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Effects of vegetation and weather on trap catches of *Glossina fuscipes fuscipes* near Lake Victoria, Kenya

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Abstract

Glossina fuscipes fuscipes Newstead was sampled in isolated thickets and forest patches near Lake Victoria, Kenya using unbaited biconical traps, between March 1992 and June 1993. Traps set at 1 m from the forest edge caught 3.3 times as many males and 5 times as many females as those set inside or 10 m away. The corresponding figures at 1 m from the edge of thicket were about 1.43 and 1.64 times, respectively. Hourly catches of males and females were positively correlated with temperature, light intensity and host (monitor lizard) prevalence, and negatively correlated with relative humidity. Light intensity and temperature were the most important variables affecting the catches of each sex. The results are discussed in relation to control and monitoring of *G. f. fuscipes* using traps.

Introduction

Traps are important for controlling and monitoring tsetse flies, Glossina spp. (Green, 1994). Novel methods have been developed to estimate their capture efficiency and range of attraction for several species (Vale & Hargrove, 1979; Dransfield, 1984; Kyorku et al., 1990; Odulaja & Mohamed-Ahmed, 1997). Trap performance is affected by several factors. These include vegetation type (Hargrove & Vale, 1980), location relative to vegetation (Dransfield et al., 1982), host abundance (van Etten, 1981), time of day (Brady, 1972), changes in weather with time of day (Turner, 1987) and the fly's physiological state (Rogers, 1978). Trap catches for savanna tsetse can be improved considerably by dispensing odours near traps (Dransfield et al., 1986). However, an effective odour bait has yet to be discovered for the riverine species (Laveissière et al., 1990). Unbaited traps are therefore used for controlling and monitoring riverine tsetse.

Near Lake Victoria, Kenya, G. fuscipes fuscipes occupies linear forest patches and thicket clumps. Information on optimum trap position in these vegetation types is a prerequisite to efficient deployment of monitoring and suppression traps, and for understanding the ecology and behaviour of the flies. In this paper we provide such information together with the effects of weather (light intensity, relative humidity and temperature) and host prevalence on trap catches.

Materials and methods

Study area. The studies were carried out near Lake Victoria, Kenya at the Mbita Point Field Station (MPFS), International Centre of Insect Physiology and Ecology (ICIPE). The topography, demographic characteristics, climate and vegetation of the area are described recently by Mwangelwa et al. (1990). The climate is hot and humid with minimal seasonality. Annual rainfall ranges between 760–1015 mm with peaks in April–May and November–December. Minimum and maximum temperatures vary between 14–18 °C and 30–40 °C, respectively. The vegetation has been affected by human activity with numerous clearings maintained for subsistence farming. The original continuous lacustrine bush has, in effect, been reduced to widely-scattered forest patches and thicket clumps. Thicket clumps are mostly only 3–10 m in diameter and consist of aggregations of *Sesbania sesban*, *Acacia* spp., *Ficus* spp. and the shrub *Lantana camara*; these are intertwined with climbers of the family Nyctaginaceae with an understorey of grasses (*Cyperus immensus* and *C. articulatus*). The few forest patches remaining are about 2–20 m wide and up to 2 km long; they consist largely of the tree *Sesbania sesban* and various climbers. The Nile monitor lizard, *Varanus niloticus niloticus*, is the main host of *G. f. fuscipes* in both vegetation types (Mohamed-Ahmed & Odulaja, 1997).

Experiments

1. Effects of vegetation and position. In May 1992, two large forest patches (1–2 km), one on the mainland and the other on Rusinga Island (Mohamed-Ahmed & Odulaja, 1997), were selected such that each could accommodate five trapping sites separated by at least 200 m. Five isolated thickets, each constituting a trap site, were also selected at each of the two locations, mainland and island. At each site, five trap positions (trap location within a site) were selected: (a) 1 m inside the vegetation, (b) at the edge of the vegetation, and (c), (d), (e) 1, 5 and 10 m from the edge of the vegetation. At each of the four vegetation types (forest on mainland, forest on island, thickets on mainland and thickets on island), one unbaited biconical trap (Challier et al., 1977) was placed at one position at each of the twenty trapping sites. At each site a trap was rotated for five days between the five positions in a 5 × 5 Latin square design experiment repeated twice (Figure 1). Traps were emptied daily. Analysis of variance (ANOVA) was used to determine significant differences in catches between positions at each vegetation type.

2. Effects of weather and host prevalence. Two sites (designated as P5 and P6) not more than 200 m apart in the same forest patch on the mainland, were selected for further investigation to identify the environmental factors determining fly catches. Hourly biconical trap catches were recorded with corresponding light intensity, temperature, relative humidity and host (monitor lizard) prevalence, from 0600 to 1800 h on four cloudless days in each month between June 1992 and June 1993. Temperature (°C) was measured with minimum-maximum thermometers, relative humidity (%) with wet bulb whirling hygrometers and light intensity (lux) with light meters (Li-COR, Model Li-189, USA). Temperature was measured at a height of about 1 m in shade, about 1 m from the trap. Light intensity and relative humidity were measured at 1-m height in the clearing around the trap. Data on light intensity and relative humidity were available only in the last two and six months of the study, respectively. Host prevalence was monitored by recording the number of monitor lizards sighted within 30 m of a trap every ten minutes. This was done by an observer located about 50 m from the trap who approached the vicinity quietly at the set intervals.

Correlation analyses were used to relate fly catches to both weather factors and host (monitor lizard) prevalence. Due to the close similarity in the diel rhythms, data for both trap locations were combined to calculate the correlation coefficients. Least squares stepwise regression analysis was also performed to model the best predictors of trap catches using the last two months data, when all variables were measured. To allow for quadratic and interaction effects, the square and cross products of the meteorological and host factors were included as independent variables in the regression analyses.

Prior to analyses, count and percentage data of both experiments were transformed to the $\log_{10}$ and arcsine scales respectively. Means were separated using the Student–Newman–Keuls (SNK) multiple range test. All statistical tests were performed at the 5% level of significance. Back-transformed means (±S. E.) are presented.

Results

1. Effects of vegetation and position. Daily catches of each sex differed considerably with trap positions in each vegetation type (Table 1). In the forest or thicket, significantly more males and females were caught within 5 m of the vegetation, with the greatest catches of each sex at 1 m from the edge. At the latter position, the trap caught about 3.3 times as many males and 5 times as many females as traps placed inside the forest. The corresponding figures for the thicket were about 1.43 times for males and 1.64 times for females, respectively (Table 1). For both vegetation types and for both sexes, catches were lowest at 10 m from the edge.

2. Effects of weather and host prevalence. The diel catches of male and female *G. f. fuscipes* are shown

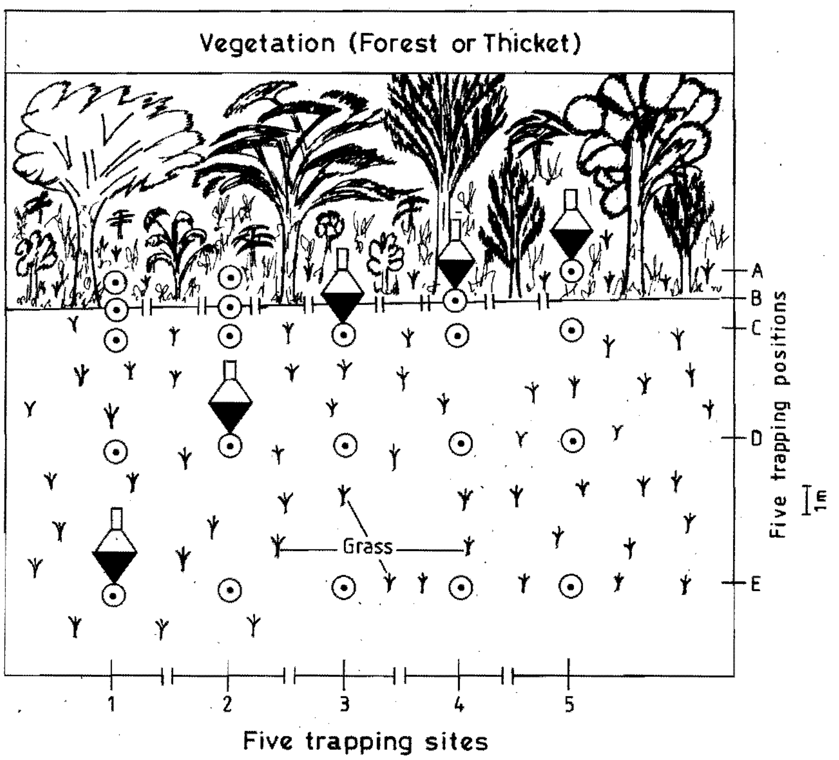

Figure 1. Schematic diagram showing the placement of traps. In each of the four vegetation types five trapping sites were selected. At each site there were five trapping positions. At each vegetation type a single trap was placed at one position at each site on each day. The trap was then rotated for five days between the five positions at each of the five trapping sites, in a 5 × 5 Latin square design. The experiment was repeated twice at each vegetation type.

Table 1. Back-transformed mean catches (±S.E.)* and catch indices** of *G. f. fuscipes* in biconical traps set within 10 m of thicket (T) and forest (F) vegetation

Postion	Male (N = 1051)				Female (N = 1169)			
	Thicket	Index	Forest	Index	Thicket	Index	Forest	Index
Inside	$4.3^{a} \pm 0.3$	1.00	$3.4^{a} \pm 0.5$	1.00	$2.6^{a} \pm 0.3$	1.00	$3.2^{a} \pm 0.4$	1.00
Edge	$6.2^{a} \pm 0.6$	1.42	$9.4^{b} \pm 0.3$	2.77	$6.1^{b} \pm 0.5$	2.35	$1.4^{b} \pm 0.3$	3.56
1 m away	$6.2^{a} \pm 0.6$	1.43	$11.1^{b} \pm 0.5$	3.28	$4.3^{b} \pm 0.3$	1.64	$15.8^{b} \pm 0.4$	4.92
5 m away	$3.9^{b} \pm 0.4$	0.91	$5.5^{b} \pm 0.6$	1.61	$4.9^{b} \pm 0.4$	1.89	$13.9^{b} \pm 0.5$	4.32
10 m away	$1.7^{b} \pm 0.4$	0.39	$2.7^{b} \pm 0.3$	0.80	$1.4^{c} \pm 0.3$	0.55	$3.2^{a} \pm 0.5$	1.00

Means in the same column with different letters are significantly different at $P < 0.05$.
*, back-transformed S.E.; **, index = back-transformed mean trap catch at any position outside the vegetation divided by the mean catch inside the vegetation.

in Figures 2a, b. Activity rhythms of flies were quite similar at P5 and P6. At both locations most catches occurred between 1000 and 1500 h and male catches peaked before female catches. Trends in temperature, light intensity, relative humidity and host prevalence were also similar at both trapping sites (Figures 3a–d). Thus for the pooled data, catches of each sex were highly positively correlated with light intensity, temperature and monitor lizard prevalence, but negatively correlated with relative humidity (Table 2). As most environmental variables were inter-correlated, the stepwise regression analyses selected light intensity and temperature as the best predictors of catches of each sex with partial R2 values between 32% and 66%. Other variables accounted for less than 5% of the variance at any given time.

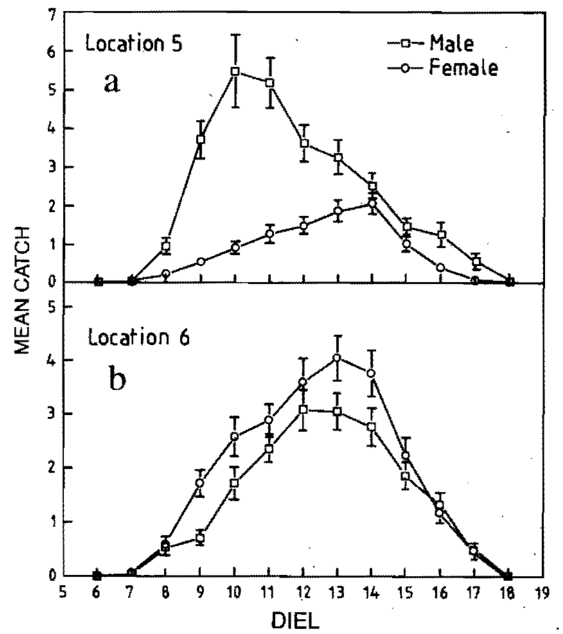

Figure 2. Hourly changes in catches of *G. f. fuscipes* caught in biconical traps placed 200 m apart at 1 m from the forest, (a) P5 and (b) P6. Bars represent the S.E.

Table 2. Correlation coefficients between hourly fly catches and the corresponding biotic and abiotic factors

Variable	*N*	Male	Female	Total
Light intensity	208	0.603*	0.649*	0.747*
Temperature	1184	0.442*	0.503*	0.547*
Relative humidity	676	−0.265*	−0.241*	−0.306*
Lizard	1196	0.252*	0.192*	0.267*

N, number of observations; *, significant at $P < 0.01$.

Discussion

In both thickets and forests traps were most effective for *G. f. fuscipes* when placed at the edge or up to 5 m from the edge of vegetation; traps were much less effective inside and 10 m away from vegetation. The low catches inside vegetation could perhaps be attributed to concealment of the trap or the difficulty for flies of navigating inside dense bush (Paynter & Brady, 1992). On the other hand, the low catches in traps set in the open, at 10 m from thicket or forest, suggest that traps were unattractive to and/or inefficient against tsetse away from vegetation.

Little is known about the range of attraction of the biconical trap for *G. f. fuscipes* and other riverine tsetse. Based on the fact that traps interfere with each other when closely spaced, Dransfield (1984) suggested 15 m as an upper limit for the visual detection of an unbaited biconical trap by *G. pallidipes* Austen. Vale (1977) reported that *G. pallidipes* could see an ox located up to 30 m downwind. In the fusca group, G. brevipalpis Newstead could detect biconical traps located 10–15 m from the forest edge (Dransfield, 1984), whereas *G. medicorum* Austen could not see a black screen beyond 25 feet (8 m) (Chapman, 1960). Chapman (1960) inferred that G. medicorum depends mainly on smell for host location. Since the riverine tsetse species are believed to hunt largely by sight (Moloo, 1993), traps placed about 10 m from vegetation should have been within the effective visual field of *G. f. fuscipes* navigating the ecotone edge. Considerations of the visual acuity of tsetse flies based on the inter-ommatidial angle in the fovea of their compound eyes (about 2%; Turner & Invest, 1973) also suggest that a fly should be able to resolve a biconical trap (ca. 1.5 m high and 0.8 m wide between the cones) at a distance of 10 m.

There are no published data for any tsetse species on the effect of distance from vegetation on trap efficiency (the proportion of flies actually caught, out of the total attracted, Vale & Hargrove, 1979). However, an unbaited biconical trap set about 3 m from the edge of forest catches about 70–80% of the male and 40–50% of the female *G. f. fuscipes* that approach it (Odulaja & Mohamed-Ahmed, 1997). The effectiveness of a trap set inside or at various distances from the edge of vegetation has yet to be determined for tsetse, including *G. f. fuscipes*.

Tsetse trap catches depend on the activity pattern of each sex (Dransfield, 1984). Activity depends on environmental factors (hosts and weather) and the interrelationships between these factors, as well as the fly's endogenous circadian rhythm. Brady & Crump (1978) estimated that 80% of the activity cycle of G. morsitans morsitans is under circadian control, and temperature controls the remaining 20%; light and relative humidity apparently played no important role. Although the circadian control of activity is also influenced by extremes of temperature in the field (Hargrove & Brady, 1992), strong intercorrelations among environmental variables still make the presumed dominant role of temperature open to debate.

In the tropics, the daily cycles of temperature, light and relative humidity are highly correlated; high light intensity is usually associated with high temperature and low relative humidity (see Figure 3). Due to the well-known photonegative behaviour of tsetse at

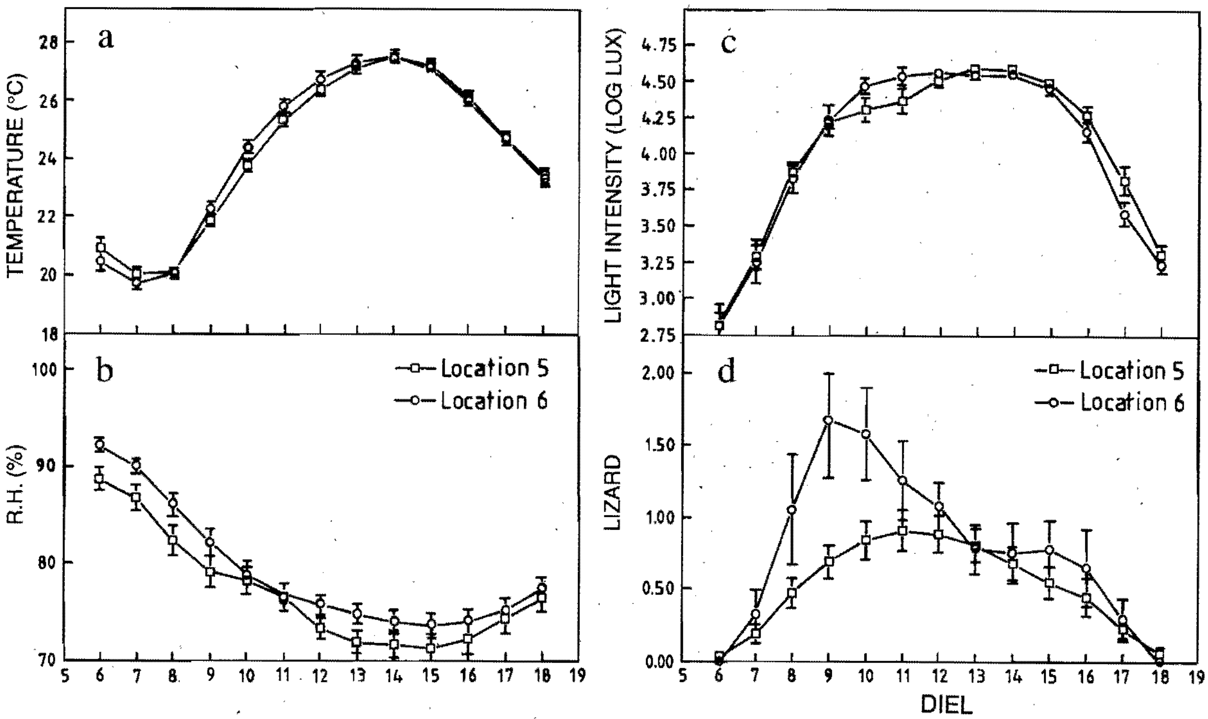

Figure 3. Diurnal profiles of abiotic and biotic factors at P5 and P6. (a) Temperature °C [hourly means were calculated from average of (minimum + maximum)/2 in each hour], (b) % relative humidity, (c) $\log_{10}$ light intensity (lux) and (d) monitor lizard prevalence (hourly means were calculated from averages records taken at 10-min interval). Bars represent the S.E.

high temperature (>32 °C; Glasgow, 1970), a fly may become less active at any level of illumination, depending on whether a critical threshold of temperature has been reached or not. There may be a specific temperature threshold for each sex but this may vary with the physiological condition of the fly (e.g., hunger, age, pregnancy), and again, weather inter-relationships. For example, a fly may remain active at a higher temperature (threshold) when the humidity is high than when it is low (Turner, 1987). Nonetheless, all environmental variables investigated in the present study produced statistically significant relationships with the rhythms of *G. f. fuscipes* (Table 2). Furthermore, the stepwise regression analyses selected light intensity and temperature as the best predictors of catches of each sex.

To conclude, the present data show that trap catches of male and female *G. f. fuscipes* correlated with the type of vegetation and the trap location with respect to vegetation, as well as with the changes in ambient temperature and light intensity. Traps were most productive for both sexes when set between 0 to 5 m from the edge of forest or thicket. This information is useful for effective placement of traps during survey, control and monitoring, as well as for experimental comparisons of trap designs and responses of *G. f. fuscipes* to odour baits.

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