide-treated nets reduced tsetse population by >95 % after 3 months (Bauer *et al* 2011).

The trend in tsetse apparent density between districts corresponded with their average trap distances. Besides trap distance, factors like trap type, selective use of attractants, nature of vegetation, livestock population density, proximity of traps to livestock areas affect tsetse apparent density (Cecchi *et al* 2015). In Jomoro, the abundant riverine vegetation suitable for *G. palpalis*, high

livestock density and close proximity of traps to kraals are likely to account for the high tsetse density observed. Essentially, however, tsetse density is a product of interactions between these factors. For instance, tsetse flies are known to be negatively related to elevation and its climatic correlates (Shereni *et al* 2016). The higher elevation in Kofikrom than Akwadum Mpaem in the eastern region could therefore suggest that tsetse flies would occur in higher density in the latter than the former. Nevertheless, in this study, tsetse flies were of higher density in Kofikrom than in Akwadum Mpaem. This could possibly be the result of higher livestock population observed in Kofikrom than Akwadum Mpaem, an example of interacting factors, elevation and livestock population in this case, affecting tsetse fly density.

In conclusion, the spatially-explicit maps of tsetse in AAT-endemic areas presented here would assist in the control efforts of the disease. However, further studies covering wider spatial area in the districts and more importantly across the country are required. With the availability of a comprehensive data, planning and execution of the AAT eradication initiative by PATTEC would be facilitated.

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