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Monthly and Daily Activity Pattern of Tsetse Fly *Glossina pallidipes* in Maze National Park, Gamo Zone, Southwest Ethiopia

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Abstract: The general pattern of fluctuations in tsetse populations is roughly related to the ambient and rainfall distribution. *Glossina pallidipes* inhabiting Maze National park was studied from November 2018 to May 2019 to investigate their seasonal and daily activity pattern. Acetone plus cow urine baited biconical traps were used to evaluate the seasonal activity pattern by taking sample every month for five consecutive days for five months and daily activity pattern was investigated by taking sample every hour for three consecutive days each in the months of November to March. The density of *G. pallidipes* was found to be high during wet months and decreased during dry months. *Glossina pallidipes* showed a bi-modal daily activity pattern with morning peak followed by mid-day depression and then late afternoon peak. Its activity rhythm showed a dual relation with temperature, positively correlated in the morning when the temperature is less than 36°C (r = 0.699 and p = 0.122) and negatively correlated when temperature is greater than 36°C (r= -0.649 and p = 0.023). The relationship between fly activity and relative humidity was also negatively correlated in the morning (r = -0.649, P=0.1626) and positively correlated in the afternoon (r = 0.989, P = 0.002). In general *G. pallidipes* were more abundant during the rainy season and active around noon and in the evening. To improve agricultural development and livestock production, strategic tsetse control methods particularly the use of traps should follow the activity pattern of the vectors.

Key words: Daily Activity · Maze National Park · Glossina Pallidipes · Seasonal Activity

INRODUCTION

Tsetse flies (*Glossina* species) can be ranked among the world's most destructive pests and are the vectors of the causative agents for sleeping sickness in humans and African Animal Trypanosomosis (AAT) or Nagana in livestock [1]. The tsetse flies are adapted to the wide range of habitats, from central African humid rain forests to the vast semiarid, open savannahs of eastern Africa. The total area infested by tsetse flies is between 8.5 and 10 million km^2, which is more than 40% of the total land area of the infested countries [2]. Out of the nine regions of Ethiopia five (Amhara, Beneshangul- Gumus, Gambella, Oromiya and SNNPR) are infested bymore than one species of tsetse flies [3].

The general pattern of fluctuations in tsetse populations is roughly related to rainfall distribution throughout the year with a basic feature of an increase when rains start and a decrease during the dry season. Their pattern of distribution is a result of mainly climatic and biological factors [4]. For most species, the optimum temperature is about 25°C, and higher or lower temperatures during particular seasons or development stages, limit their existence [5]. Long cold winters, often with frost, make conditions that are not suitable for tsetse. In cold weather, the fly cannot move about to feed. In cold soil, the pupa cannot complete its development before its stored food supplies are finished. The occurrence of tsetse flies requires the presence of their host. Therefore, insufficient food may cause some areas to be without tsetse, even though the areas may be suitable in other respects [6].

Tsetse fly exacts a high public health burden and has a devastating impact on livestock and agriculture. One of such disease that has plagued sub-Saharan Africa is caused by protozoan African trypanosomes (the trypanosome species) and transmitted by tsetse flies [7]. Tsetse flies of the *morsitans* group such as

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G. pallidipes have been shown to be the main vectors for the trypanosomes which cause Nagana in cattle, mainly: *T. b. brucei* and *T.congolense*[8]. Furthermore, the movement of cattle infected with *T. b.rhodesiense* has been implicated in new outbreaks of HAT in Uganda [9]. Africa Animal Trypanosomiasis is prevalent in some of the poorest areas in Sub-Saharan Africa and imposes a significant burden on development in this region [10].

Southern Nation Nationality and people Regional state has a total area of 438,370 hectare, which accounts for about 10 percent of the country. The main occupation of rural population is mixing farming practice where by crop and livestock are managed hand- in hand together. Cattle directly provide food such as meat, milk, by products such as hide. Indirectly they contribute over 30 percent to agricultural production by supplying essential input such as manure for replenishing soil fertility and restoring nutrient, and animal traction and power for ploughing and trashing; increasing the productivity of small holdings. Nevertheless, many factors affect the maximum benefit to be obtained cattle. Livestock disease is among the major factors that affect production and productivity, and trypanosomosis is the most important disease that influences livestock productivity in the region [11].

In 1970, *G. pallidipes* was recorded from lower Omo River and on the Woitto River and at Keiafer (1550 masl) also near Bako in GamoGofa province. It was found along the Segan River near Lake Chamo in GamoGofa. The lower Omo was also infested bythis species up to down wards as far as Omorate. In addition, it found the upper part of the GalanaDulei valley (Woitto) with the Maze River valley (Daramalo) [12]. The whole Omo belts which are indicated above are infested by *G. pallidipes.* Various types of Tsetse surveys undertaken in KindoKoyisha and Boloso Bombe Woreda of Wolaita Zone and Zima Waruma PA of Dawro Zone revealed the presence of *G. pallidipes* [13, 14].

G. pallidipes is one of the main vectors that transmit the sleeping sickness to humans and Nagana to animals [15]. It is therefore believed that *G. pallidipes* plays a central role in the disease burden of both HAT and AAT [16]. Current vector control interventions involve the use of insecticides either through sequential aerosol spraying technique (SAT); ground spraying; insecticide-treated targets or insecticide treated animals - live baits; the use of traps, and the sterile insect technique (SIT) [17]. It was important that the knowledge of the daily activity and seasonal abundance of this particular species, *G. pallidipes* would be fundamental importance to determine what hour of the day and what month of the year to apply effective eradication strategy against it. The main objectives of this study were to investigate the monthly and daily activity pattern of *G. pallidipes* in study area to apply effective control and eradication measures.

MATERIALS AND METHODS

Study Area Description: The study was conducted from November 2018 to May 2019 in Maze National park at Gamo Zone, Southern Nations, Nationalities and Peoples' Regional State (SNNPRS), southwest Ethiopia. The Maze National park was located at 460 km and 235km south west of Addis Ababa and Hawassa, respectively in Gamo zone. The name of the park "Maze" is derived from the largest river that crosses the park. Maze River rises from southern parts of the surrounding highland and passes through the Maze national park from south to north direction and eventually drains in to Omo River. The study area Maze national park located 6°25' N latitude and 37°14'E longitude in Gamo zone and altitude ranges from 900 meter to 1400 meter above sea level [18].

The annual rainfall is between 843.8 mm and 1375.3 mm. The area experience a long rainy season that extends from April to October in which high amount of rainfall is recorded between April and June. The dry season is from November to march with mean maximum temperature 32.88°C. The cooler months in the area include June, July and August with mean minimum temperature of 17.5°C. Maze national park and its surroundings have unique natural, cultural, and historical attractions wide range of wildlife and vegetation types. The district should have different vegetation types were covered namely, woodland, savanna grassland, bushland, riverine forest and mixed types (woodland and grassland). The different wild animals found in the study area include: Baboon monkey, warthog, bush pig, antelope, bushbuck, lion, waterbuck, porcupine, greater kudu, lesser kudu, leopard, buffalo, wild cat other carnivores, and hippopotamus. Domestic animals in the studyarea include zebu cattle and goats [18].

Study Population: The study populations for the study were tsetse flies (*G. pallidipes)* that occur in Maze National park at Gamo Zone, Southern Nations, Nationalities and Peoples' Regional State (SNNPRS), southwest Ethiopia.

Study Design: Longitudinal study was conducted to determine the seasonal and daily activity pattern of tsetse flies (*G. pallidipes*) in Maze national park. The study populations were collected based on sex, temperature, and relative humidity into account. Sample collection method was by using conical trap having different visual and odour attractants.

Study Methods

Monthly Activity Pattern of Fly: For sampling *G. pallidipes,* six biconical traps [19] were used. The traps were set along transect from the open savanna grassland and riverine forest; sampling was taken every month for five consecutive days per month fromNovember 2018 to May 2019. The distance between traps was 200 meter [20]. Each trap site was cleared of vegetation sufficiently to ensure reasonable visibility of the trap and dispersion of the odour attractants. Acetone plus cow urine was used as odour baits. The release rate of 500–600mg/h for acetone and 1–1.2g/h for cow urine were applied [21]. The trap has small cone that was placed on the upper part of the large cone where metal cage covered with white netting mashes was kept. The lower part is freely open for flies' entrance. The trap was held in place by the metal pole, which passes through the wide opening. The lower part of the pole above the ground was greased to protect ants. To evaluate the environmental determinants of activity, hourly temperature and relative humidity were simultaneously recorded using temperature and moisture sensor thermo hygrometer.

Daily Activity Pattern of the Fly: The area where tsetse population is high was selected for studying daily activity patterns. The study was done for three consecutive days over four month's period. For this, six biconical traps were set up and the distance between the traps was 100 meter. The number of tsetse flies caught in the traps was recorded every hour from dawn to dusk. Catch was made only for clear days, without rainfall and cloud, since the activity of tsetse flies are affected by weather condition of the area [22]. Trap catches were collected athourly interval from 6:00am to 6:00 pm hour. To evaluate the environmental determinants of activity, hourly temperature and relative humidity were simultaneously recorded using temperature and moisture sensor thermo hygrometer. The flies caught were killed by gently squeezing their thorax then identified, sexed and counted.

Statistical Analysis: The data was analyzed using STATA statistical software program (window version 11). The seasonal fluctuation of *G. pallidipes* was analyzed using one-way analysis of variance (ANOVA). The daily activity pattern *G. pallidipes* was obtained by plotting the mean hourly catches ± S.E. against hour of the day. Pearson correlation analysis was used to relate fly catch with temperature and relative humidity.

RESULTS

Seasonal activity of *G. pallidipes* occurred with a monthly mean of 26.22±1.59 SE. Its population built up during the rainy period (Fig. 1 and Table 1). During the studyperiod *G.pallidipes* population peaked during the rainy months April and May (Table 1). There was statistically significant variation in population during the five months (F= 31.79, DF = 4 and p = 0.000) (Table 2). There was also a positive correlation between fly abundance and rainfall during the rainy season.

The daily activity profile for *Glossina pallidipes* at maze national park shows two prominent peaks during the study period, a morning and afternoon peak. The activity increased gradually in the morning and peaked at 5:00 hour before declining between 6:00 and 10:00 hour local time. Their activity in evening was more vigorous, increasing steadily to peak at 12:00 hour and presumably continuing in the night.

Daily activity of *G. pallidipes* showed a bi-modal activity (Fig. 2). The relation between fly activities and the prevailing temperature and relative humidity are shown in Table 3. There was a positive correlation of fly activity with temperature below 36°C. However, the relationship was insignificant (r=0.699, p=0.122). When the temperature exceeded 36°C there was negatively correlated (r = -0.649, p = 0.023) and the relationship was significant (Table 3). The relationship between fly activity and relative humidity was negatively correlated in the morning (r = -0.649, P=0.1626) and positively correlated in the afternoon (r = 0.989, P = 0.002).

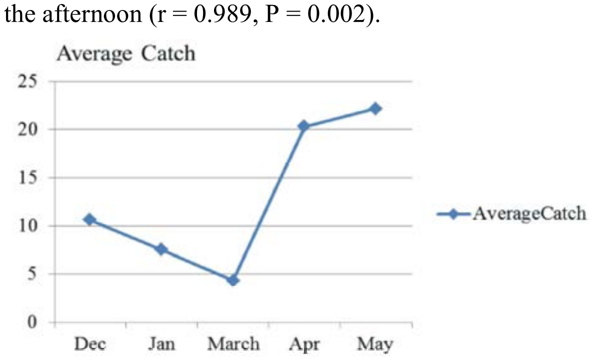

Fig. 1: Monthly infestation of *G. pallidipes* in the maze national park

Table 1: Monthly variations in *Glossin apallidipes* apparent density during the study period in maze national park

Month	RH% mean ± SE	Tem. °C mean ± SE	Catch mean ± SE
December	40.28 ± 1.70	30.66 ± .84	21.19 ± 1.04
January	28.89 ± 1.89	35.10 ± 1.7	15.06 ± 0.95
March	31.3±1.3	36.48 ± .68	8.68 ± .46
April	60.26 ± 1.5	28.07 ± .83	40.60 ± 1.69
May	54.04 ± 1.5	27.96 ± .81	44.33 ± 1.72

Table 2: Correlation of *G. pallidipes* apparent density with some ecological factors in study area

Variables	Mean±SE	F	Df	P- value
Temperature	31.70 ± 0.98	14.35	4	0.0000
RH	45.1 ± 1.58	91.31	4	0.0000
Catch	26.22 ± 1.59	31.79	4	0.0000

Table 3: Correlation coefficients showing the relationship between fly activity with temperature and relative humidity in the morning (1-6) and afternoon (7-12)

Variables	Hour	Temp (°c)/RH%	Correlation coefficient	P – value
Temperature Vs catch	1-6	23.93 – 36.24	0.699	0.122
Relative humidity Vs catch	1-6	53.27 –29.93	-0,649	0.1626
Temperature Vs catch	7-12	33.44 – 45.76	-0.867	0.0256
Relative humidity Vs catch	7-12	22.76—34.34	0.989	0.0002

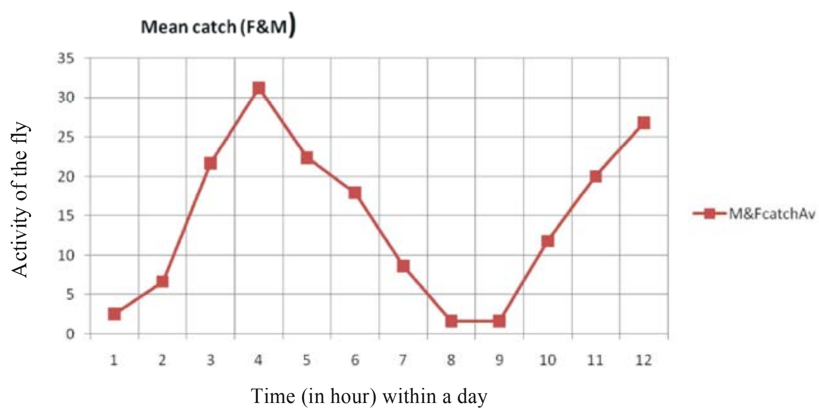

Fig. 2: Daily activity of *G. pallidipes* in maze national park

DISCUSSION

From the present investigation, *G. pallidipes* were more abundant during the rainy months (April and May). Tsetse populations exhibit various patterns of population fluctuation related to local climates and vegetation. In general, pattern of fluctuations in tsetse populations is closely related to rainfall distribution throughout the year with a basic feature of an increase when rains start and decrease during the dry season [4]. In the present study, *G. pallidipes* populations increased at the start of the rains to reach a peak and then declined as the dry season starts.

The relatively low density of *G. pallidipes* during the dry months may be due to an accelerated consumption of its fat stored for further development of the pupa presumably due to high temperature associated with the low moisture content of the soil, which adversely affects the development of the puparium to the adult stage [6]. The tsetse fly distribution is usually affected mostly by the rainfall and vegetation cover [23]. Similarly the present study shows that, during the wet season, especially during April to early May, flies were widely distributed when the vegetation cover of the area rehabilitate. This in turn provided shade and maintained a suitable microclimate for the flies and a better habitat for their vertebrate hosts. However, during the dry season, they have restricted distribution because of the scanty vegetation particularly shrubs.

The present study shows that *G. pallidipes* exhibited bimodal dry season activity for both sex. Unlike the case in the dry season, the activity profile during the wet season was unimodal and showed steady increases with time throughout the day. Since flies were compelled to concentrate in restricted areas where there is suitable habitat for their breeding and survival, attempt to control their population can be effective if conducted during dry season. According to Dransfield *et al*. [24] about 99% reduction can be obtained for *G. pallidipes,* with baited traps applied during the dry season. Rainfall is known to affect puparial development directly and the eco-distribution of the fly and the mammalian hosts indirectly [6]. The fact that the abundance of flies was statistically significant with rainfall (Table 2) indicates that the fly density increases as the rainfall increases.

Daily activity profile for *G. Pallidipes* at maze national park shows two prominent peaks during the study period (December to March), a morning and afternoon peak. The activity increased gradually in the morning and peaked at 4:00 hour before declining between 6:00 and 10:00 hour local time. In the evening, the flies were more vigorous, increasing steadily to peak at 12:00 hour and presumably continuing in to the night. Similarly, the activity profile for combined male and female *G. Pallidipes* at Nguruman- Kenya showed two prominent peaks during the dry season, while at wet season *G. pallidipes* did not show any prominent peak in the morning and afternoon [25]. In addition, Owaga *et al.* [26] observed that the activity of *G. pallidipes* at the Kenyan coast was throughout the day but with significant peak of activity between 9:00 and 10:00 and between 14:00 and 17: 00 hour. Most tsetse species are not active at night, but *G. pallidipes* was caught after 19.00 hour, i.e. 1:00 at the evening in local time [27]. In line with this, Fuller [28] also caught this species and *G. longiperinis* at night in Ethiopia when there were no lights; but the weather was very hot.

The result of the current study on the daily activity profile is also in accordance with other works [29-33]. Both sexes reached peak during the same hours of the day. Moreover, climatic factors influence the activity pattern to some extent [34]. Starvation also has an enormous effect on activity [35, 36]. Therefore, activity pattern may be unimodal or bimodal depending on whether optimal levels of abiotic and biotic factors have been exceeded or not, under particular circumstances.

There was a dual relation between the activity and temperature (Table 3). There was a positive correlation in the morning i.e., up to 6 am local time when the temperature was below 36°C and a negative correlation in the afternoon starting from 7:00 local time. This implies that the activity of *G. pallidipes* increased with a rise of temperature during the morning. This result agrees with that of Popham and Vickers [37] who reported that tsetse flies are positively photo tactic below 30°C. The morning peak is followed by mid-day depression starting from 6 am up to 9 pm local time when the temperature was greater than 36°C. At higher temperatures the flies begin to seek shade [38]. During the afternoon, the fly number increased starting from 10:00 pm, when the temperature was less than 32°C Like as tsetse flies have an innate pattern of activity. The savanna species, such as *G. morsitans* and *G. pallidipes*, are active mostly for the first two hour and the last two hours of the day [39]. These innate rhythms are influenced by temperature and thus the cool of morning in maze national park, when temperature less than 23°C can suppress the early morning peak of activity. Conversely, high (greater than 36°C) afternoon temperature, such as occur in maze national park can suppress the afternoon activity. But tsetse needs to feed and so when one peak was suppressed then the other compensates. For example, on very hot days in study area, tsetse flies are most active in the early morning.

CONCLUSION AND RECOMMENDATIONS

From the investigation, it was clear that the reaction of *G. pallidipes*to abiotic and biotic factors is particularly important to their spatio-temporal distribution. The result showed that vector activity was majorly influenced by temperature and relative humidity and the activity pattern was sensitive to season. There was a seasonal change in habitat and abundance of the flies. They were more abundant during the rainy season and active around noon and in the evening. The main activity period is also dependent on temperature. Based on the conclusion, the following recommendations are forwarded:

- To improve agricultural development and livestock production, strategic vector control should be strengthened to eradicate vector depending on the activity pattern.
- It is also advisable to undertake intervention program during the dry season.
- Further study, particularly involving all the months, should be conducted in a wider area where the tsetse flies are known to cause significant impact on cattle production.

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