

The black colour of the shelf and the target encourages the flies to land. Once they have landed on the target, the white netting of the cone encourages the flies to move up towards the light and find their way into the collection cage on top of the cone.

The flies may regard the unbaited trap as a refuge when they fly towards it. In the case of a baited trap, the flies may regard the trap as a source of food.

6.3 IDENTIFICATION OF GLOSSINA PALLIDIPES AND G. LONGIPENNIS IN THE FIELD

The two species of tsetse flies, G. pallidipes and G. longipennis have been distinguished using the method of Nash (1969), while the sexes of the flies have been determined using the method of Austen (1903). Both methods are described in chapter 5 section 5.2.

Teneral and non-teneral flies can be distinguished by squeezing the thorax between the finger and the thumb. The thorax feels soft in teneral flies and firmer in non-teneral flies (Pollock, 1982).

6.4 SAMPLING

Transects have been cut through the different vegetation types covering the study area. Along these transects, biconical and Nguruman traps were set and emptied at intervals ranging from 1 to 4 days. The flies were separated into species, sexed and counted to give data on the distribution of tsetse flies both in space and time.

6.5 WEATHER STATION

6.5.1 DELTA-T

Climatic conditions were monitored from the middle of May 1989 to June 1990 using the Delta-T weather station, which consists of a set of sensors and a Delta logger.

The Delta-T weather station mast is 2m high and is supported by four guy ropes. A solar radiation sensor is mounted at the top of the mast. A horizontal cross-bar, mounted near the top of the mast, supports an anemometer and windvane. The relative humidity and air temperature sensors are housed in a screen, which is attached to an offset mounting arm just below the cross-bar. The rain-gauge is anchored to the ground about 5m away from

the mast. The soil temperature sensor is attached to a 5m cable. The soil temperature sensor can be buried in the soil or used to measure the air temperature. The standard weather station consists of a set of sensors for the following: air and soil temperature, relative humidity, rainfall, wind speed and direction, and solar radiation.

The Delta logger records and stores readings from the sensors. The recording of data is completely automatic and the recorded data is stored electronically in the logger's random access memory. Stored data can be output to a printer or to a computer for analysis.

6.5.2 STEVENSON SCREEN

Climatic conditions for the period January to May 1989 were monitored using wet and dry bulb thermometers, and minimum and maximum thermometers which were kept in a Stevenson screen. Readings were made at 8:00 and 15:00h daily.

6.6 MAPPING OF TSETSE DISTRIBUTION

Baseline information was gathered by digitizing a Kenya Survey map covering Nguruman, the 100m elevations, rivers, both seasonal and permanent, roads and lakes. Vegetation maps were prepared for the Nguruman study site from aerial photographs.

The locations of the traps, number, species and sex of the flies caught in each trap were entered into a computer using a database management package, dBase III. This dBase file was then transformed into an American Standard Code for Information Interchange (ASCII) file which can be read directly into the Geographical Information System (GIS) for surfacing and displaying the results.

Both pc ARC/INFO and CRIES GIS systems are installed on IBM AT clones. The output devices from the GIS include a Calcomp pen plotter and a HP pen plotter which draw maps; a Polaroid palette enables us to take photographs of the screen display.

Williams (1988) states that GISs give us an enormously powerful and flexible tool for constructing visual representation of our models which enable us to absorb, understand and extract

meaning from information we could not take in if it were presented in non-pictorial form.

6.7 COMPUTER SOFTWARE

6.7.1 dBASE III

A computer data-base management program (dBase III) was used to compute average monthly trap catches for male and female G. pallidipes and G. longipennis. These numbers were then reformatted into an ASCII format to be put directly into the GIS and the surfaces were calculated.

6.7.2 LOTUS 123

Data other than that for mapping tsetse distribution was entered in a personal computer using Lotus 123. The raw data was then edited by the use of consistency and range checks. Probability plots and histograms were also used in the editing of the raw data. Data in Lotus was exported to StatGraphics, a statistical package, for advanced analysis. Simple statistical analysis was done within Lotus. All graphs were produced using Lotus or StatGraphics.

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6.7.3 STATGRAPHICS

An interactive statistical analysis package, StatGraphics, was used to carry out analyses of variance and to determine partial correlation coefficients.

In this chapter we have discussed materials and methods that were frequently used in a series of experiments. Further details of materials and methods used in particular experiments are discussed in later chapters dealing those experiments.

CHAPTER 7

DENSITY OF G. PALLIDIPES AND G. LONGIPENNIS IN THE
OLOIBORTOTO AND SAMPU VALLEYS AND THEIR MOVEMENT
BETWEEN THE VALLEYS

7.1 INTRODUCTION

Dransfield et al. (1990) have shown at Nguruman that trap catches of G. pallidipes and G. longipennis give good indications of the absolute population density. Monitoring these apparent densities using trap catches of the tsetse flies G. pallidipes and G. longipennis was started in January 1989 and lasted for six months covering both the wet and dry seasons at Nguruman. We were interested in movement between the Oloibortoto valley to the north and the Sampu valley to the south. Estimating the relative population densities of the tsetse flies from trap catches and monitoring the movement of marked and released flies from both valleys should give us an indication of the nature of fly movement and distribution within and between these two valleys. It has been suggested that tsetse populations in the two valleys are fairly well isolated during the dry season, although there is some movement southwards from the Oloibortoto valley to the Sampu valley

(Dransfield et al., 1990). If there is indeed movement of flies between the valleys, we need to understand what is triggering this movement and what can be done to alleviate or prevent the movement of flies into the suppression zone, that is the southern zone referred to in the General Introduction on page 1.

7.2 MATERIALS AND METHODS

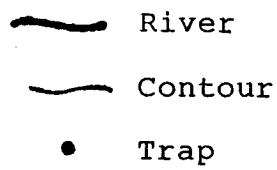
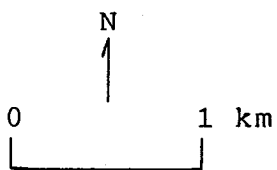
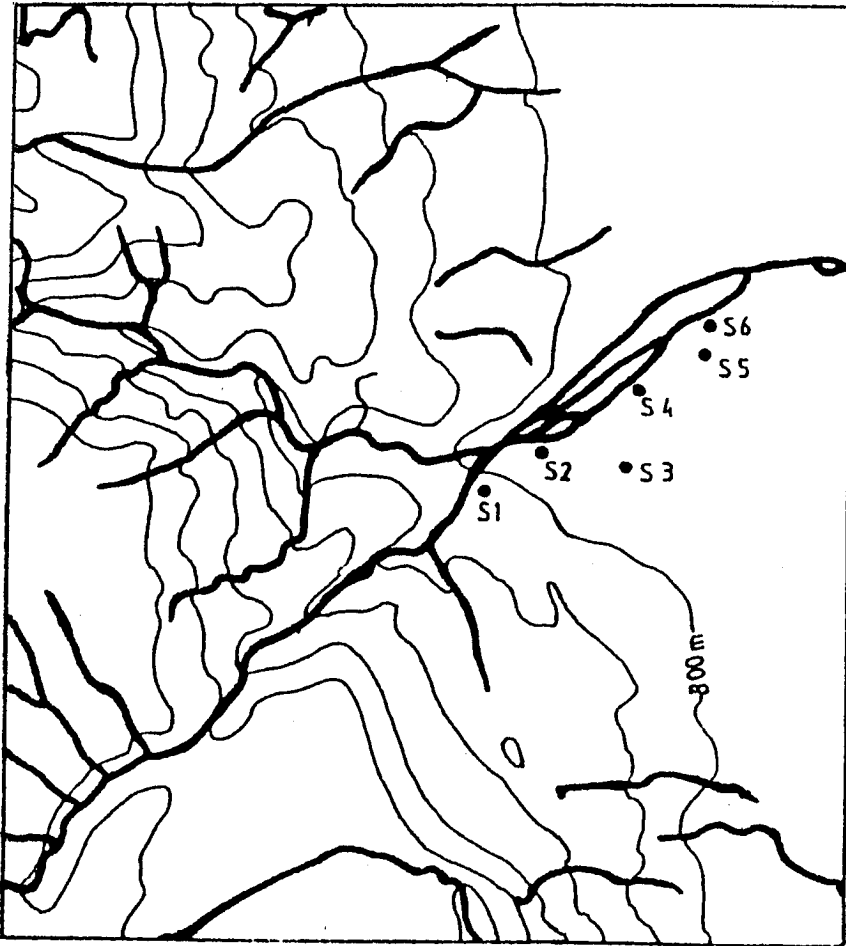
Apparent Density

In this study, cow urine and acetone were used as odour attractants and blue biconical traps (Challier et al., 1973; 1977; Laveissiere et al., 1979) were used to catch the flies. The cow urine, obtained from the local east African Zebu cattle, was dispensed from a 600 ml jar at about 1000 mg/h, while the acetone was dispensed from a 250 ml bottle at about 150 mg/h. The odour attractants were positioned on the ground about 30 cm from the base of the trap.

Six baited biconical traps (S1-S6 in Figure 7.1) were set along the Oloibortoto river at the foot of the Nguruman escarpment. Trap S1 was the closest to the edge of the escarpment. The traps were spaced about 500m apart except for traps S5 and S6 which

FIGURE 7.1

S-traps locations in the Oloibortoto valley



were about 200m apart due to the lack of an appropriate site for S6. Another six baited biconical traps (B1-B6 in Figure 7.2) were set along the Sampu river at the foot of the escarpment. These too were spaced about 500m apart. Trap B6 was the closest to the edge of the escarpment followed by B5 and then B4 and so forth.

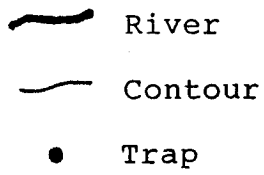
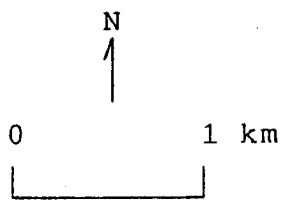
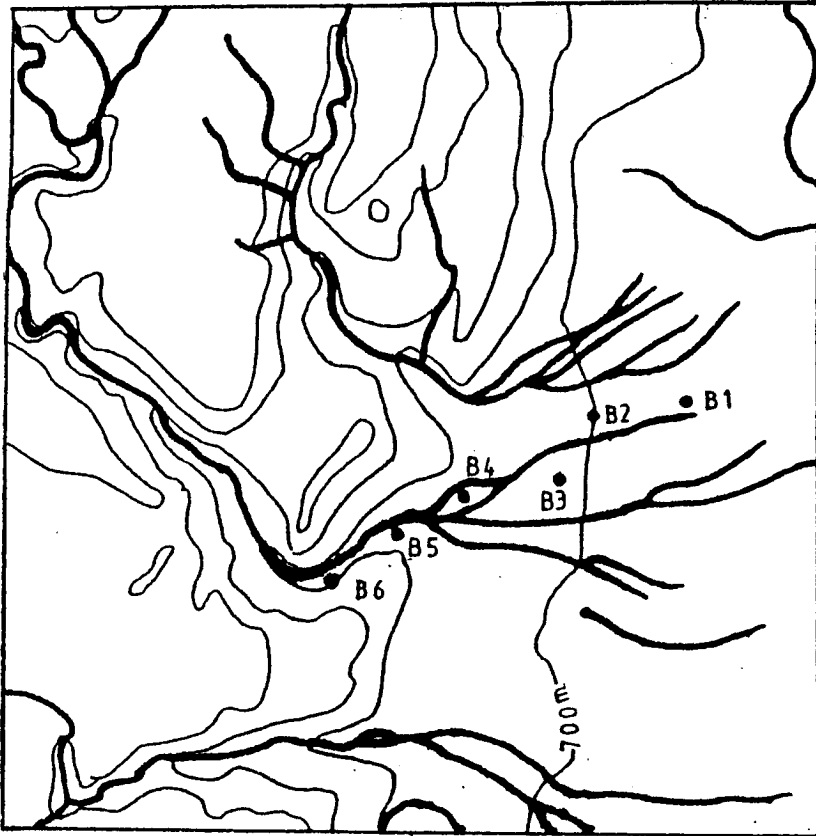
Before being newly erected and at the start of a sampling period in each month, the traps and collection cages were checked for holes through which tsetse flies could escape. The cages were emptied daily for about one week at the end of each month for six months starting in January 1989, except for the month of May when there was no field trip. No sampling was done along the Sampu river in January 1989. Chloroform was used to kill the flies which were then separated into species, G. pallidipes and G. longipennis, sexed and counted.

Capturing, Marking and Releasing

In each month between January and June 1989, excluding May, tsetse flies were captured, marked and released at the Oloibortoto and Sampu valleys for three consecutive days in each valley. In each valley up to 10 baited Nguruman traps were set at the

FIGURE 7.2

B-traps locations in the Sampu valley



edge of the escarpment to catch tsetse flies for marking. The traps were set in the shade and wet cotton wool of about 4 cm in diameter was placed inside the collection cage in order to reduce desiccation of flies. Collections were made every 45 minutes in order to minimize stress on the flies.

The flies were marked using artist's oil paint (Jackson, 1953). An entomological pin was used to apply the paint to the thorax of each tsetse fly, which was held between the fore-finger and the thumb. Separate marks were used for flies released at the Oloibortoto and Sampu valleys. Flies released at the Oloibortoto valley were marked with two dots of paint placed across the meso-thorax, while those released at the Sampu valley were marked with two dots of paint placed left-diagonally on the pro- and meso-thorax. For each month a distinctive colour was used. For January to June, excluding May 1989, the colours were pink, green, blue, orange and red, respectively. The colours were obtained by mixing one part of white oil paint with two parts of the desired colour. Linseed oil was used for diluting the mixture when it became too thick, but this occurred rarely.

During a marking occasion, the individually marked tsetse flies were put into a marking cage which was covered with a damp black cloth in order to reduce desiccation, activity and the risk of marks being rubbed off. To further reduce desiccation and stress on the flies, the marked tsetse flies were released 15 minutes after they were collected from the traps.

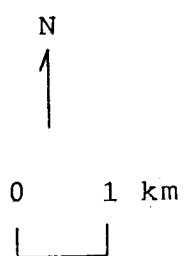
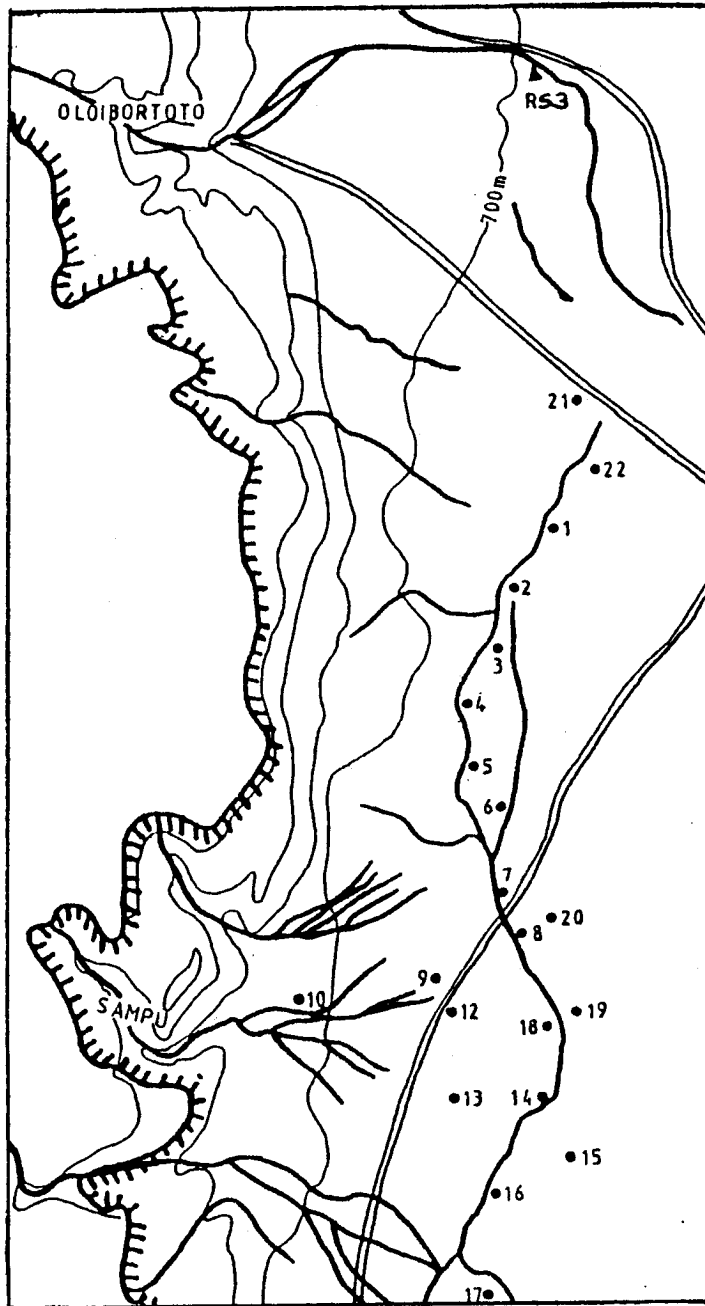
Monitoring of Intervalley Movement






During the dry season, the Sampu and Oloibortoto tsetse populations are believed to be separated by a narrow strip of woodland between X-traps 5 and 4 (see Figure 7.3 for trap positions). In view of this demarcation line, X-traps 5 to 20 were, therefore, closest to the Sampu valley, while X-traps 21, 22 and 1 to 4 were closest to the Oloibortoto valley (Figure 7.3).

The flies were marked and released at the edge of the escarpment for three consecutive days in both valleys in each month between January and June 1989, except in May. The movement of these marked flies between the Oloibortoto and Sampu valleys was monitored by checking for marked flies trapped in the 22 X-traps. These X-traps were greased on all

FIGURE 7.3

X-traps locations in the suppression zone



-  Escarpment
-  100m contour
-  River
-  Road
-  Trap

supports to prevent ants from damaging the catch and emptied every 3 to 4 days between January and July 1989. The flies were killed using chloroform. For the recaptured marked tsetse flies, records were kept of the mark, sex, X-trap number and date of recapture.

Data Analysis

The logarithm to base 10 of the tsetse fly catches was used in the analysis. This transformation normalizes the distributions of samples of field-caught tsetse flies and permits direct transfer to a linear time-scale (Randolph and Rogers, 1978). The analysis of variance was used to test for statistical significant differences in catches of tsetse flies among the main factors and to detect the presence of the two-factor interactions. The error sum of squares was the sum of the four three-factor and the four-factor interactions. Because the models were unbalanced and of full rank, a GLM procedure on a statistical package SAS was used to do the analyses of variance. Type III sums of squares which are the adjusted sums of squares assuming all other terms fixed were noted.

Quantification of Intervalley Movement

The exchange of tsetse flies between the Sampu and Oloibortoto valleys can be quantified by calculating the percentage of the total number of recaptured flies marked at one valley that had moved to the other valley before recapture (Randolph and Rogers, 1984):

$$(R_n \text{ valley}_1 \times 100) / (R_n \text{ valley}_1 + R_n \text{ valley}_2),$$

with $R_n \text{ valley}_i$ ($i=1, 2$) being the total number of marked flies recaptured in one of the two valleys. The authors suggest that this method of quantifying movement of flies between sites is not affected by differential sample sizes.

7.3 RESULTS

Apparent Density

The G. pallidipes had better predictability with coefficients of determination of 89.6% (Coefficient of Variation (CoV) 17.1) and 76.7% (CoV 18.8) in the Sampu and Oloibortoto valleys, respectively than the G. longipennis which had coefficients of determination of 57.4% (CoV 125.6) and 48.6% (CoV 208.1) in the Sampu and Oloibortoto valleys,

respectively. Results of the analyses of variance are shown in Tables 7.1a,b and 7.2a,b.

The variability due to the Trap factor in the analyses of variance reflects the sampling site variability because the traps were all identical.

All the main factors were significant except for sex for G. longipennis in both valleys. But there was slight evidence to suggest that sex was a significant factor for G. longipennis in the Sampu valley ($p=0.053$).

The Month*Day interaction was significant ($p<0.001$) for both species in the Oloibortoto valley and for G. pallidipes in the Sampu valley. It was not significant for G. longipennis in the Sampu valley.

In both valleys, the Month*Trap interaction was significant for both species of Glossina. This interaction was stronger for G. pallidipes ($p<0.001$) than for G. longipennis ($p<0.05$).

TABLE 7.1a

Analysis of variance table for G. pallidipes catches at the Oloibortoto valley.

Source of variation	d.f.	Type III sum of squares	Mean square	F-ratio
Month	4	9.221	2.305	53.36***
Day	5	1.005	0.201	4.65***
Trap	5	8.834	1.767	40.90***
Sex	1	3.618	3.618	83.75***
Month*Day	19	3.767	0.198	4.59***
Month*Trap	20	4.327	0.216	5.01***
Month*Sex	4	0.998	0.250	5.78***
Day*Trap	25	2.189	0.088	2.03**
Day*Sex	5	0.223	0.045	1.03
Trap*Sex	5	0.975	0.195	4.51***
Residual	254	10.973	0.043	
Total	347	46.961		

TABLE 7.1b

Analysis of variance table for G. longipennis catches at the Oloibortoto valley.

Source of variation	d.f.	Type III sum of squares	Mean square	F-ratio
Month	4	0.777	0.194	14.24***
Day	5	0.329	0.066	4.82***
Trap	5	0.188	0.038	2.76*
Sex	1	0.018	0.018	1.35
Month*Day	19	0.706	0.037	2.72***
Month*Trap	20	0.474	0.024	1.74*
Month*Sex	4	0.059	0.015	1.08
Day*Trap	25	0.577	0.023	1.69*
Day*Sex	5	0.018	0.004	0.26
Trap*Sex	5	0.084	0.017	1.23
Residual	254	3.467	0.014	
Total	347	6.747		

TABLE 7.2a

Analysis of variance table for G. pallidipes catches at the Sampu valley

Source of variation	d.f.	Type III sum of squares	Mean square	F-ratio
Month	3	25.106	8.369	295.44***
Day	5	2.597	0.519	18.34***
Trap	5	8.952	1.790	63.21***
Sex	1	0.800	0.800	28.24***
Month*Day	15	2.293	0.153	5.40***
Month*Trap	15	5.149	0.343	12.12***
Month*Sex	3	3.461	1.154	40.73***
Day*Trap	25	1.127	0.045	1.59*
Day*Sex	5	0.172	0.034	1.21
Trap*Sex	5	0.105	0.021	0.74
Residual	205	5.807	0.028	
Total	287	55.567		

TABLE 7.2b

Analysis of variance table for G. longipennis catches at the Sampu valley.

Source of variation	d.f.	Type III sum of squares	Mean square	F-ratio
Month	3	0.479	0.160	5.94***
Day	5	1.447	0.289	10.76***
Trap	5	1.951	0.390	14.50***
Sex	1	0.102	0.102	3.78a
Month*Day	15	0.533	0.036	1.32
Month*Trap	15	0.836	0.056	2.07*
Month*Sex	3	0.010	0.003	0.13
Day*Trap	25	1.863	0.075	2.77***
Day*Sex	5	0.053	0.011	0.39
Trap*Sex	5	0.168	0.034	1.25
Residual	205	5.517	0.027	
Total	287	12.960		

a $p=0.0533$

The Month*Sex interaction was significant for G. pallidipes ($p < 0.001$) and not for G. longipennis in both valleys.

The Day*Trap interaction was significant for G. pallidipes ($p < 0.01$) and G. longipennis ($p < 0.05$) in the Oloibortoto valley, and significant for both G. pallidipes and ($p < 0.05$) G. longipennis ($p < 0.001$) in the Sampu valley.

The Trap*Sex interaction was only significant ($p < 0.001$) for G. pallidipes in the Oloibortoto valley.

In both the Oloibortoto and Sampu valleys, the Day*Sex interaction was not significant for either species of Glossina.

Month*Day Interaction

Oloibortoto Valley

The standard error for comparing any two mean catches of G. pallidipes for the Month*Day interaction was 0.085, while that for G. longipennis was 0.048.

G. pallidipes

Figure 7.4a highlights the Month*Day interaction for G. pallidipes in the Oloibortoto valley. There were no significant differences in mean catches in January and February among sampling days. In March, higher mean catches were on Days 1, 3 and 4 than on Days 2, 5 and 6. The lowest mean catch of G. pallidipes in April was on Day 4. Higher mean catches in both April and June were on the first three sampling days.

G. longipennis

The Month*Day interaction for G. longipennis in the Oloibortoto valley is highlighted in Figure 7.4b. The average number of G. longipennis caught on the first day of sampling in January was significantly higher than that on subsequent sampling days, suggesting a significant trapping out effect for G. longipennis in this month.

There were no significant differences in the mean numbers of G. longipennis caught in traps among sampling days in February, March and April. In June, the mean catch on Day 1 was significantly different from that of Day 5, but no significant differences

FIGURE 7.4a

Presence of month by day interaction
for G. pallidipes in Oloibortoto

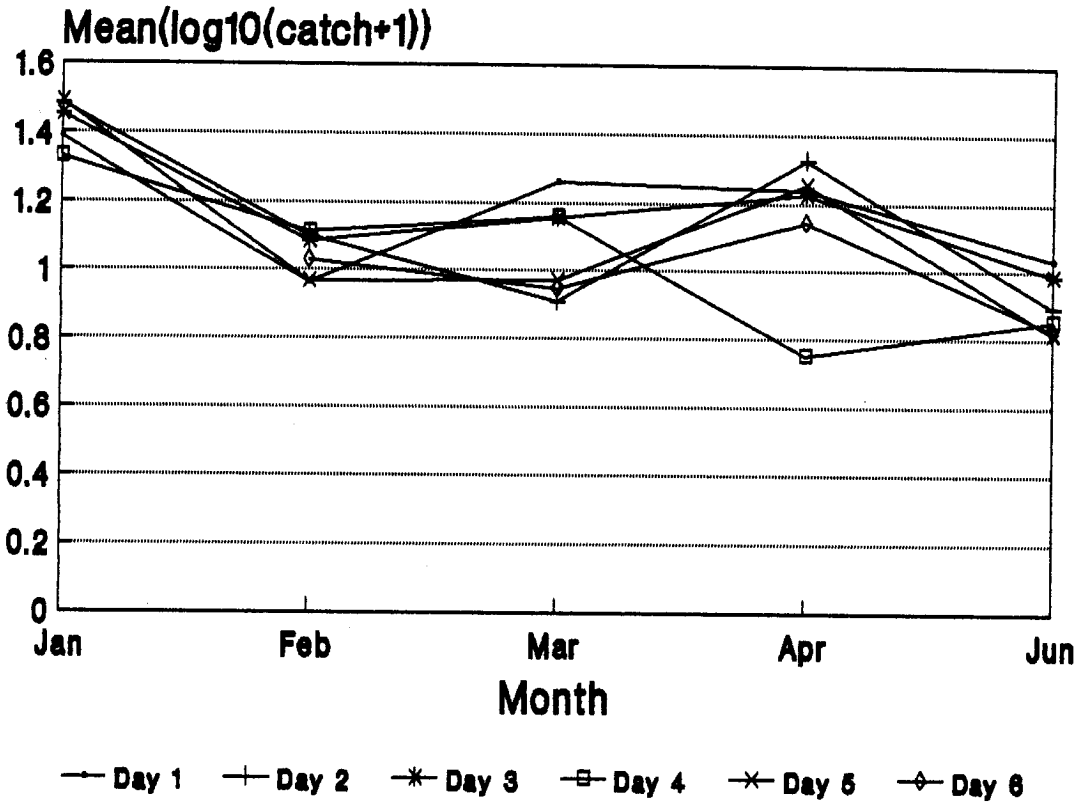
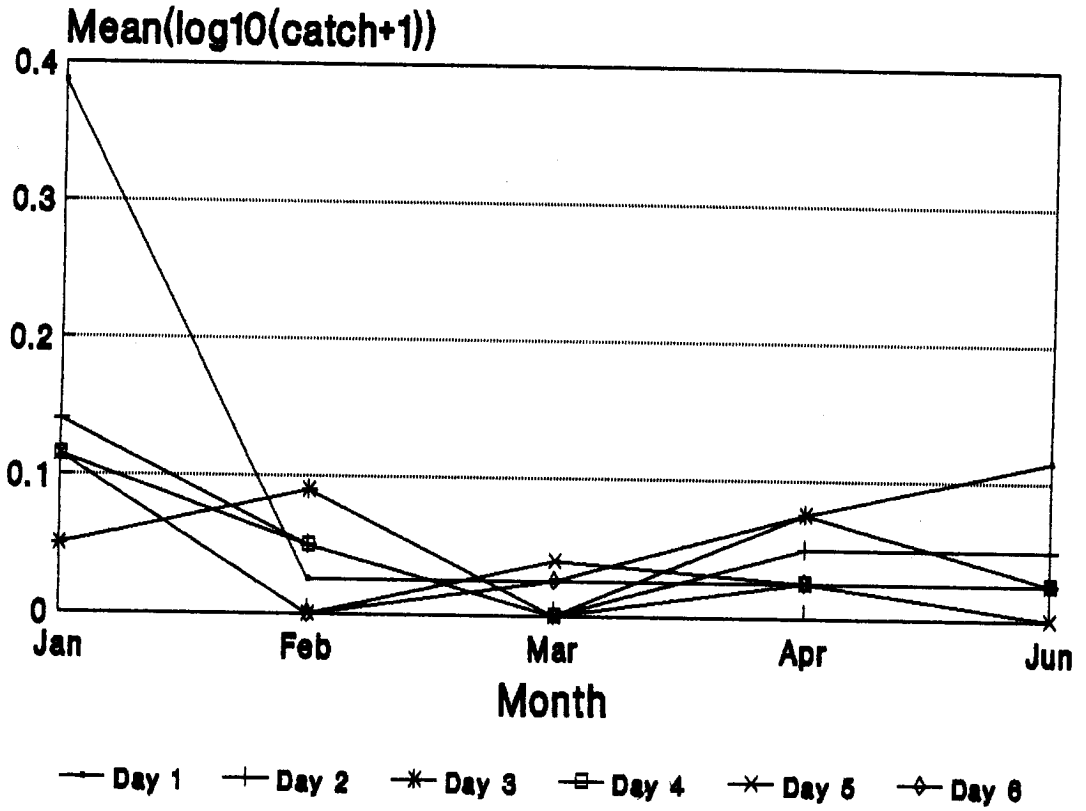


FIGURE 7.4b

Presence of month by day interaction
for *G. longipennis* in Oloibortoto



were observed in mean catches among sampling Days 1 to 4 and 6.

Sampu Valley

G. pallidipes

The standard error for comparing any two mean catches for G. pallidipes for the Month*Day interaction was 0.069. Figure 7.5 shows a plot of mean catches of G. pallidipes in the Sampu valley as a function of month and sampling day. The mean catch of G. pallidipes on Day 1 in February was significantly higher than that on subsequent sampling days. Although the mean catch on the first day of sampling remained the highest in March, April and June, the average catches on Days 1, 4 and 6 did not significantly differ in March; and were not significantly different in April on Days 1 and 2; and not significantly different in June on Days 1, 2, 4 and 5.

Month*Trap Interaction

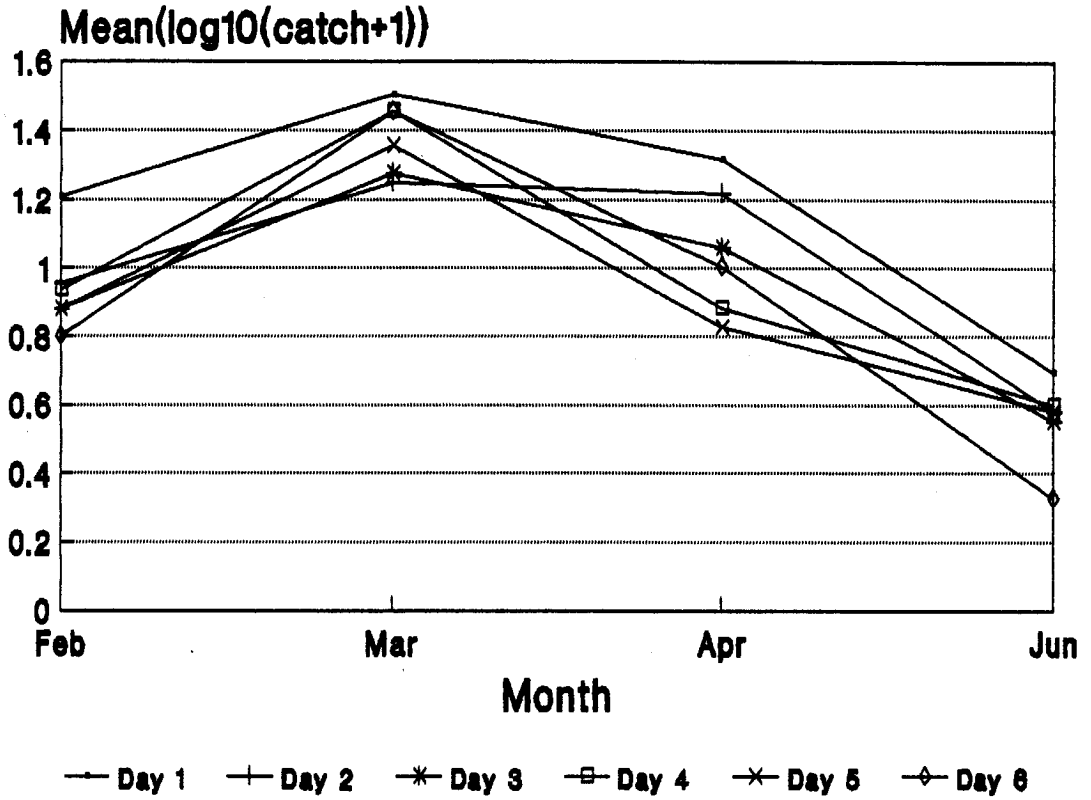
Oloibortoto Valley

G. pallidipes

Comparisons of mean catches between any two traps in January were done using a standard error of 0.093. As for February, March, April and June, a

FIGURE 7.5

Presence of month by day interaction
for *G. pallidipes* in Sampu



standard error of 0.085 was used. Traps S2 and S4 were among the traps with the highest catches in January, February and March. In April and June, Trap S2 had significantly higher mean catches than the rest of the traps (Figure 7.6a). Among the traps catching low numbers of G. pallidipes was Trap S3.

G. longipennis

The standard error for comparing any two mean catches of G. longipennis in the Oloibortoto valley in January was 0.052 and in February, March, April and June was 0.048. Trap S1 was one of the traps catching high mean numbers of G. longipennis in the Oloibortoto valley in February, March, April and June but was one of the traps with the least mean catch in January. Trap catches in Trap S3 were among the least catches through out the sampling period. Mean catches in all the traps in March were not significantly different from zero. Figure 7.6b highlights the Month*Trap interaction.

Sampu Valley

G. pallidipes

Figure 7.7a highlights the Month*Trap interaction for G. pallidipes in the Sampu valley.

FIGURE 7.6a

Presence of month by trap interaction
for Q. pallidipes in Oloibortoto

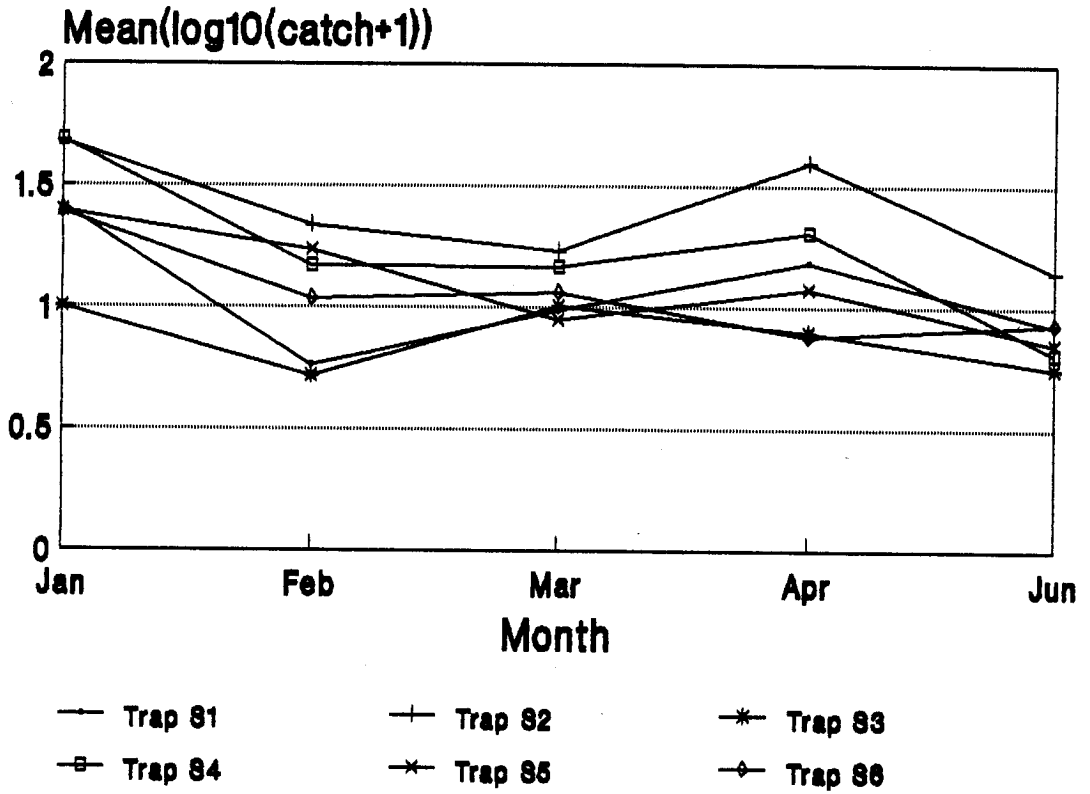


FIGURE 7.6b

Presence of month by trap interaction
for G.longipennis in Oloibortoto

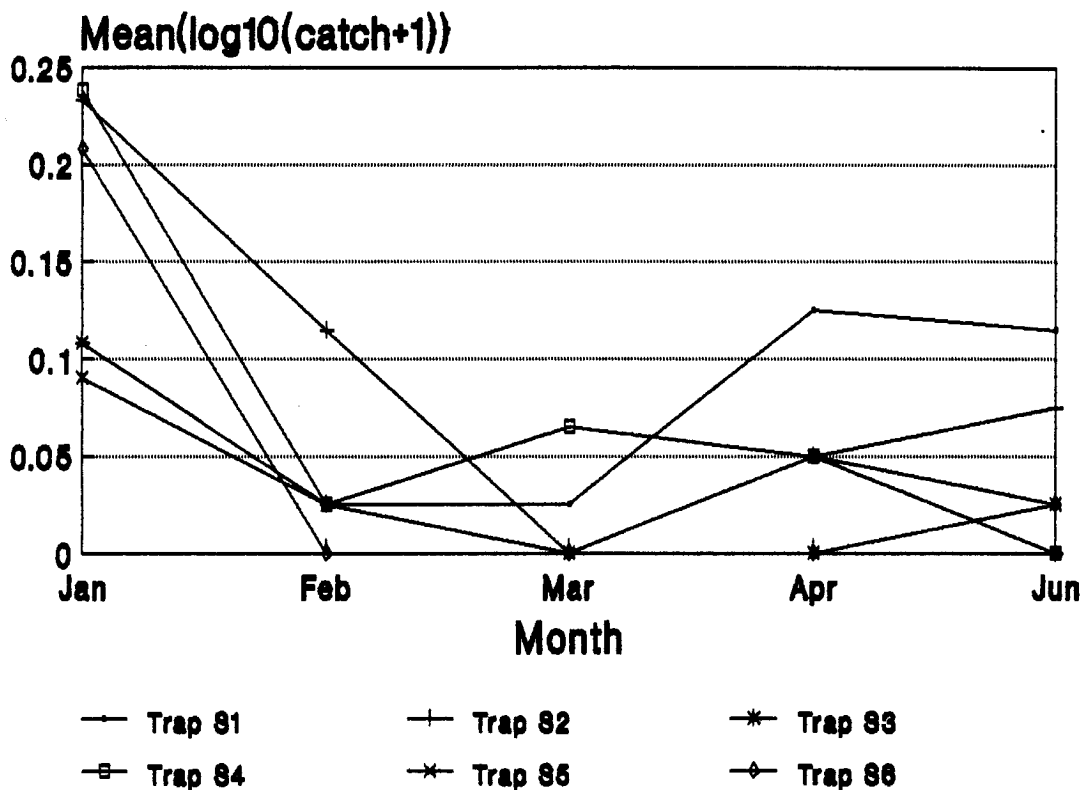
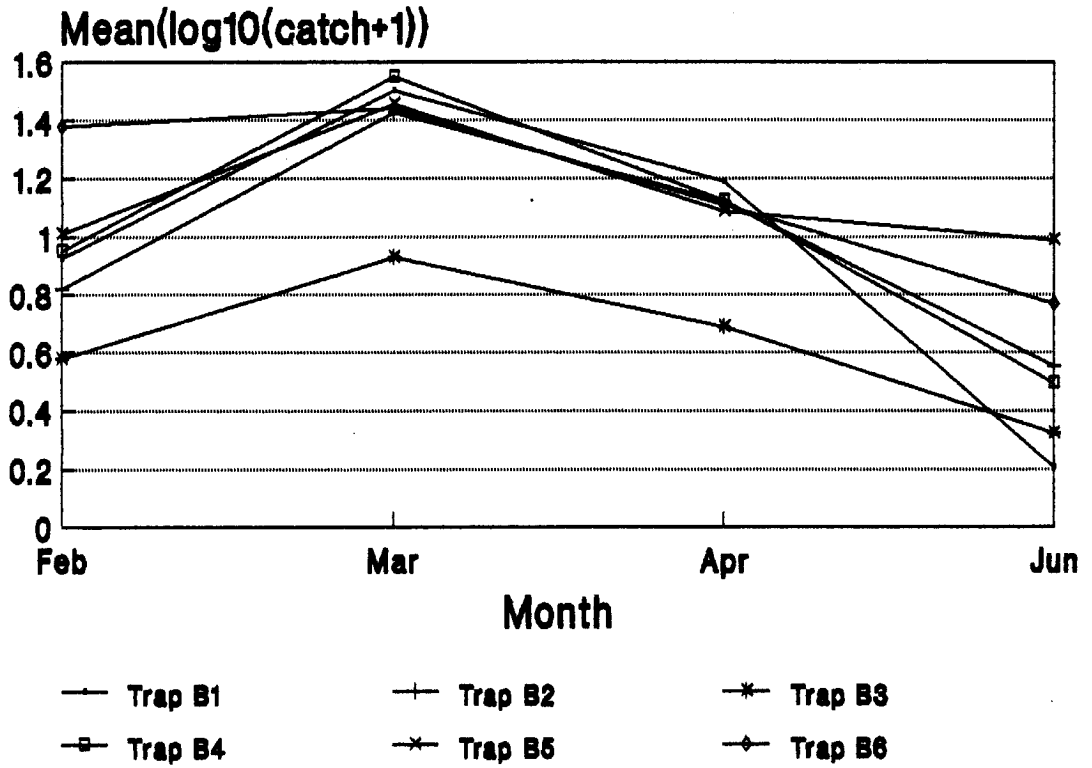


FIGURE 7.7a

Presence of month by trap interaction
for G. pallidipes in Sampu



The standard error for comparing any two means was 0.069. On average, Trap B3 caught significantly fewer numbers of G. pallidipes than any other trap in February, March and April. In June, the least mean catches in Traps B3 and B1 did not differ significantly.

G. longipennis

The standard error for comparing any two mean catches of G. longipennis for the Month*Trap interaction in the Sampu valley was 0.067. Mean catches in all the traps in February did not significantly differ. Trap B1 had a significantly higher mean catch than the rest of the traps in March. Meanwhile, in April and June, Trap B1 remained as one of the traps catching high numbers of G. longipennis on average. The mean catch in Trap B1 did not significantly differ from that of Trap B3 nor Trap B2 in April and June, respectively (Figure 7.7b).

Month*Sex Interaction

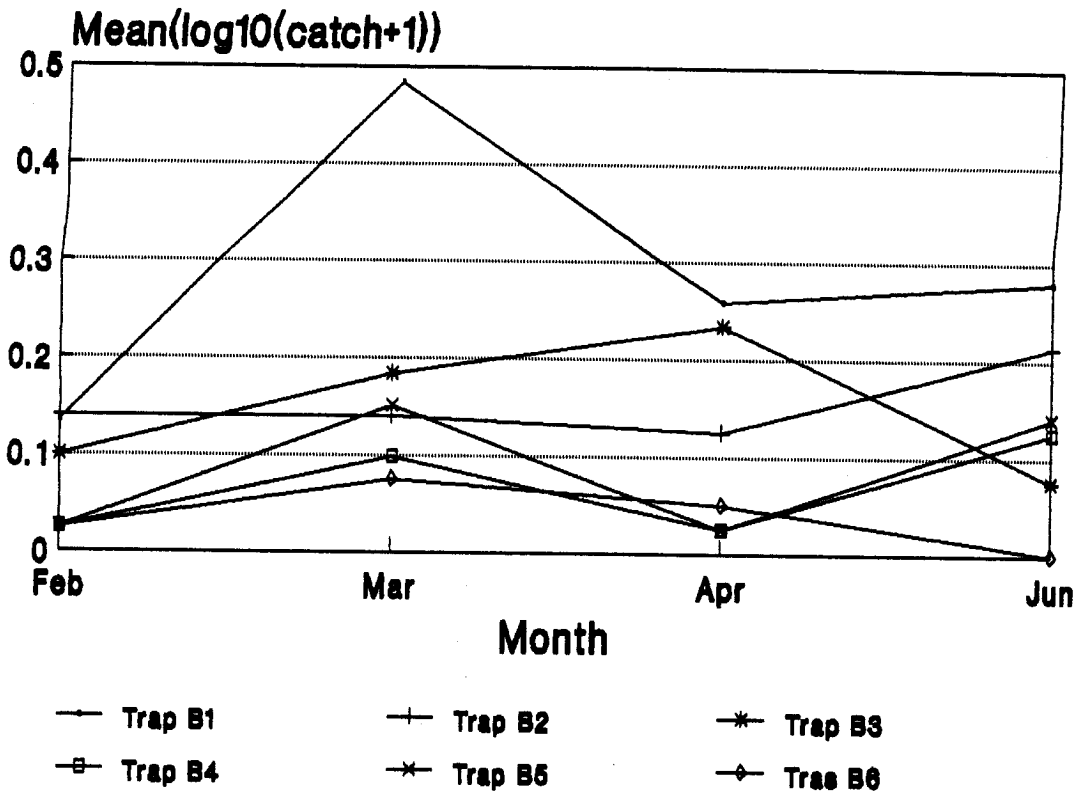
Oloibortoto Valley

G. pallidipes

The standard error for comparing any two mean catches of G. pallidipes in January was 0.054 and in

FIGURE 7.7b

Presence of month by trap interaction
for G. longipennis in Sampu



February, March, April and June was 0.049. From January to April, the mean number of female G. pallidipes caught was significantly higher than that for males. But in June, there was no significant difference in mean catches between sexes. Figure 7.8a shows the distribution of mean catches of G. pallidipes in the Oloibortoto valley by month and sex.

Sampu Valley

G. pallidipes

In order to compare any two mean catches of G. pallidipes for the Month*Sex interaction in the Sampu valley, a standard error of 0.040 was used. The mean numbers of female G. pallidipes caught in the Sampu valley were significantly higher than those for males in February to April, but significantly lower in June (Figure 7.8b).

Day*Trap Interaction

Oloibortoto Valley

G. pallidipes

In the comparison between any two means on Day 1 to 5 of sampling, a standard error of 0.093 was used. On the sixth day of sampling, a standard error of 0.104 was used. High mean catches were observed in

FIGURE 7.8a

Presence of month by sex interaction
for G. pallidipes in Oloibortoto

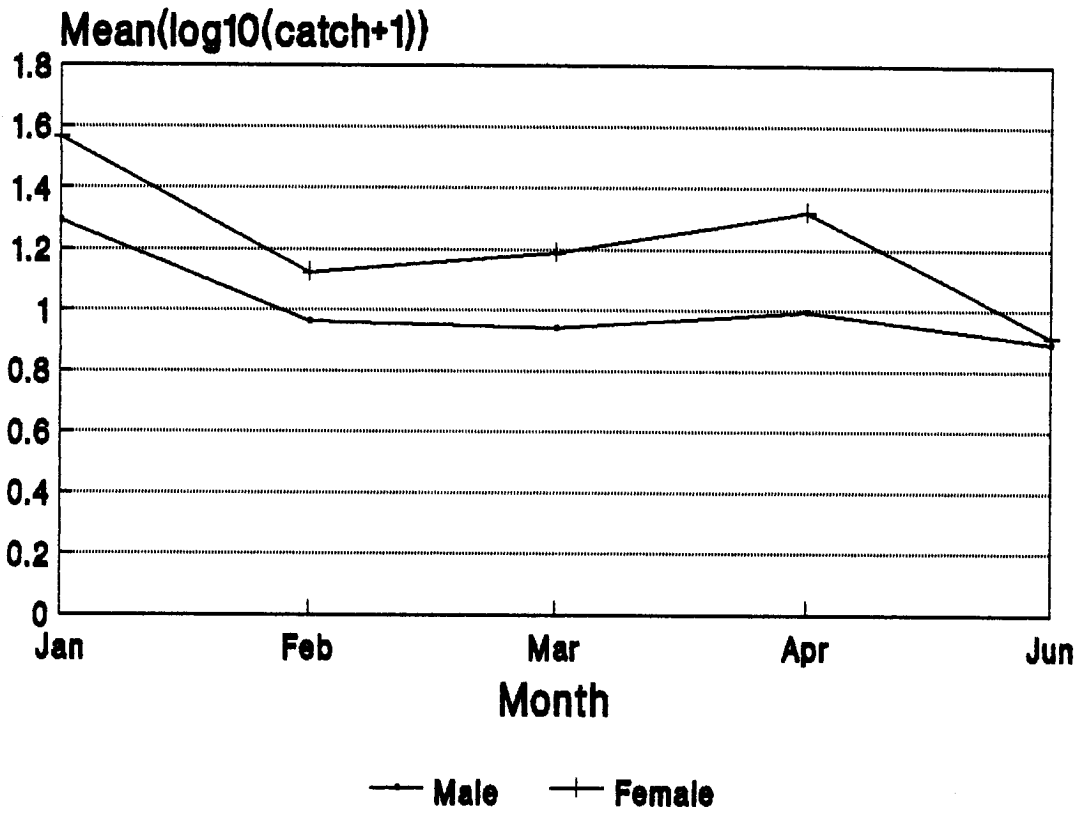
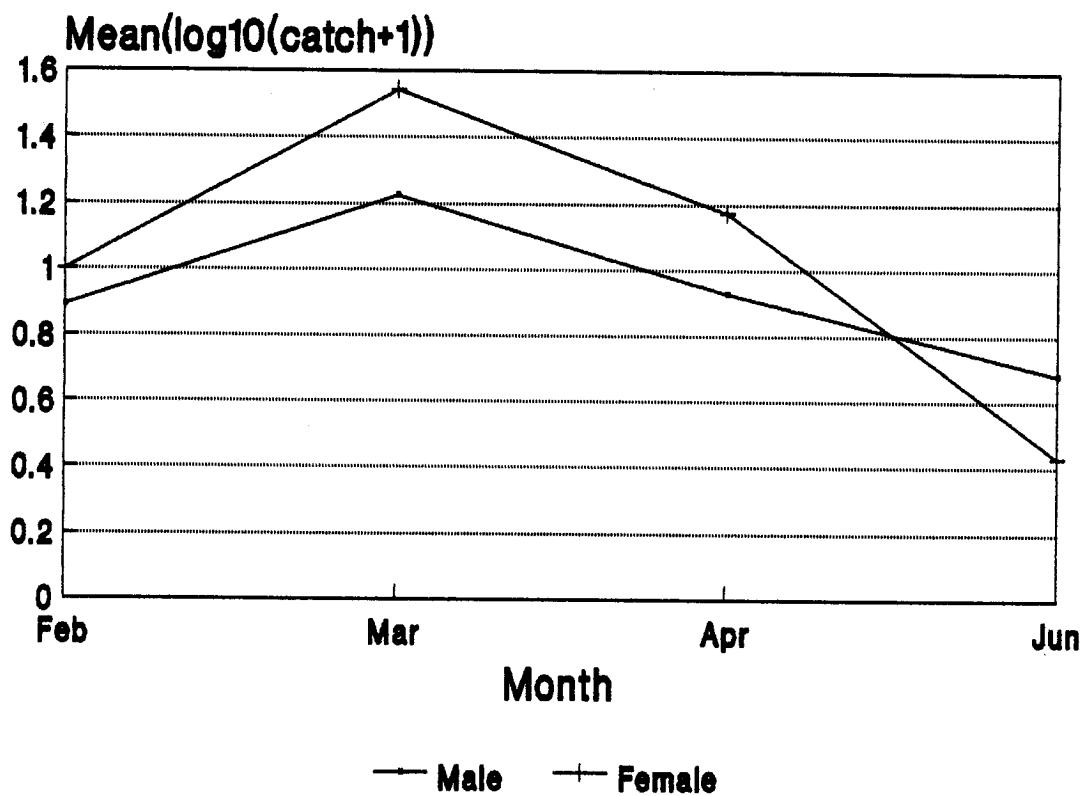


FIGURE 7.8b

Presence of month by sex interaction
for G. pallidipes in Sampu



Traps S2 and S4 through out the sampling days. On Days 2 and 3, the mean catch in Trap S2 was significantly higher than that in Trap S4. Generally, Trap S3 had the least mean catch through out the sampling period (Figure 7.9a).

G. longipennis

The standard error for comparing any two means from Day 1 to 5 of sampling was 0.052 and that for Day 6 was 0.058. Figure 7.9b shows the distribution of mean catches of G. longipennis in the Oloibortoto valley by sampling day and trap. On the first day of sampling, mean catches in Traps S1, S2, S4 and S6 were not significantly different; and on the second day of sampling, mean catches in Traps S1 and S4 did not significantly differ. Trap S2 had the highest mean catch on the third day of sampling. Meanwhile, there were no significant differences in mean catches among traps on Day 4 to 6.

Sampu Valley

G. longipennis

The standard error for comparing any two means was 0.082. Figure 7.10 highlights the Day*Trap interaction for G. longipennis in the Sampu valley. Through out the sampling period, Trap B1 had large

FIGURE 7.9a

Presence of day by trap interaction
for G. pallidipes in Oloibortoto

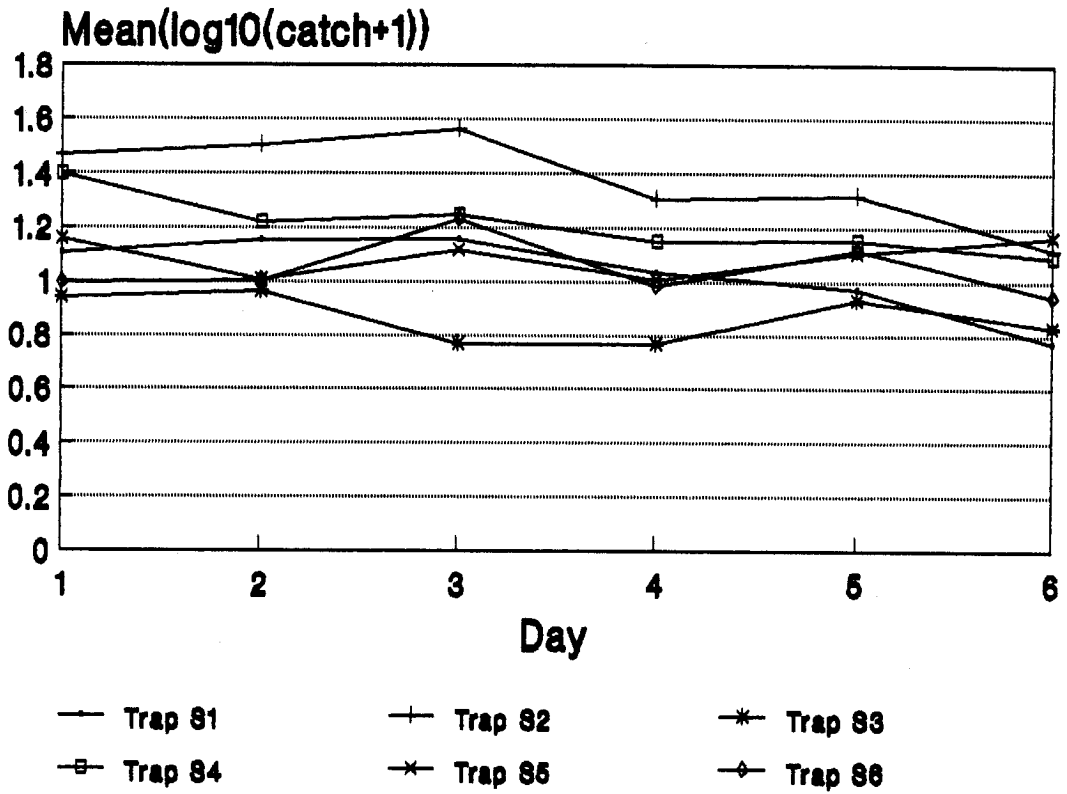


FIGURE 7.9b

Presence of day by trap interaction
for G.longipennis in Oloibortoto

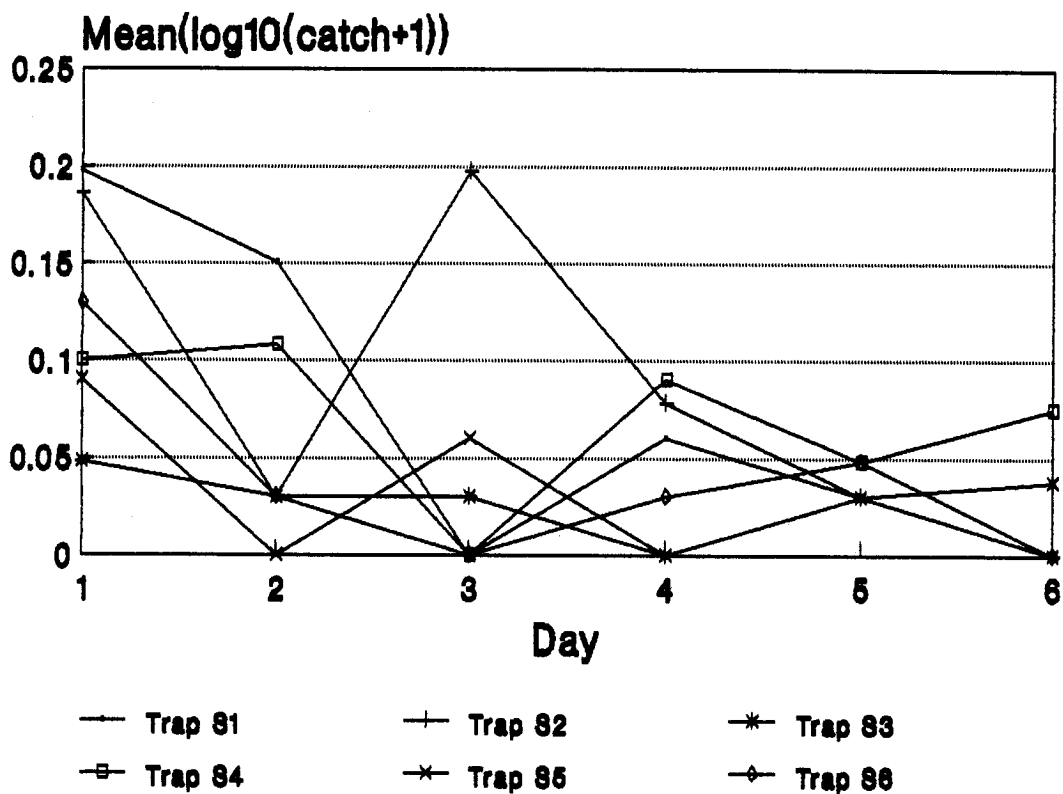
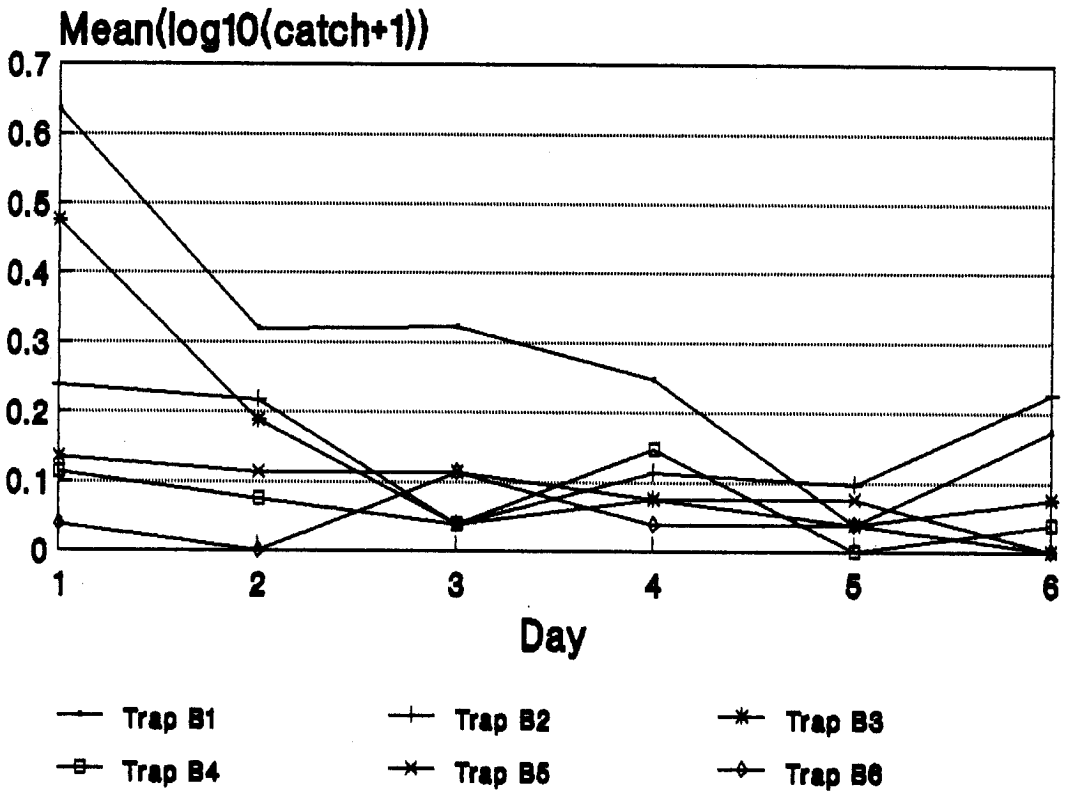


FIGURE 7.10

Presence of day by trap interaction
for G. longipennis in Sampu



catches, while Trap B6 had small catches in number on average. There were no significant differences in mean catches among traps on the fifth day of sampling.

Trap*Sex Interaction

Oloibortoto Valley

G. pallidipes

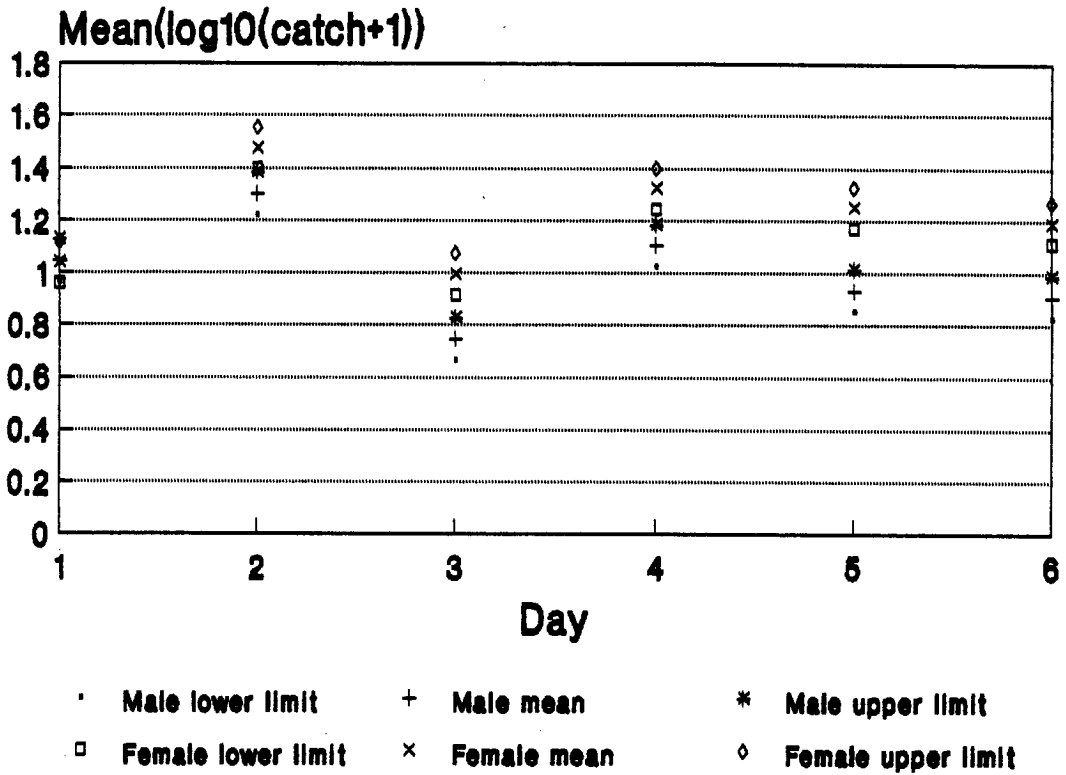
The Trap*Sex interaction for G. pallidipes in the Oloibortoto valley is highlighted in Figure 7.11. For hypotheses testing between any two means, a standard error of 0.054 was used. On average, more females than males were caught in all the traps except in Trap S1 in which there was no significant difference in mean catches of G. pallidipes between sexes.

Intervalley movement

Tables 7.3a,b,c show the distribution of numbers of marked G. pallidipes and their movement patterns between the Oloibortoto and Sampu valleys. In the dry season, July to August 1989, no marked tsetse fly was observed to have moved into another valley (Table 7.3b). But during the rainy season, April to May 1989, 61% of marked and recaptured Oloibortoto females moved into the Sampu valley, whilst only 11%

FIGURE 7.11

Presence of trap by sex interaction
for G. pallidipes in Oloibortoto



Limits are that of 95% confidence

TABLE 7.3a

Distribution of numbers of marked G. pallidipes in both the Oloibortoto and Sampu valleys.

Date marked	Site	Male	Female
01-03.iv.89	Sampu	207	431
04-06.iv.89	Oloibortoto	312	591
26-28.iv.89	Sampu	163	221
29.iv - 01.v.89	Oloibortoto	328	913
27 - 29.vi.89	Sampu	173	98
30.vi - 02.vii.89	Oloibortoto	147	115

TABLE 7.3b

Distribution of numbers of marked G. pallidipes recaptured in the Oloibortoto and Sampu valleys in the dry season from July to August 1989

Marking site	Recapture site	Number recaptured	Percent recaptured
Male:			
Oloibortoto	Oloibortoto	2	
Oloibortoto	Sampu	0	-
Sampu	Sampu	8	
Sampu	Oloibortoto	0	-
Female:			
Oloibortoto	Oloibortoto	2	
Oloibortoto	Sampu	0	-
Sampu	Sampu	2	
Sampu	Oloibortoto	0	-

TABLE 7.3c

Distribution of numbers of marked G. pallidipes recaptured in the Oloibortoto and Sampu valleys in the wet season from April to May 1989.

Marking site	Recapture site	Number recaptured	Percent recaptured
Male:			
Oloibortoto	Oloibortoto	4	
Oloibortoto	Sampu	0	-
Sampu	Sampu	10	
Sampu	Oloibortoto	0	-
Female:			
Oloibortoto	Oloibortoto	9	
Oloibortoto	Sampu	14	60.9
Sampu	Sampu	24	
Sampu	Oloibortoto	3	11.1

of the marked Sampu females moved into the Oloibortoto valley (Table 7.3c). No marked male had moved to another valley even during the rainy season.

7.4 DISCUSSION

The number of flies trapped will depend on the availability of the game, visibility of the area surrounding the trap, the efficiency of the trap, the prevailing climatic conditions, the mobility and sex of the flies.

There was better predictability for G. pallidipes than for G. longipennis probably because the catches of G. pallidipes were higher than those for G. longipennis. This may suggest that the sampling device, biconical trap, may have been inefficient for the G. longipennis.

Even though all the main factors were significant except for sex for G. longipennis in both valleys, their effects in the presence of interaction must be interpreted with caution.

The short rains are normally from October to December and the long rains from March to May. The period of study was an unusual one with the short

rains extending to February 10, 1989. Though it rained on 14 out of 31 days in January 1989, these were light rains of less than 15 mm except on January 6 and 22 when over 30 mm of rainfall was recorded.

The climatic conditions in January may have been favourable for the movement of G. pallidipes in the Oloibortoto valley because there was no evidence for the trapping out effect in this month. But the same conditions may not have been favourable for the movement of G. longipennis in the Oloibortoto valley. Hence, the significant trapping out effect observed in this month when the mean catch of G. longipennis on the first day of sampling was significantly higher than that on subsequent sampling days.

There was no evidence of the trapping out effect in February, March and April. This suggests that there was a lot of movement of G. longipennis taking place just before the onset of the long rains and during the long rains. The movement of G. longipennis appeared to have been slightly altered in June but with no obvious evidence for the trapping out effect.

It, finally, appears that G. pallidipes and G. longipennis in the Oloibortoto valley responded differently in their movement in relation to changes in the climate in January.

A marked effect of seasonality on the density of G. pallidipes in the Sampu valley was such that high mean catches occurred in March on sampling Days 1, 4 and 6, and low mean catches in June on the sixth day of sampling.

The peaking of the numbers of G. pallidipes at the beginning of the long rains accords well with Snow's (1981) observation at the south Kenyan coast. This is also similar to Dransfield et al.' (1990) observation that the population of G. pallidipes in the suppression zone between February 1987 and February 1988 rose during the main rains and declined during the dry season. High catches of G. pallidipes in the Sampu valley in March on sampling Days 1, 4 and 6 suggest a high rate of diffusion of this fly in this month which could be attributed to the movement of the flies from outside the Sampu valley. This movement could have been in search of food, for game was abundant in the Sampu valley.

However, in the Oloibortoto valley the population of G. pallidipes was higher immediately after the short rains in January and this was similar to the observations of Kangwagye (1974) in western Uganda. The case for the rise in population size of G. pallidipes in the Oloibortoto valley after the rains could be explained by the nature of the vegetation found there. In the Oloibortoto valley the vegetation close to the edge of the escarpment was rather marginal for the most of the year and degeneration of the vegetation may have lowered the population size during the dry season. However, the vegetation regenerated during the rainy season thereby attracting more flies as game also thriving due to abundance of pasture became more available.

Trap S1 was one of the three traps that caught the least number of G. longipennis in January but became one of the traps catching high numbers of G. longipennis between February and June. This may reflect the movement of G. longipennis during the main rains towards the edge of the escarpment where Trap S1 was erected.

Overall mean catches of G. pallidipes between February and June were high in Trap S2, and those for

G. longipennis were high in Trap S1. This difference in the species' distribution may have been due to Trap S1 being in a more open area than Trap S2.

Further evidence for the species' vegetational preferences was gathered in the Sampu valley where more G. pallidipes were caught in traps erected at the edge of the escarpment than in Trap B3 which was erected furthest away from the water course which had an adjacent riverine vegetation in which flies were concentrated in. Meanwhile, more G. longipennis were caught in traps erected in an open woodland (Traps B1, B2 and B3) than in traps erected in the thicket habitat at the edge of the escarpment (Traps B4, B5 and B6).

It is also documented that G. pallidipes prefers the thicket habitat (Swynerton, 1936) in which Trap S2 was erected, while G. longipennis prefers Acacia type of woodland (Buxton, 1955) to other types of woodlands.

Trap S3 may have caught few numbers of G. pallidipes and G. longipennis through out the sampling period because it was close to a homestead where game was absent. The tsetse prefer to feed on

game (especially suids, Tarimo, Golder et al., 1985) to feeding on humans and goats. The flies probably remained in areas where game was found, especially the area close to the river between Traps S2 and S4.

It is interesting to note that catches of G. longipennis in both valleys in February were about equal but became fewer in March in the Oloibortoto valley and increased in the same month in the Sampu valley. This suggests that G. longipennis may have migrated to the Sampu valley from the Oloibortoto valley.

Generally, biconical traps catch more females than males and it is, therefore, not surprising that more female G. pallidipes than males were caught in S-traps from January to April. But about equal numbers of females and males were captured in June. An explanation could be that female numbers in the Oloibortoto valley may have gone down as a result of emigrating to a more suitable area for larvipositing, as the vegetation in the Oloibortoto valley was rather marginal which degenerated during the dry season.

The rate at which female G. pallidipes in the Sampu valley went down in June is greater than that for female G. pallidipes in the Oloibortoto valley. While the vegetation in the Sampu valley was denser than that for the Oloibortoto valley, the rocky soil may not have been favourable for larvipositing making the female flies to search for softer soils into which the larvae may burrow.

Generally, more G. pallidipes were caught in Traps S2 and S4 than in any other trap through out the sampling period, while Trap S3 generally had the least catch. Apart from Traps S2 and S4 being nearest to the water course, they were erected in areas where game was plenty. Because Trap S3 was close to a homestead, catches of G. pallidipes were low in this trap.

Traps S1, S2, S4 and S6 caught equally the highest numbers of G. longipennis on the first day of sampling because these traps were nearest to the water course in which adjacent riverine vegetation the flies were concentrated in. Catches on subsequent sampling days were generally lower except on Day 3 when numbers of G. longipennis caught in Trap S2 were comparable to catches in the same trap

on the first day of sampling. It is not clear as to why catches in Trap S2 on Day 3 soured high.

Equal numbers of female and male G. pallidipes were caught in Trap S1 which was at the edge of the escarpment. Because more females than males get caught in traps, the equal sex-ratio observed at the edge of the escarpment suggests that females may have left the edge of the escarpment.

Further away from the edge of the escarpment, there was more movement of female G. pallidipes from the north (Oloibortoto valley) towards the south (Sampu valley) than the reverse; this was probably a result of tsetse seeking game which was abundant in the Sampu valley which also provided more wooded vegetation cover.

Clearly, the onset of the rains directly or indirectly triggered the movement of tsetse flies in Nguruman. As pasture became available during the wet period and game moved into the grasslands for grazing, tsetse flies will have followed the game for their food. If it were practical to control the movement of the game, one might alleviate or stop the movement of the flies into the suppression zone. The

rains may have affected tsetse movement into the suppression zone directly by providing the required humidity for increased activity of the flies. Once active, tsetse flies disperse irrespective of the presence or absence of the game. One way to prevent tsetse from moving from one area into another would be to set up a barrier to trap the flies. A barrier line of traps could be set between X-traps 4 and 5 in order to reduce or stop the movement of flies across this region. This would be an appropriate site for setting up a barrier because the wooded vegetation, through which most tsetse flies pass, is narrower at this site and fewer traps would be needed here than in a wider area of wooded vegetation.

Since invading flies are also thought to be coming from the top of the escarpment, other appropriate sites to set barriers are those close to the edge of the escarpment. The river valleys are narrower at the edge of the escarpment and series of lines of traps could be set to prevent flies getting away from the edge of the escarpment into the suppression zone. The question of how far apart should the traps be set will be discussed in another chapter. In the next chapter we look at the movement pattern and rate at which G. pallidipes is moving

on the first day of sampling. It is not clear as to why catches in Trap S2 on Day 3 soured high.

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away from the edge of the escarpment in the Sampu valley; and try to see if the movement of tsetse flies could be explained by a simple random diffusion model.

CHAPTER 8

FITTING DIFFUSION MODELS

8.1 INTRODUCTION

Rogers (1977) and others have shown that in many different situations the movement of tsetse flies can be accounted for on the basis of a random walk model equivalent to classical gaseous diffusion (Tabor, 1979; Pielou, 1977; Wannier, 1966; Kennard, 1938). At Nguruman the vegetation varies from grassland to thicket to high forest. Since the random walk model has mainly been applied to tsetse flies inhabiting homogeneous habitats, we wish to determine whether the movement of tsetse flies in a heterogeneous habitat such as that at Nguruman can also be accounted for on the basis of diffusion models.

8.2 MATERIALS AND METHODS

Dispersal of marked flies

The Nguruman trap was used to capture tsetse flies for marking and monitoring their movements. The flies were marked individually using artist's oil paint (Jackson, 1953) and were released at positions RS2 and RS6 (Figure 4.1) within 15 minutes from about 9:00 to 18:00h for the periods shown in Table 8.2.

Their movements were monitored until there were no more recaptures. Trap positions for monitoring how far tsetse flies travelled were plotted on Government of Kenya 1:50,000 ordinance survey map, from which the distance travelled in a straight line by the marked tsetse flies between release and recapture points were determined.

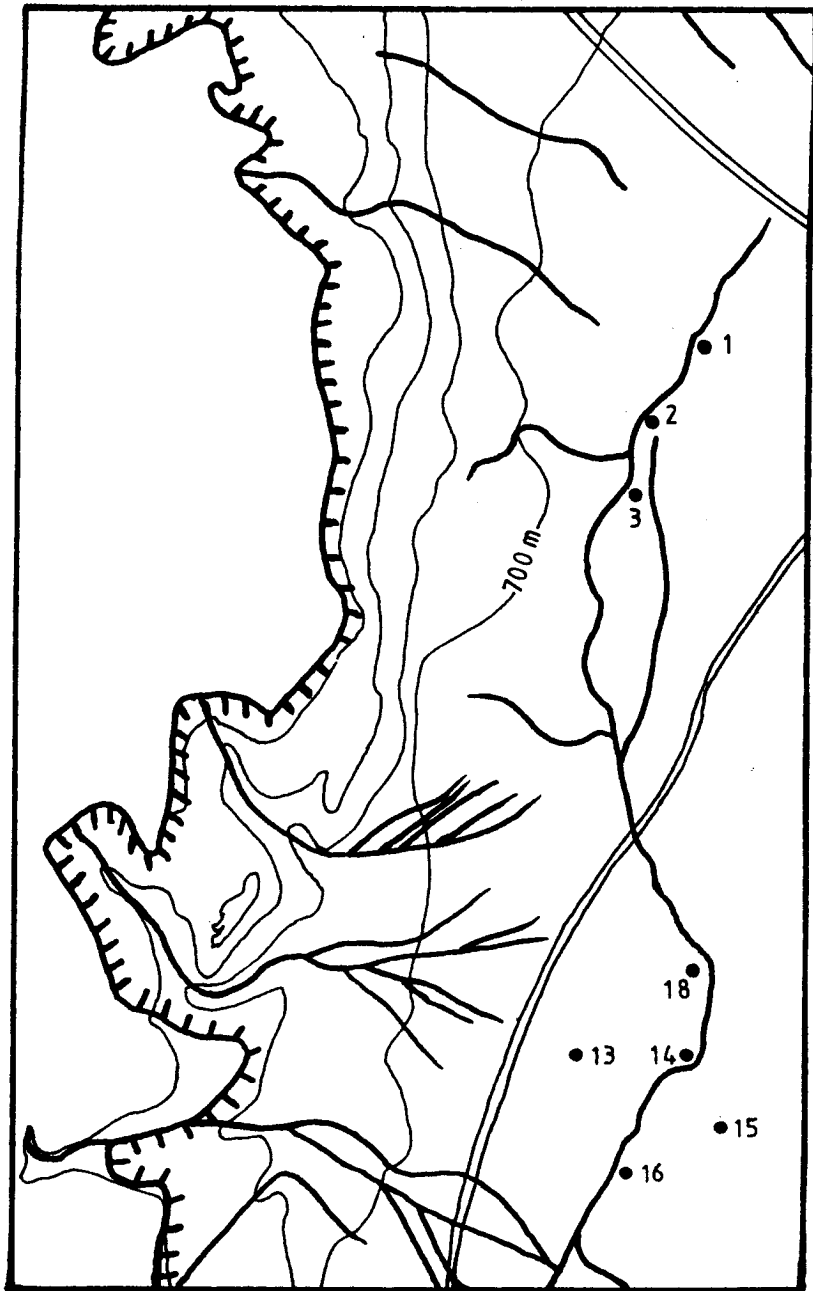
Apparent densities of tsetse flies as measured by trap catches and the movement of marked flies were monitored every 3 to 4 days using the 22 X-traps whose sites are marked 1 to 22 in Figure 7.3. Three of the 22 X-traps: X1, X2 and X3 were along a strip of wooded vegetation in the Oloibortoto valley, while Traps X13, X14, X15, X16 and X18 were in an extensive woodland in the Sampu valley (Figure 8.1). Trap catches in these two groups of traps which were erected in a strip of woodland and in an extensive woodland were used to monitor apparent movement of tsetse flies in a 1- and 2-dimensions habitat, respectively.






Weather monitoring

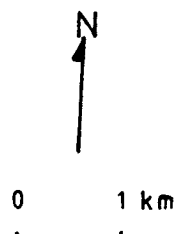
Daily rainfall, minimum and maximum temperatures and relative humidity were recorded in a Stevenson screen on each day during the monitoring period at a

FIGURE 8.1

X-traps locations used in the study on fitting diffusion models



-  Escarpment
-  River
-  Road
-  100m contour
-  Trap



station about 7 km from the five traps in the Sampu valley, and about 3 km from the three traps in the Oloibortoto valley.

Analysis

Average distance travelled

The root mean square (σ_{rms}) deviation (Jenkins and Slacks, 1985) was used to compute the average distance travelled by the marked flies where

$$\sigma_{\text{rms}} = \sqrt{((d_1^2 + d_2^2 + \dots + d_n^2)/n)}$$

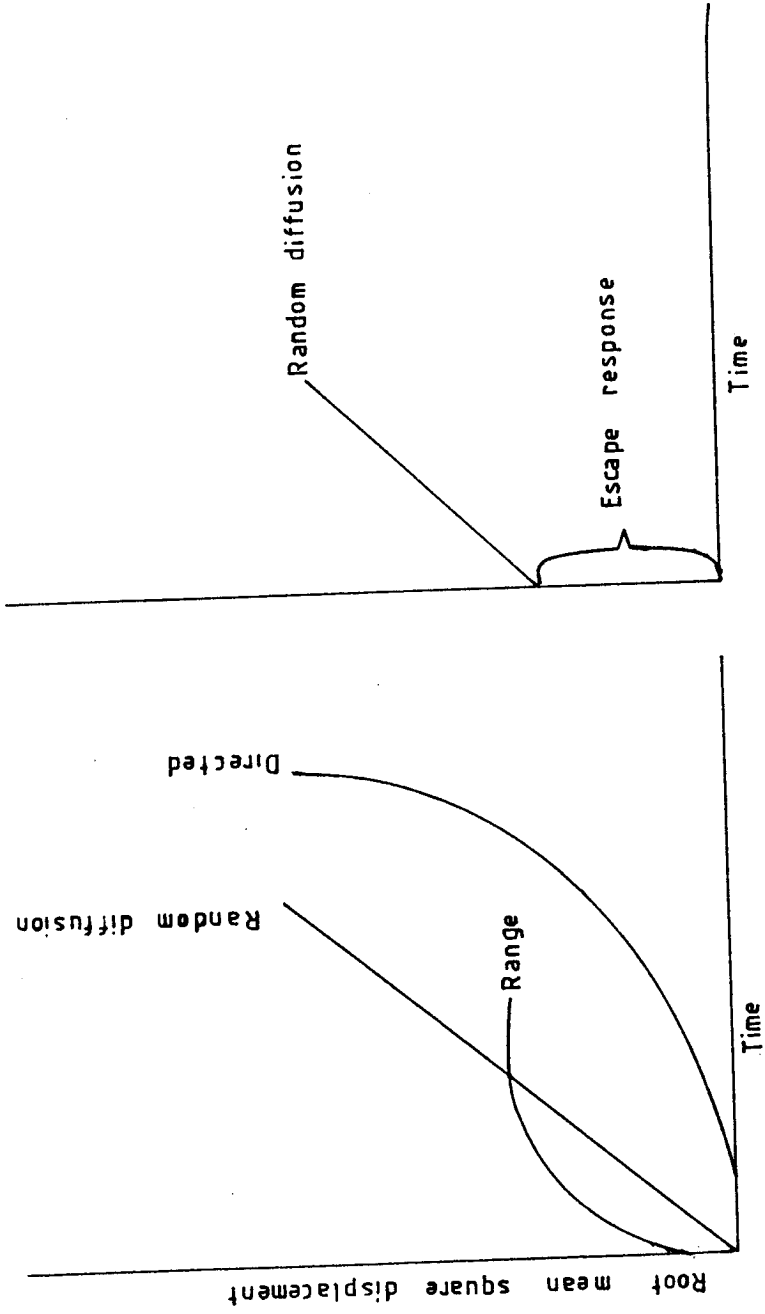
and d_i^2 is the squared distance travelled by each marked fly. The root mean square deviation method has been found to give an appropriate estimate of the average distance transversed by grasshoppers with time (Clark, 1962). Figure 8.2 shows hypothetical graphic models for types of movement.

The relation between the root mean square deviation and the diffusion coefficient

By the Central Limit Theorem, the distribution of discrete randomly dispersing tsetse flies can be approximated by a Gaussian distribution.

FIGURE 8.2

Hypothetical graphic models for types of movement



1-dimension

Suppose a fly is released at the origin of a one-dimensional coordinate system. The probability distribution function of marked flies at the point x at time t is:

$$p(x,t) = (1/\sqrt{(2\pi\sigma^2t)}) * \exp(-x^2/2\sigma^2t)$$

for which (Mood, Graybill and Boes, 1974)

$$\langle x^2, t \rangle = \sigma^2 t$$

Writing k for the diffusion coefficient σ^2

$$\begin{aligned} \sigma_{\text{rms}} &= \sqrt{\langle x^2, t \rangle} \\ &= \sqrt{(kt)} \end{aligned}$$

This means that in a one-dimensional coordinate system, for a diffusive process the root mean square deviation of the flies' position increases as \sqrt{t} .

2-dimension

For a Cartesian coordinate system

$$\langle r^2 \rangle = \langle x^2 + y^2 \rangle = \langle x^2 \rangle + \langle y^2 \rangle$$

and since

$$\sigma_{\text{rms}} = \sqrt{(2\sigma^2)}$$

in two-dimensions, we have

$$\sigma_{\text{rms}} = \sqrt{(2kt)}$$

Diffusion equation

The differential equation that describes a uniform diffusion process is

$$\partial\phi/\partial t = k \nabla^2 \phi$$

where ϕ is the density of flies, k is the diffusion constant, as before, and ∇^2 is $\partial^2/\partial x^2 + \partial^2/\partial y^2$ in two-dimensions.

Consider a one-dimensional problem with ϕ_{-1} , ϕ_0 and ϕ_1 being the density of flies at positions x_{-1} , x_0 and x_1 , respectively. Let d be the grid spacing. Then

$$\partial^2\phi/\partial x^2 \approx (\phi_{-1} - 2\phi_0 + \phi_1)/d^2$$

so that

$$\partial\phi/\partial t \approx k(\phi_1 - 2\phi_0 + \phi_{-1})/d^2$$

Solving for a steady state ($\partial\phi/\partial t = 0$)

$$\phi_0 \approx (\phi_{-1} + \phi_1)/2$$

so that at each point the density of flies is the average of the densities of the flies at the adjacent positions.

In two-dimensions

$$\begin{aligned} \partial^2\phi/\partial x^2 + \partial^2\phi/\partial y^2 \approx & ((\phi_{10} - 2\phi_{00} + \phi_{-10}) \\ & + (\phi_{01} - 2\phi_{00} + \phi_{0-1}))/d^2 \end{aligned}$$

so that at equilibrium

$$\phi_{00} \approx (\phi_{10} + \phi_{-10} + \phi_{01} + \phi_{0-1})/4$$

This means that if we have a central position surrounded by four positions, the density of the flies at the central position will be equal to the average of the four densities at the four peripheral positions.

8.3 RESULTS

There were four marking occasions in the Sampu valley at the edge of the escarpment. Only one marking occasion (April 1 to 3, 1989) gave enough recaptures to carry out an analysis for female G. pallidipes. No recaptures were made of G. longipennis. The distribution of recaptures for each marking occasion and sex is shown in Table 8.1.

The prevailing weather conditions in April 1989, when the monitoring of the movement of marked tsetse flies was in progress, are shown in Figures 8.3a,b,c. On average, the air temperature was about 27°C (Figure 8.3a). It rained on 17 out of 30 days with maximum precipitation on day 8 of about 40 mm (Figure 8.3b). On 22 out of 30 days the r.h. taken at 8:00h was above 90% with minimum r.h. being about 70% (Figure 8.3c). On 4 out of 30 days the r.h. taken at 15:00h was above 90% with the minimum r.h. being 40%.

Comparing the data points in Figures 8.4 and 8.5 with the hypothetical graphic models in Figure 8.2, the released marked female G. pallidipes may have dispersed at random during the first 10 days after release and after that they spread over the whole area, being restricted by the edge of the grassland

TABLE 8.1

Distribution of recaptures of G. pallidipes marked and released at position RS6 between February 26 and July 20, 1989.

Mark	Release date	Sex	Last recapture date	Number marked and released	Number recaptured
DGD	26.ii	Male	27.ii	52	1
		Female	10.iv	111	2
DBD	2.iv	Male	21.v	207	12
		Female	15.v	431	24
DOD	27.iv	Male	1.vi	163	9
		Female	18.v	221	10
DRD	28.vi	Male	20.vii	173	7
		Female	3.vii	98	5

FIGURE 8.3a

Prevalling air temperatures in April 1989

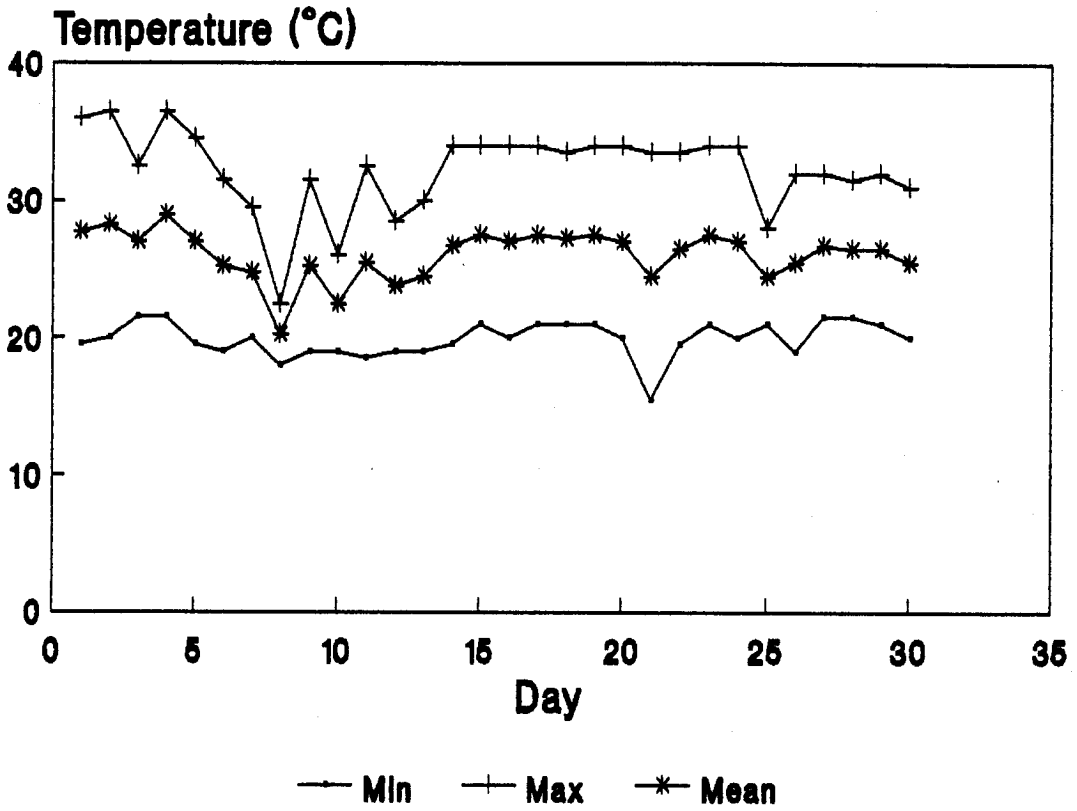


FIGURE 8.3b

Prevailing rainfall in April 1989

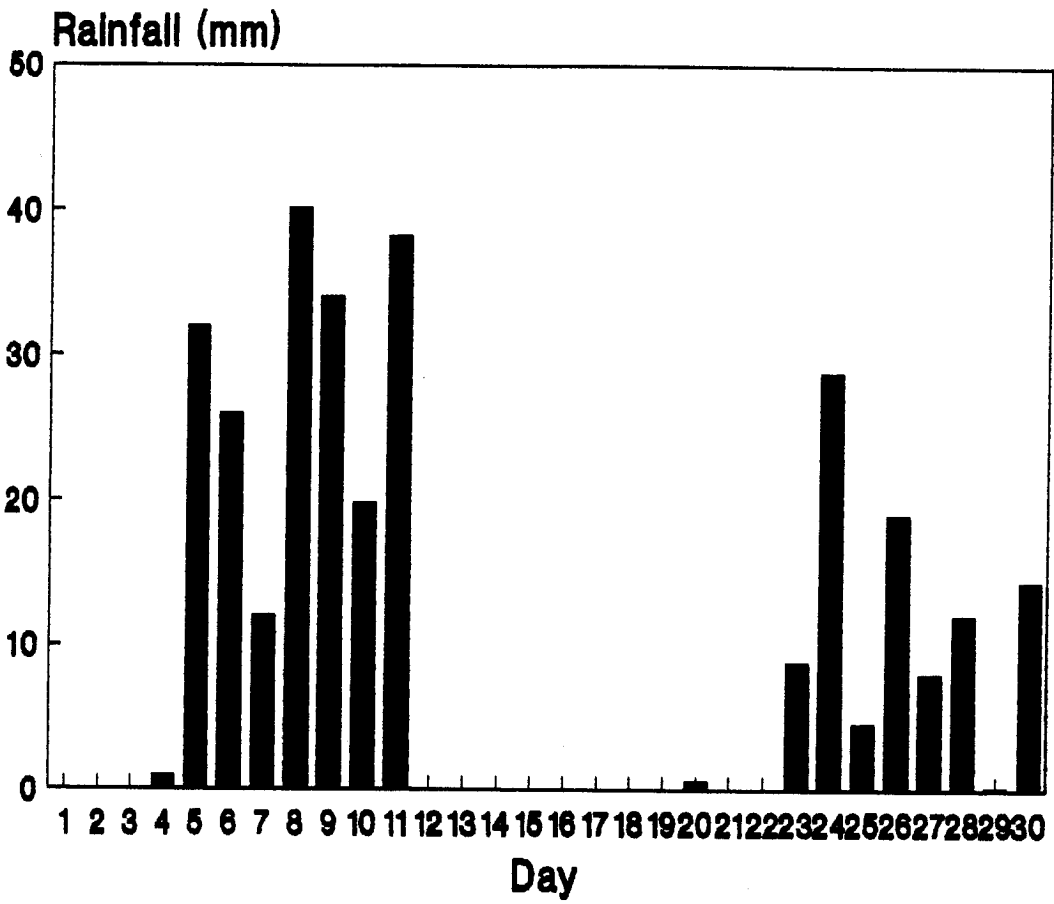


FIGURE 8.3c

Prevalling relative humidities in April 1989

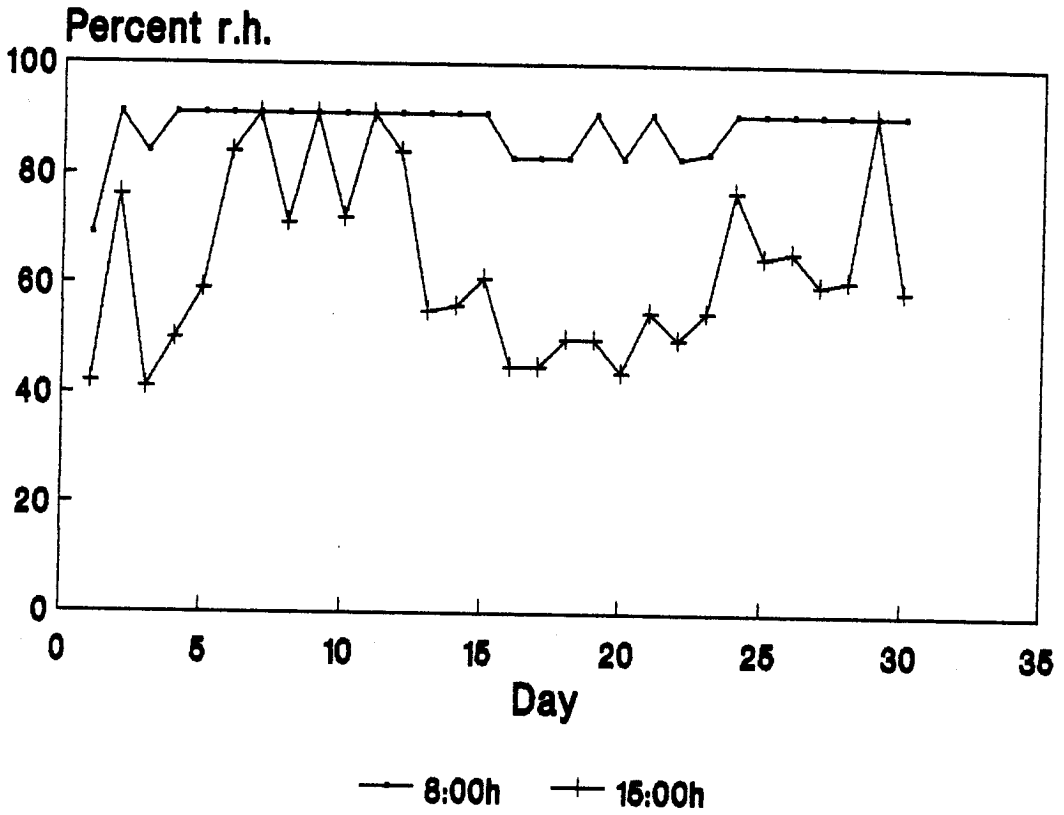


FIGURE 8.4

Dispersal of female DBD G.pallidipes
released at site RS6

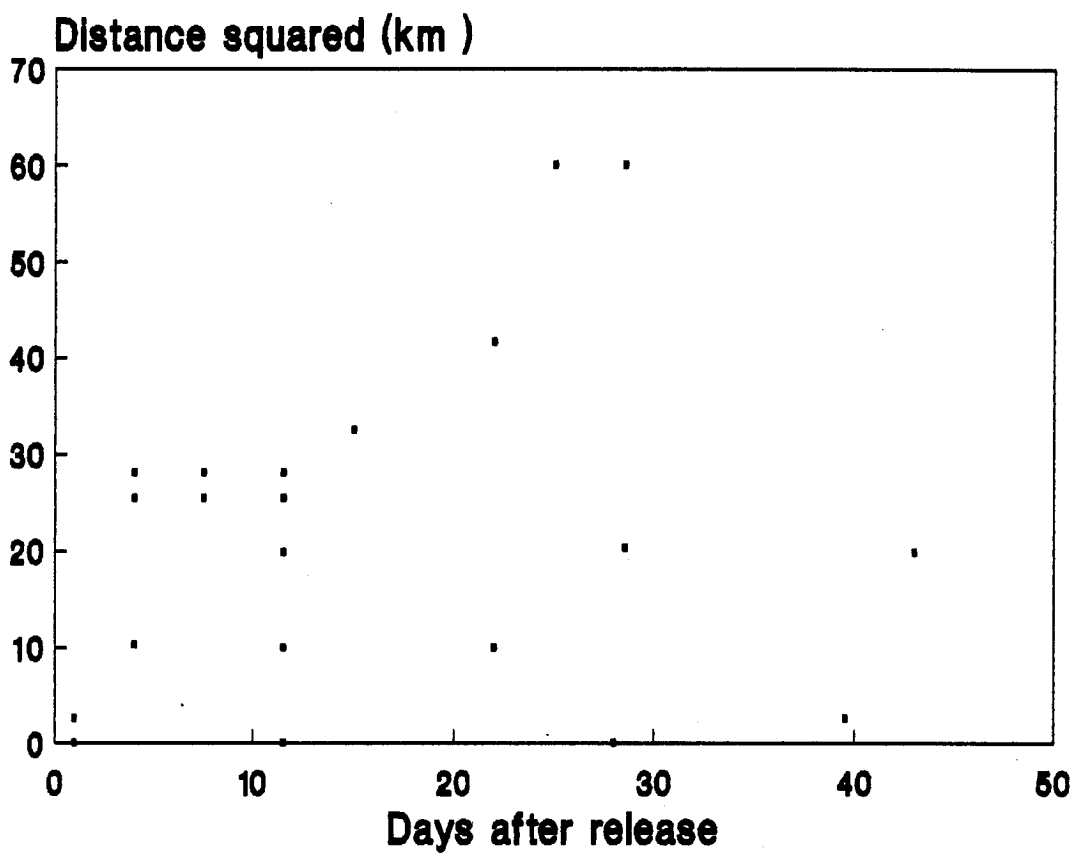
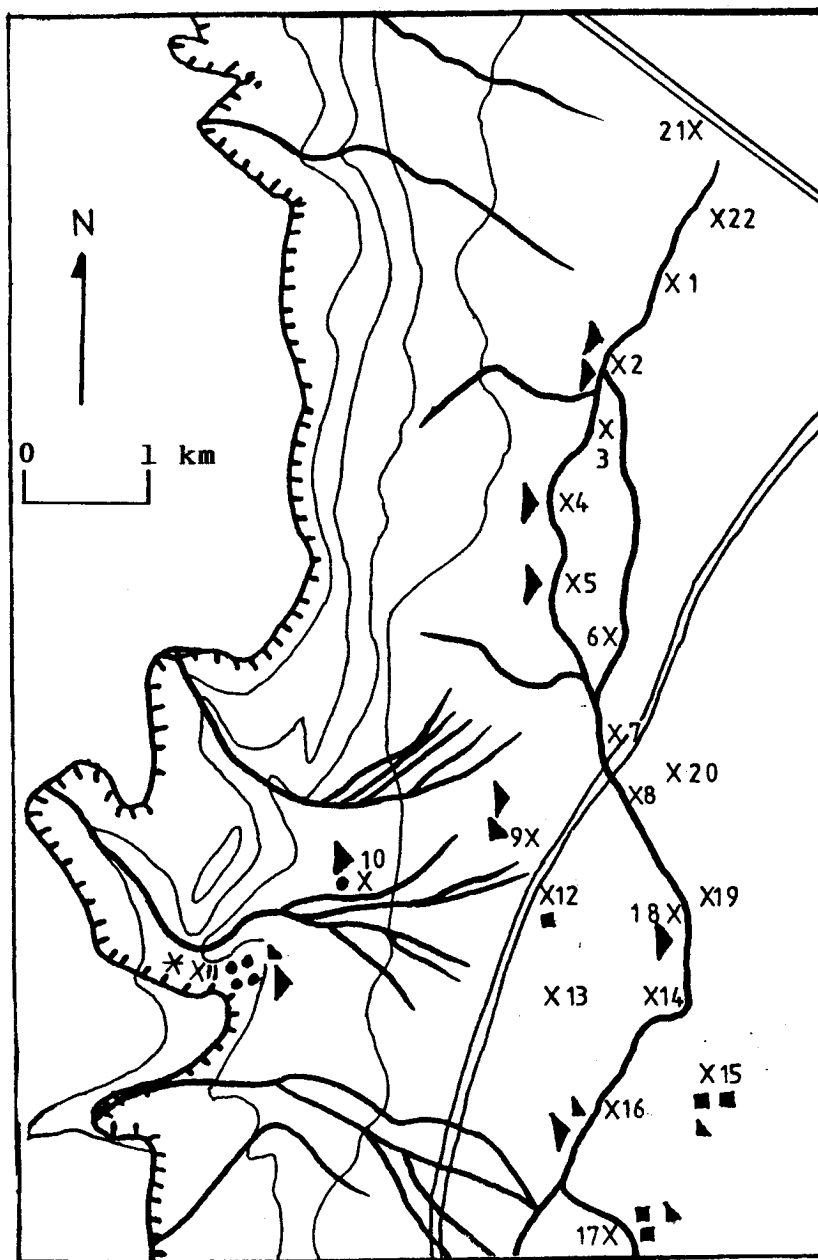


FIGURE 8.5

Map showing recapture points for female DBD G.pallidipes released at site RS6



Days after release

- 0-3.5
- 4-7.5
- ▲ 8-11.5
- ▶ 12+

mtm Escarpment

— River

— Road

— 100m contours

* Release site RS6

x Trap

vegetation. Fitted models in Figure 8.6 have been plotted using the relation $\sigma_{\text{rms}} = \sqrt{(2kt)}$ and suggest that during the first 10 days after release the flies may have diffused at a rate between 1.5 and 2.0 km² per day: giving a dispersal rate in a linear habitat of between 1.2 and 1.4 km in one day.

Mean distance transversed with time

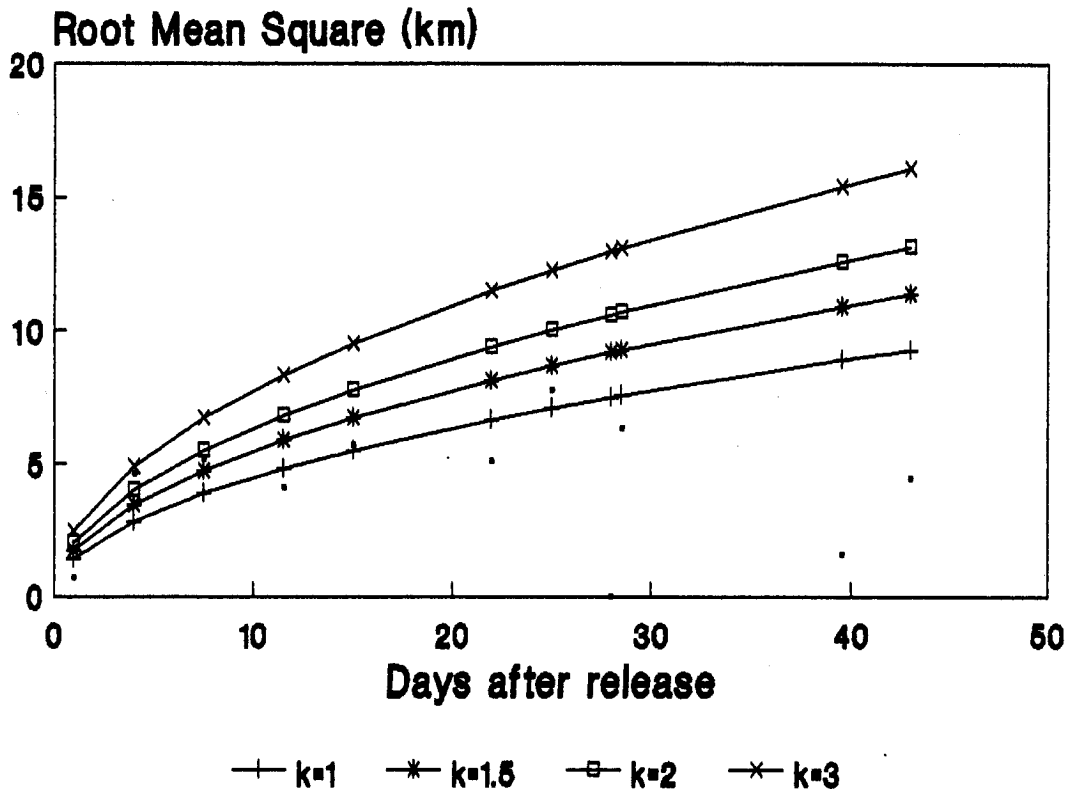
In general, female G. pallidipes dispersed about twice as far as males (Table 8.2) in both the Sampu and Oloibortoto valleys. In April and May 1989, females in the Oloibortoto valley dispersed about 1.5 times further than those in the Sampu valley but no clear difference emerged between the mean distance covered by males in the two valleys.

Apparent Movement of G. pallidipes

In Figures 8.7a,b and 8.8a,b, catches in traps X1 and X3 were averaged and plotted against the catch in trap X2, while in Figures 8.9a,b and 8.10a,b, an average of catches in traps X13, X15, X16 and X17 was plotted against the catch in trap X14. If movement of tsetse flies was by random diffusion, the points in Figures 8.7a to 8.10b would lie on or near the model's expectation line (solid line), where the mean

FIGURE 8.6

Mean distance flown by female DBD
G.pallidipes released at site RS6



k is the diffusion constant

TABLE 8.2

Dispersion for marked G. pallidipes populations in the Sampu and Oloibortoto valleys in 1989 (numbers marked and released are in brackets).

Date released	Number recaptured		Root mean square (km)	
	Male	Female	Male	Female
Sampu:				
25-27.ii	0 (52)	7 (11)	-	2.2
1-3.iv	27 (207)	39 (431)	1.0	2.7
26-28.iv	12 (163)	11 (221)	1.8	2.7
Combined	39 (422)	57 (763)	1.3	2.6
Oloibortoto:				
28.i	10 (44)	14 (110)	4.5	3.3
28.ii-2.iii	6 (35)	7 (66)	0	2.8
4-6.iv	68 (312)	47 (591)	1.0	4.2
29.iv-1.v	58 (328)	73 (913)	1.2	4.9
Combined	142 (719)	141 (1680)	1.6	4.4

FIGURE 8.7a

Mean catch of male G.pallidipes in traps X1 and X3
(peripheral catch) plotted against catch in trap X2
(central catch)

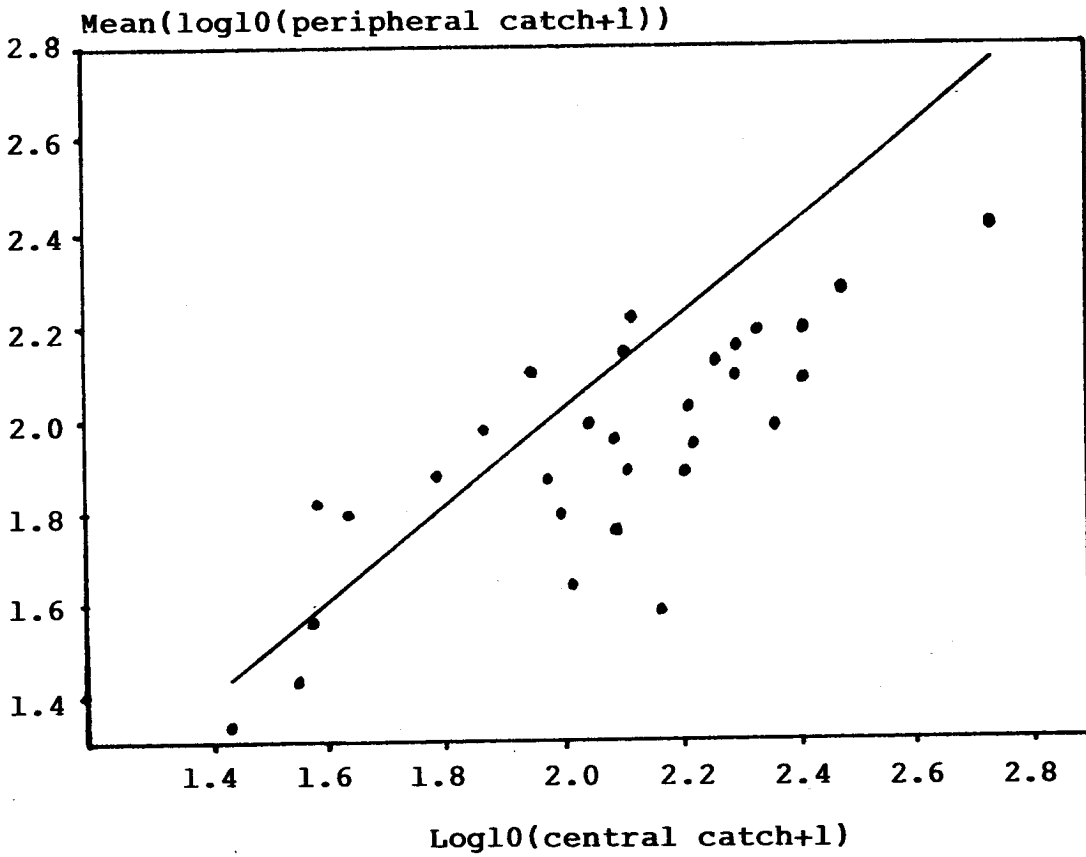


FIGURE 8.7b

Mean catch of female G.pallidipes in traps X1 and X2 (peripheral catch) plotted against catch in trap X2 (central catch)

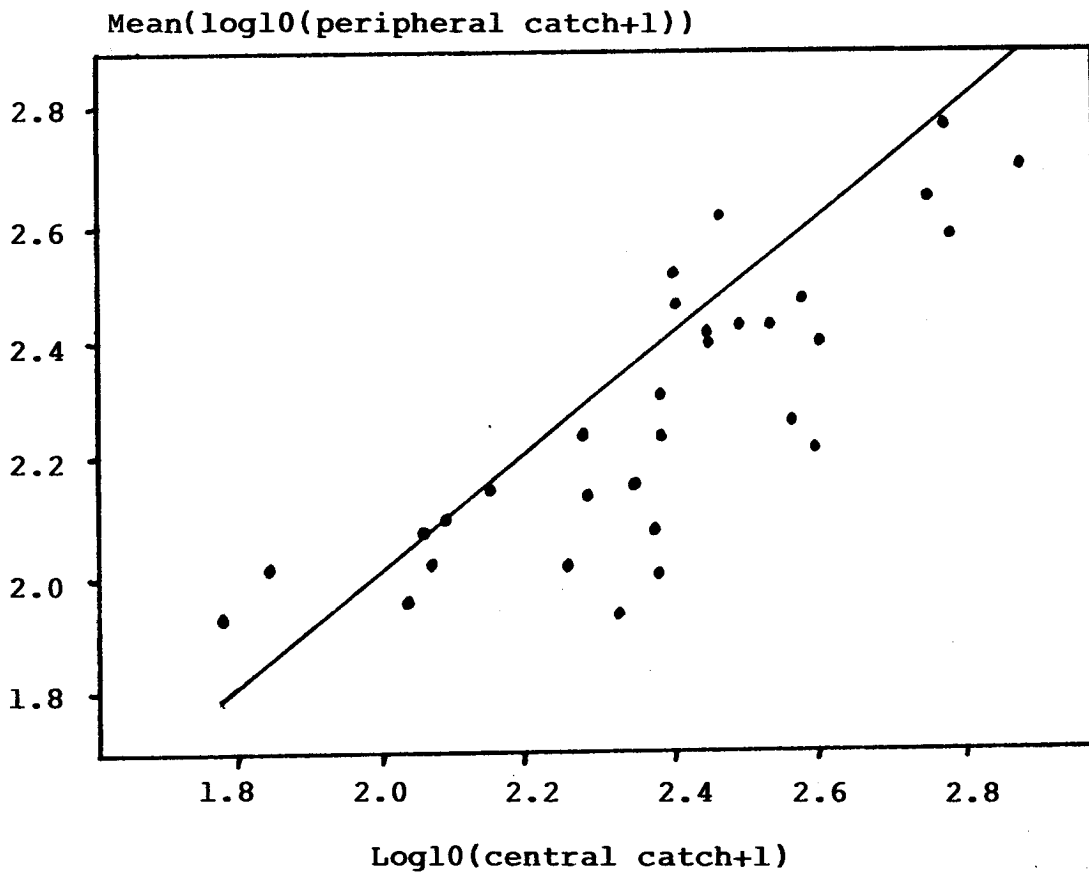


FIGURE 8.8b

Mean catch of female G.longipennis in traps X1 and X3 (peripheral catch) plotted against catch in trap X2 (central catch)

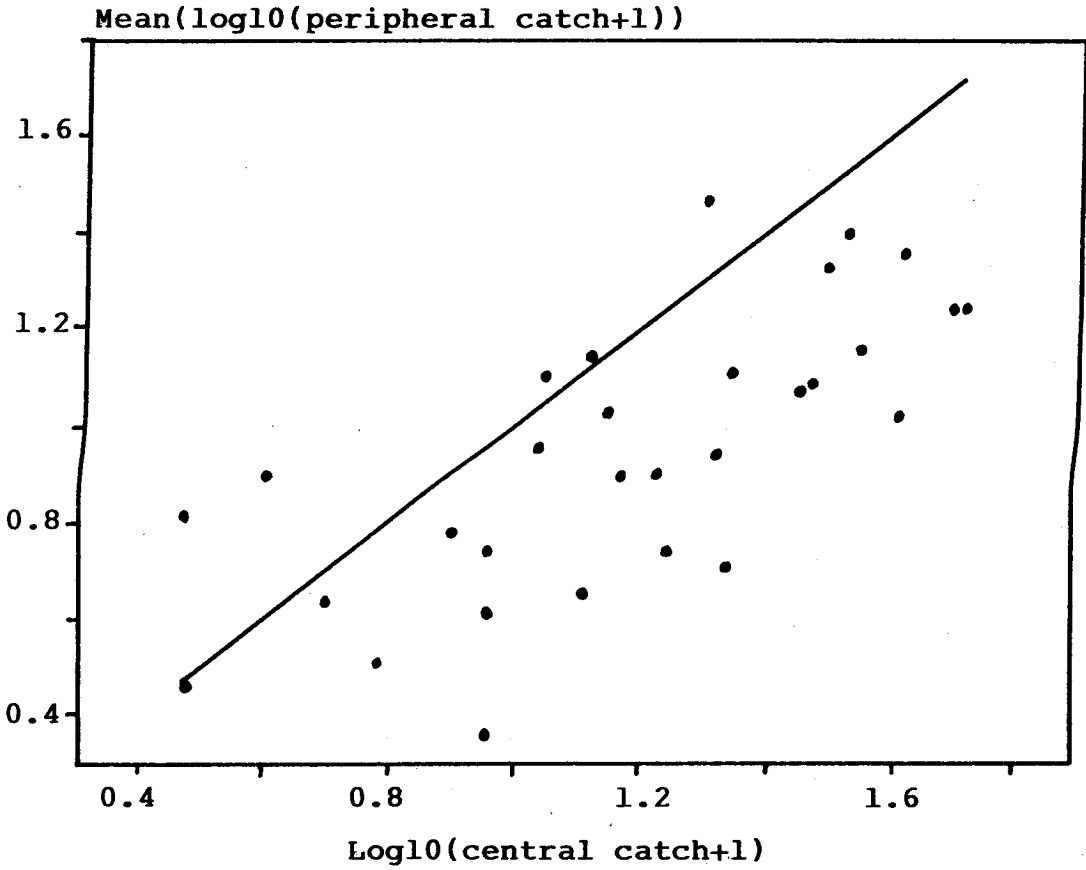


FIGURE 8.9a

Mean catch of male G.pallidipes in traps X13, X15, X16 and X18 (peripheral catch) plotted against catch in trap X14 (central catch)

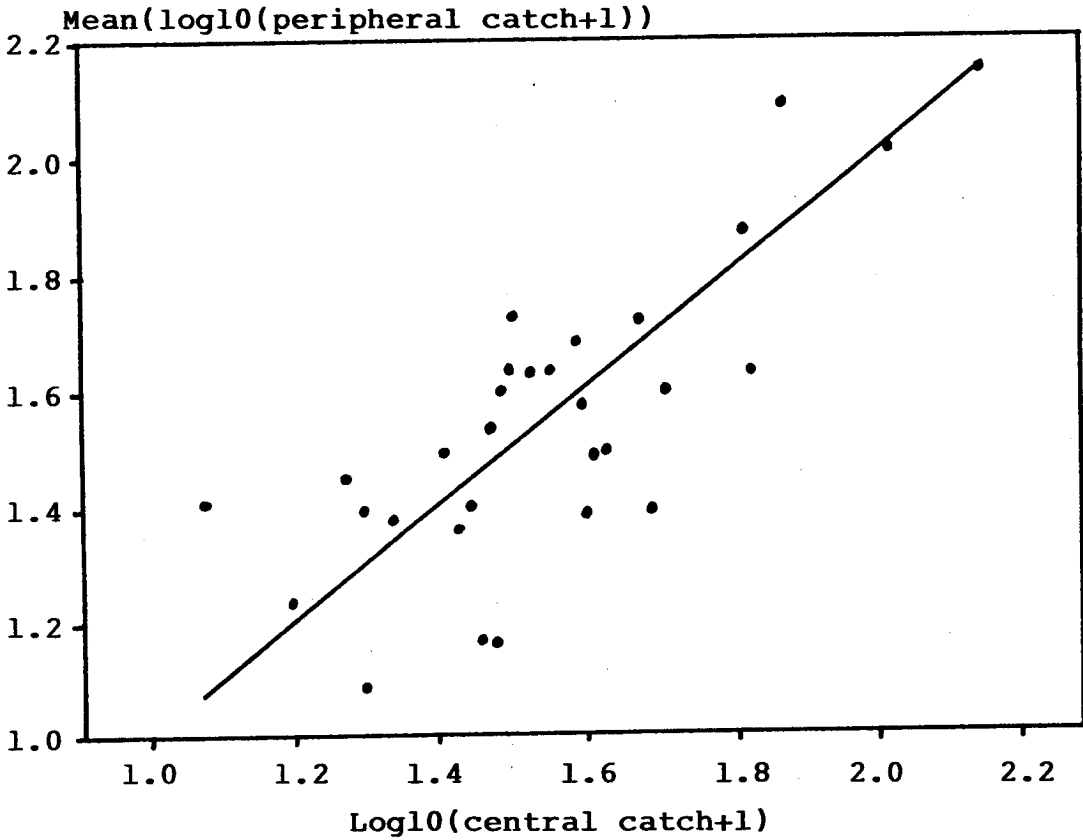


FIGURE 8.9b

Mean catch of female G.pallidipes in traps X13, X15, X16 and X18 (peripheral catch) plotted against catch in trap X14 (central catch)

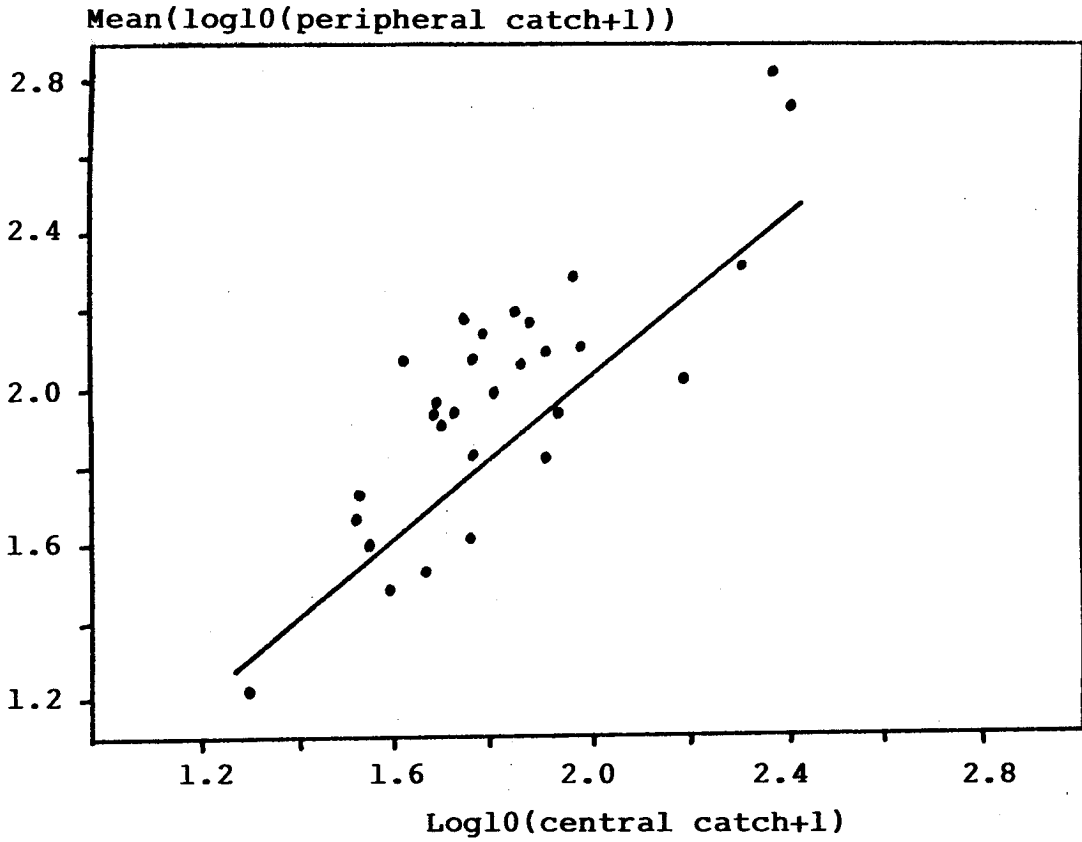


FIGURE 8.10a

Mean catch of male G. longipennis in traps X13, X15, X16 and X18 (peripheral catch) plotted against catch in trap X14 (central catch)

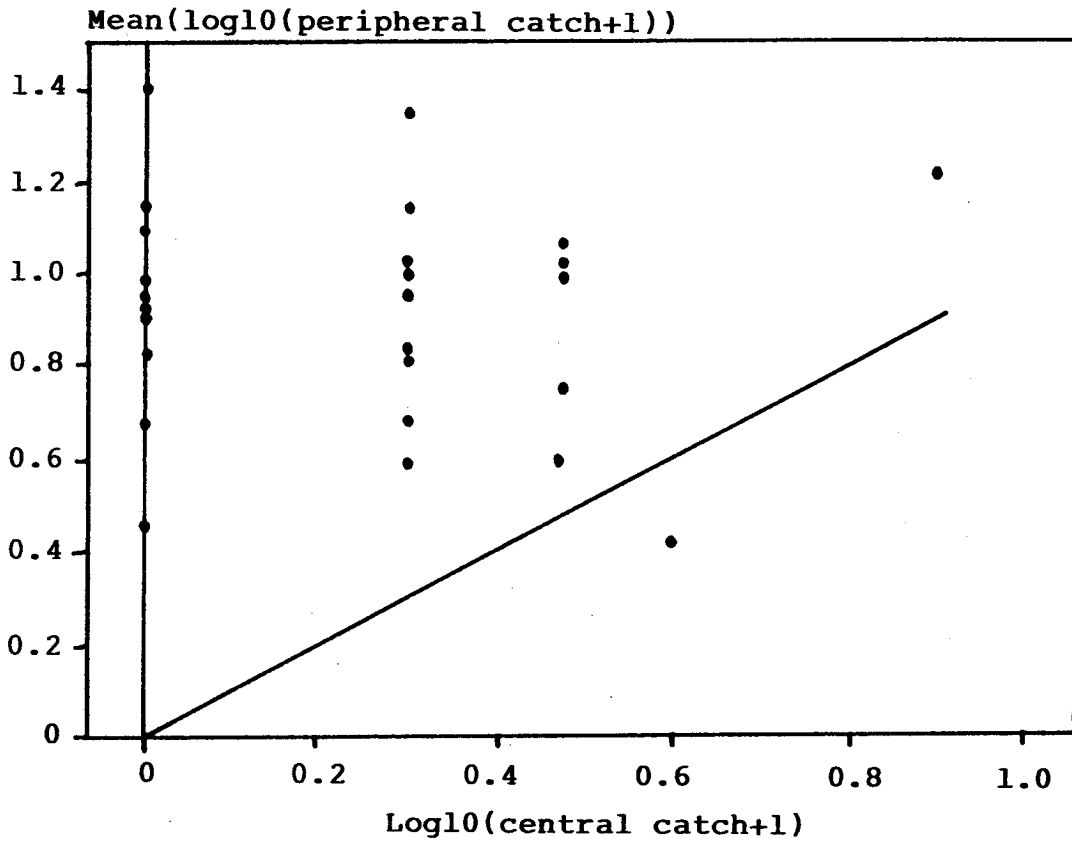
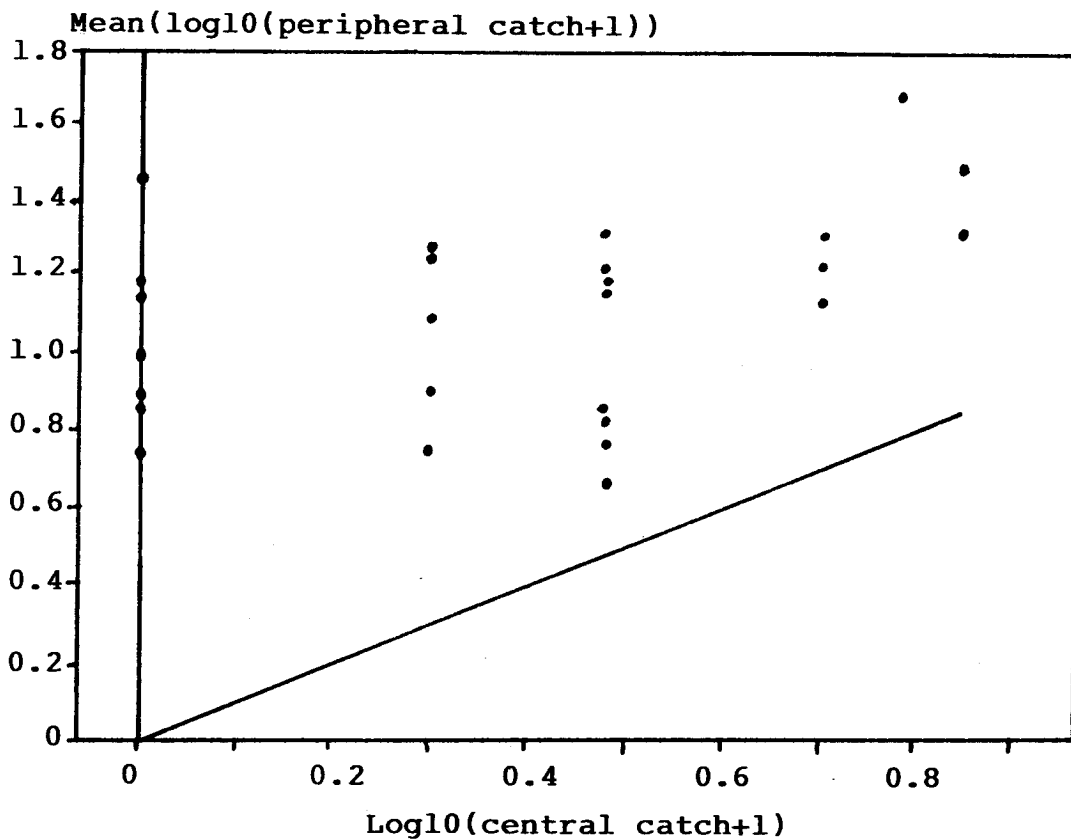


FIGURE 8.10b

Mean catch of female G.longipennis in traps X13, X15, X16 and X18 (peripheral catch) plotted against catch in trap X14 (central catch)



catch in the peripheral traps was to be equal to that of the catch in the central trap.

Assuming that changes in the apparent densities along a linear habitat were mainly due to fly movement, then Figures 8.7a,b and 8.8a,b suggest that the movement of G. pallidipes and G. longipennis, respectively, was generally not by random diffusion.

There is evidence in Figure 8.9a to suggest that male G. pallidipes may have been moving at random in a homogeneous habitat in the Sampu valley during the monitoring period February 1 to May 16, 1989; but not for female G. pallidipes (Figure 8.9b) nor for either sex of G. longipennis (Figure 8.10a and 8.10b).

8.4 DISCUSSION

The dispersal rate of tsetse flies in a strip of woodland is likely to be larger than that of flies in an extensive woodland. The large daily displacement of female G. pallidipes of between 1.2 and 1.4 km per day found in this study supports this hypothesis. Vale et al. (1984) found that both sexes of G. pallidipes in the Zambezi valley of Zimbabwe dispersed at a rate of about 800m per day. The Zambezi valley study area is homogeneous over a much

wider area than that of the Sampu valley. Therefore, we would expect the rate of dispersal of flies at the Sampu valley to be larger than that of flies in the Zambezi valley. Daily displacements reported for other species of Glossina, inhabiting homogeneous habitats range between 110 and 550m (calculated by applying Hargrove's (1981b) method on Rogers' (1971) findings), provide further support for the above argument.

The finding that the apparent movement of G. pallidipes and G. longipennis along a strip of woodland in the Oloibortoto valley was generally not by random diffusion is in line with the finding in the previous chapter that there was more movement towards the south than the north.

Female G. pallidipes at the Oloibortoto valley dispersed more than the females at the Sampu valley probably due to the differences in the type of vegetation between the two valleys. The larger daily displacement found in the Oloibortoto valley may relate to the fact that the valley offered only sparse vegetation cover.

It appears that the step length of female G. pallidipes is longer than that of males, and the same was found for G. caliginea by Cuisance and Itard (1973b), but it is suggested that the step lengths of the sexes do not differ significantly. Vale et al. (1984) have suggested that the difference between the mean distances transversed with time by the two sexes may be females change their flight direction less often than males. Moreover, Bursell and Taylor (1980) suggested that females have less energy available for flight than do males so that the daily flight times for females should be shorter than for males.

In the homogeneous woodland, male G. pallidipes (Vale et al., 1984) appeared to be moving more at random than females probably due to its apparently greater turning rate. Movement of female G. pallidipes may have been interrupted by the edges of the habitat so that they do not obey the conditions for diffusion.

We may have been unable to gather evidence for random movement of G. longipennis because the monitoring of apparent densities was carried out inside the woodland, while G. longipennis prefers the

edges of the woodland (Kyorku, 1989). Even then, the edges of the woodland may not be wide enough to allow uninterrupted movement of the flies and it is likely that the flies would move between the woodland and scattered trees and shrubs in the adjacent more open habitat. In Nguruman, the movement of G. longipennis may not obey the conditions for diffusion.

In the next chapter we discuss the distribution and apparent movement of tsetse flies between the woodland and scattered trees and also try to relate this apparent movement to the prevailing weather conditions.

CHAPTER 9

DISTRIBUTION AND APPARENT MOVEMENT OF GLOSSINA
PALLIDIPES AND G. LONGIPENNIS IN THE SAMPU WOODLAND

9.1 INTRODUCTION

Tsetse flies use vegetation such as trees, shrubs or thickets to shelter from the worst effects of heat (Pollock, 1982) and cold (Goodier, 1960). Areas of pure grassland or very low vegetation are almost never used by tsetse flies but they may visit and cross such areas (Pollock, 1982).

Here we describe the distribution of G. pallidipes and G. longipennis in the inner woodland and at the edge of the woodland at Nguruman with a view to suggesting movement patterns of tsetse flies in relation to changes in temperature and humidity.

Movement by tsetse flies poses a major problem at Nguruman where a suppression program has been going on since 1987. Knowledge of the movement patterns and areas of concentration of tsetse flies should help in planning the suppression program to ensure the optimal distribution of traps and

placement of barriers in relation to the movement patterns of the flies.

9.2 MATERIALS AND METHODS

Two Nguruman traps baited with acetone, octenol and cow urine were set about 500m apart in the Sampu valley, one in the woodland and the other at the edge of the woodland, which is composed of scattered trees and shrubs. The two traps are X8 and X20 in Figure 7.3. The traps were emptied every 3 to 4 days from February 1 to May 16, 1989 in order to investigate the distribution and apparent movement of tsetse flies between the inner woodland and its edge. Minimum and maximum temperature and the relative humidity from a wet and dry bulb thermometer were recorded about 5.5 km away from the site in a Stevenson screen; rainfall was also recorded. On each day, temperature and rainfall readings were taken at 8:00h, while relative humidity readings were taken at 8:00 and 15:00h.

The numbers of flies caught were transformed by taking logarithms to the base 10. A matrix of Pearson product-moment correlations between $\log(\text{catch}+1)$ and climatic variables was generated.

9.3 RESULTS

The study covered both the dry period following the short rains and the wet period during the long rains (Figure 9.1a). The highest mean maximum temperature was 41°C recorded in the sampling period March 1 to 3 and the lowest mean minimum temperature was 17°C, recorded in this same period (Figure 9.1b). The minimum temperature remained fairly constant at 20.5°C apart from the depression to between 17 and 18°C between February 15 and March 3. The maximum daily precipitation occurred in the period April 8 to 11 of about 33 mm per day. Minimum relative humidities of about 65 and 20% taken at 8:00 and 15:00h, respectively, were recorded in the period February 25 to 28 (Figure 9.1c).

On over 85% of the sampling occasions, G. pallidipes catches were higher in the woodland (Figures 9.2a,b) than at the edge of the woodland, suggesting that G. pallidipes prefers woodland vegetation to more open areas. During the dry period from the middle of February to the middle of March 1989, there was slight evidence to suggest that G. longipennis was more concentrated at the edge of the woodland than inside the woodland (Figures 9.3a,b;

FIGURE 9.1a

Total rainfall for each 3 or 4 day period between
February 1 and May 16, 1989

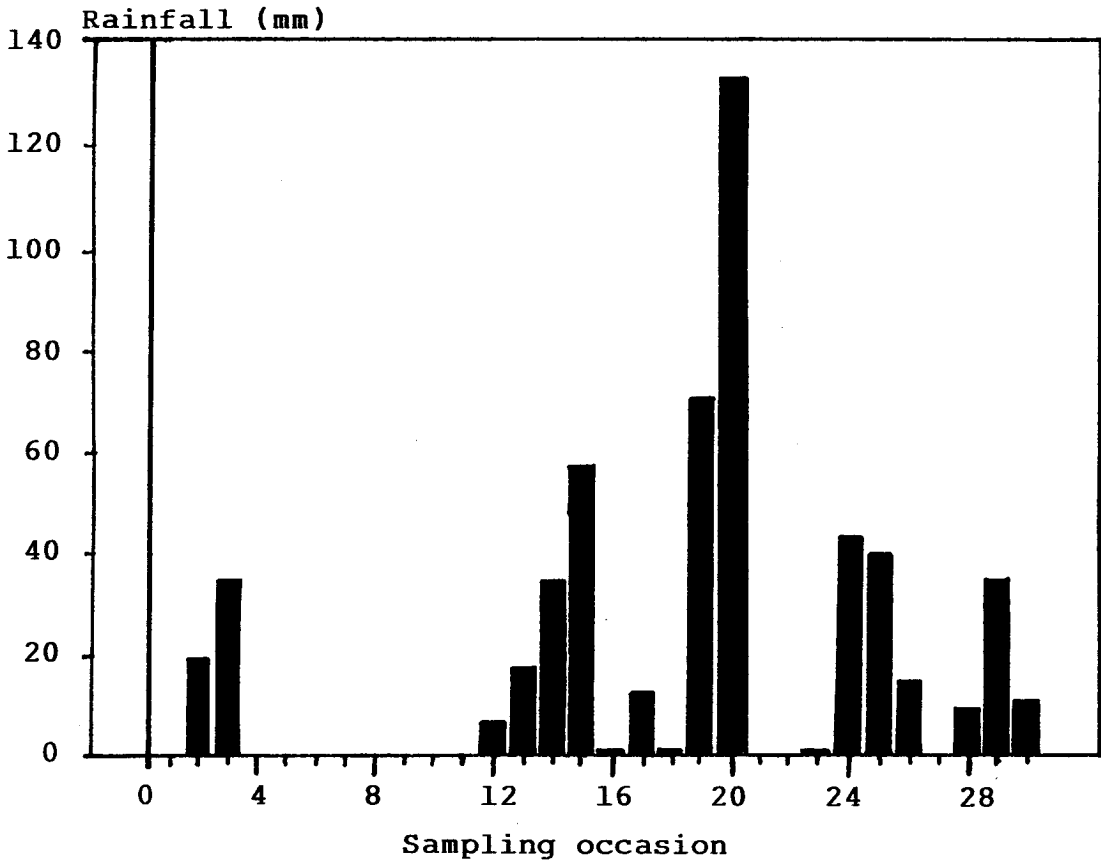


FIGURE 9.1b

Mean temperatures for each 3 or 4 day period between February 1 and May 16, 1989

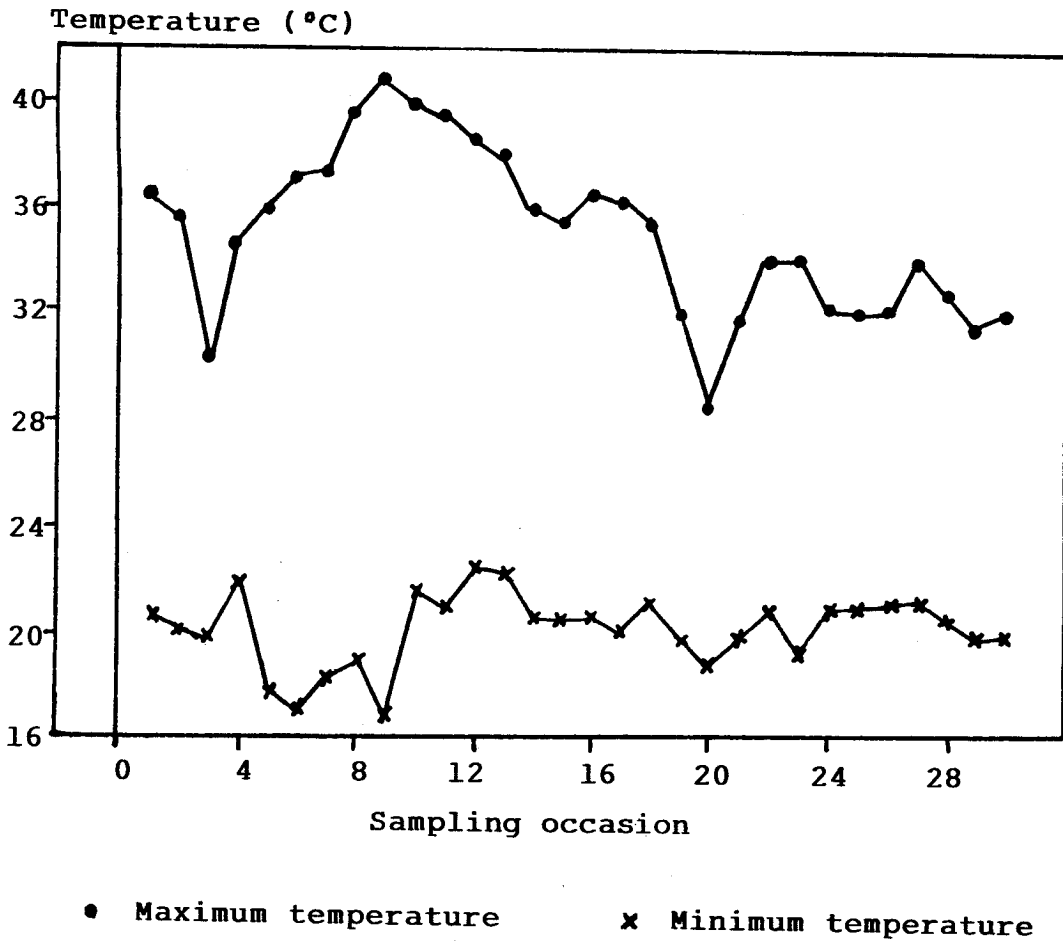
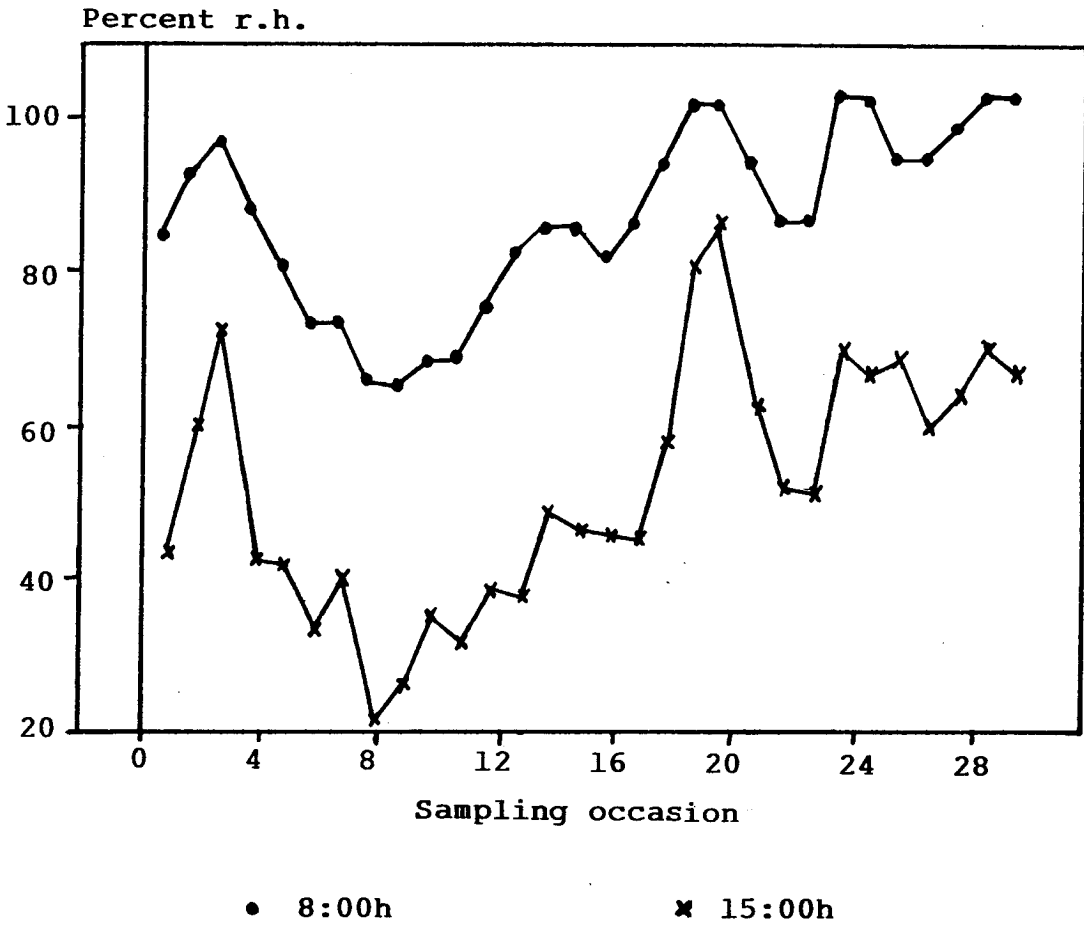


FIGURE 9.1c

Mean relative humidities for each 3 or 4 day period
between February 1 and May 16, 1989



0.05<p<0.10), further suggesting that G. longipennis prefers open environment to thickets.

The apparent density of G. longipennis in both the inner woodland and at its edge generally rose during the period of no rains between sampling periods 4 and 11 (Figure 9.1a) and declined during the main rains, suggesting that G. longipennis thrives in dry environment. Meanwhile, the apparent density of G. pallidipes in the inner woodland, not only rose during the dry period but also continued rising in the wet period. At the edge of the woodland, the density of G. pallidipes declined during the dry period and rose with the onset of the main rains and continued rising in the wet period. This suggests that the marginal vegetation of the edge of the woodland which defoliates during the dry season is less used by G. pallidipes during this period than during the wet period when it refoliates and flies spread out in the more open areas.

Significant negative correlations between catches of G. longipennis, at the edge of the woodland, and relative humidity were observed (Table 9.1a), reflecting the association between the relative density of G. longipennis and the relative

TABLE 9.1a

Correlation coefficients between trap catches of tsetse flies and climatic variables for the period February 1 to May 16, 1989.

Climatic variables	<u>G. pallidipes</u>		<u>G. longipennis</u>	
	Male	Female	Male	Female
Edge of Woodland:				
Relative humidity 8:00h	-0.24	0.24	-0.45*	-0.47**
Relative humidity 15:00h	-0.17	0.36	-0.47**	-0.45*
Minimum temperature	0.15	0.04	0.21	0.15
Maximum temperature	0.28	-0.24	0.55**	0.50**
Inner Woodland:				
Relative humidity 8:00h	-0.11	-0.24	-0.34	-0.26
Relative humidity 15:00h	-0.01	-0.09	-0.32	-0.24
Minimum temperature	-0.19	-0.34	0.10	-0.03
Maximum temperature	0.09	0.15	0.44*	0.38*

Sample size=30

humidity shown in Figures 9.1c, 9.3a and 9.3b. The initial decline of the relative humidity between sampling periods 4 and 8 was generally associated with the initial rise in the apparent density of G. longipennis. And a rise in the relative humidity corresponded to a general decline in the density of G. longipennis both in the woodland and at its edge between sampling periods 8 and 24.

Table 9.1b shows the correlations between the trap catches of tsetse flies and values of climatic variables lagged behind by about 4 days.

The magnitude of the correlation coefficients between G. longipennis and climatic variables increased when values of climatic variables were lagged behind by about 4 days in the inner woodland, but the correlation coefficients at the edge of the woodland remained almost unchanged, suggesting that the density of G. longipennis in the inner woodland changed slowly in response to changes in relative humidity and air temperature. In both the inner and at the edge of the woodland, the changes in the density of G. longipennis were inversely proportional to the changes in the relative humidity but directly

TABLE 9.1b

Correlation coefficients between trap catches of tsetse flies and climatic variables lagged behind by 4 days for the period February 1 to May 16, 1989.

Climatic variables	<u>G. pallidipes</u>		<u>G. longipennis</u>	
	Male	Female	Male	Female
Edge of Woodland:				
Relative humidity 8:00h	-0.33	0.08	-0.51**	-0.46*
Relative humidity 15:00h	-0.22	0.17	-0.44*	-0.44*
Minimum temperature	-0.09	-0.20	-0.06	0.003
Maximum temperature	0.29	-0.05	0.54**	0.52**
Inner Woodland:				
Relative humidity 8:00h	-0.11	-0.18	-0.39*	-0.32
Relative humidity 15:00h	-0.12	-0.12	-0.41*	-0.38*
Minimum temperature	-0.08	-0.36	0.07	0.10
Maximum temperature	0.18	0.17	0.49**	0.43*

Sample size=30

proportional to the changes in the maximum temperature.

There is some evidence ($r=-0.33$, $0.05 < p < 0.10$) to suggest that the density of male G. pallidipes at the edge of the woodland may have changed only slowly in response to changes in the relative humidity taken at 8:00h, and that the changes in the density of G. pallidipes were inversely proportional to the changes in the relative humidity readings taken at 8:00h. In the inner woodland the density of female G. pallidipes may have changed only slowly in response to changes in the minimum temperature ($r=-0.36$, $0.05 < p < 0.10$), with which it was inversely correlated.

The density of male G. pallidipes was only weakly correlated with the relative humidity taken at 8:00h at the edge of the woodland and lagged behind by about 4 days ($r=-0.33$, $0.05 < p < 0.10$), and the density of female G. pallidipes was only weakly correlated with the minimum temperature in the inner woodland, lagged behind by about 4 days ($r=-0.36$, $0.05 < p < 0.10$) (Table 9.1b). However, there is evidence from Figures 9.1b, 9.2a and 9.2b to suggest that with a rise in the maximum temperature, G. pallidipes appeared to have moved from the edge of

FIGURE 9.2a

Male G.pallidipes catch in a trap in the centre of woodland and at its edge plotted against sampling occasion

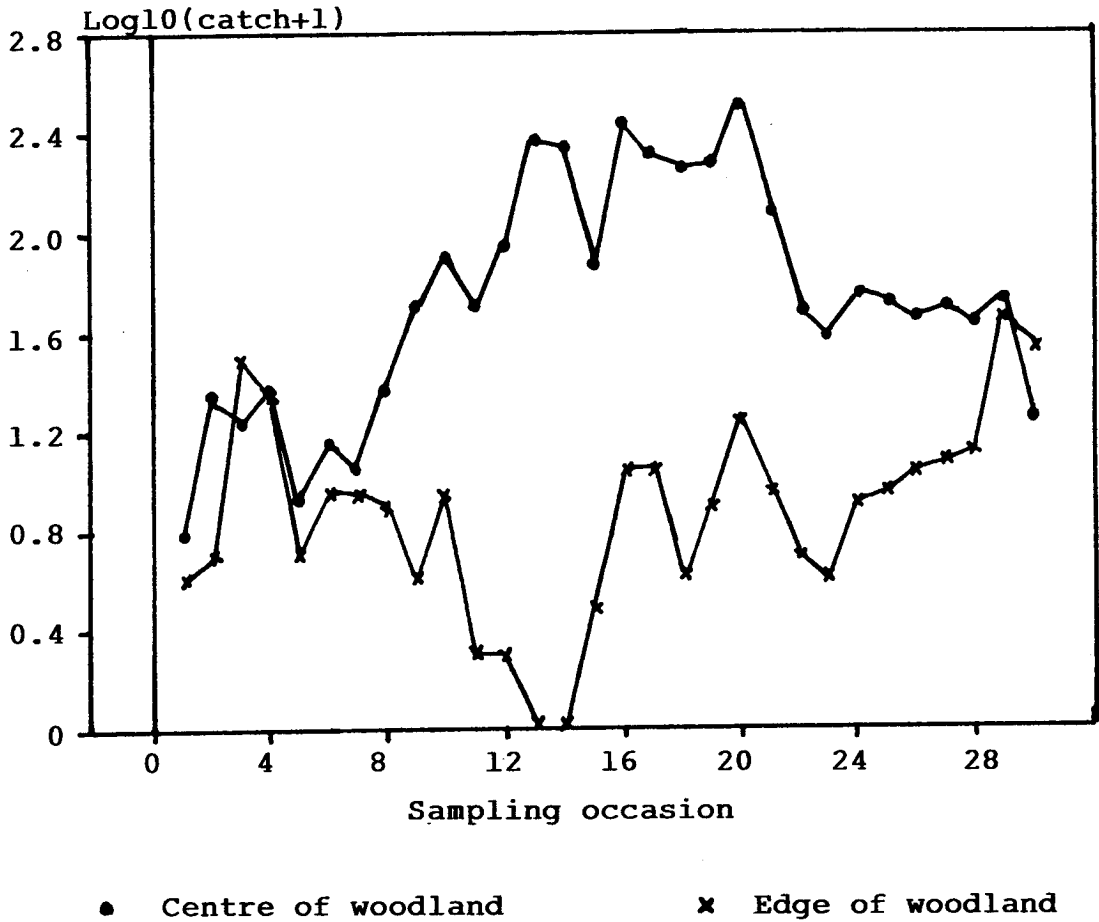
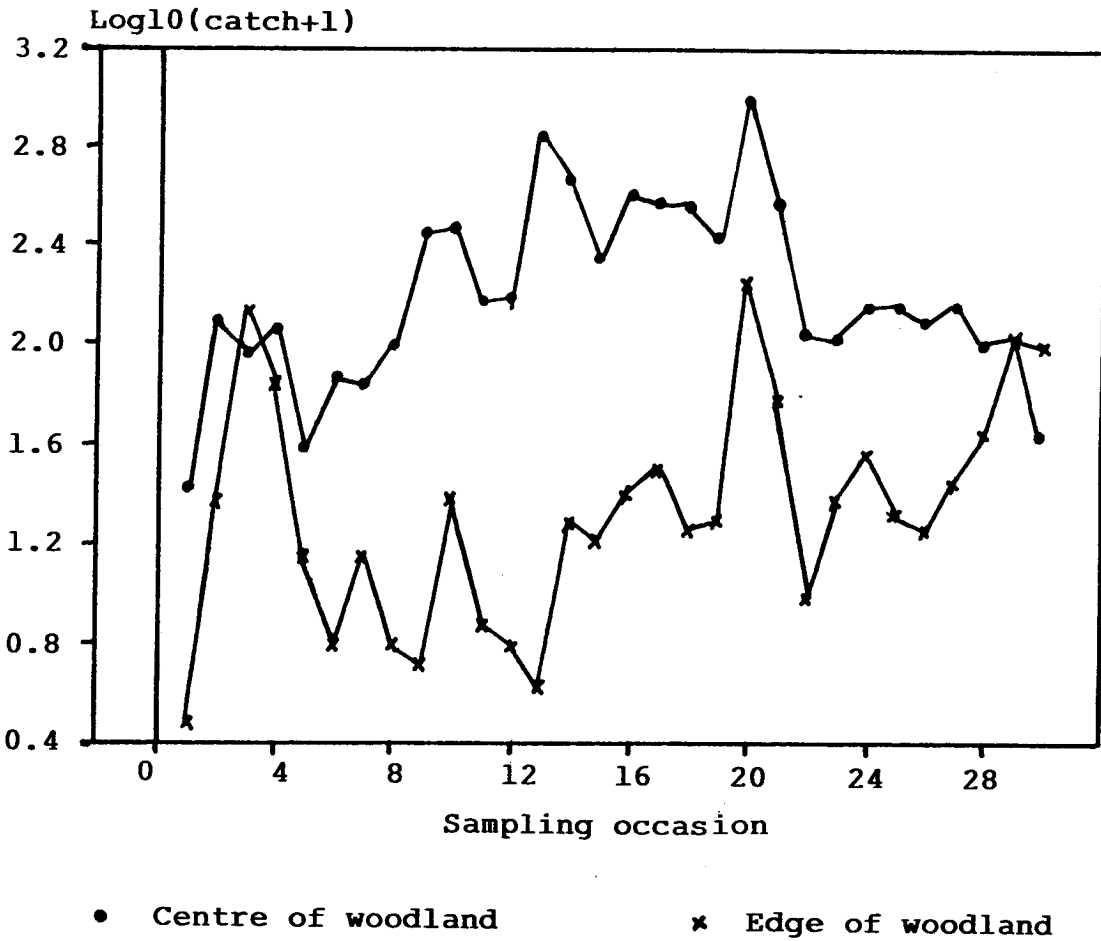


FIGURE 9.2b

Female *G. pallidipes* catch in a trap in the centre of woodland and at its edge plotted against sampling occasion



the woodland to the inner woodland while a drop in the maximum temperature may have made the flies take the reverse journey. The picture is different for G. longipennis, where the maximum temperature is positively correlated with the number of G. longipennis caught in both the inner woodland and at its edge (Figures 9.1b, 9.3a and 9.3b). This does not provide evidence to suggest that there may have been an interchange of G. longipennis populations between the inner woodland and its edge, in spite of the significant correlations between catches of G. longipennis and maximum temperature (Table 9.1a).

9.4 DISCUSSION

The temperature and relative humidity are highly inversely correlated. The apparent density of G. pallidipes is associated with the maximum temperature but not with the minimum temperature. This accords with the fact that the activity pattern of G. pallidipes peaks in the middle of the afternoon (see chapter 10), as does the daily temperature profile. The picture is less clear for G. longipennis whose activity peaks at dawn and dusk. Nevertheless, it appears that the maximum temperature or the relative humidity is important and should be considered in the

FIGURE 9.3a

Male G. longipennis catch in a trap in the centre of woodland and at its edge plotted against sampling occasion

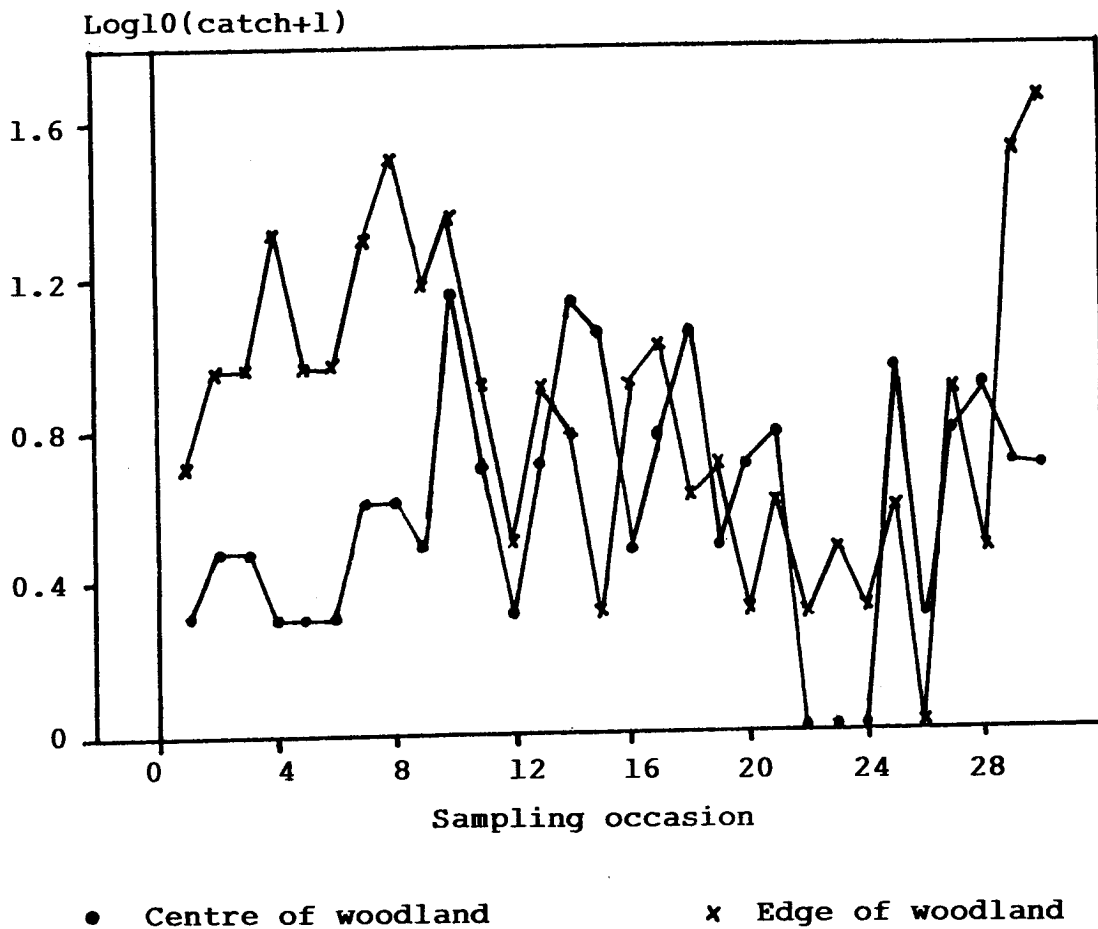
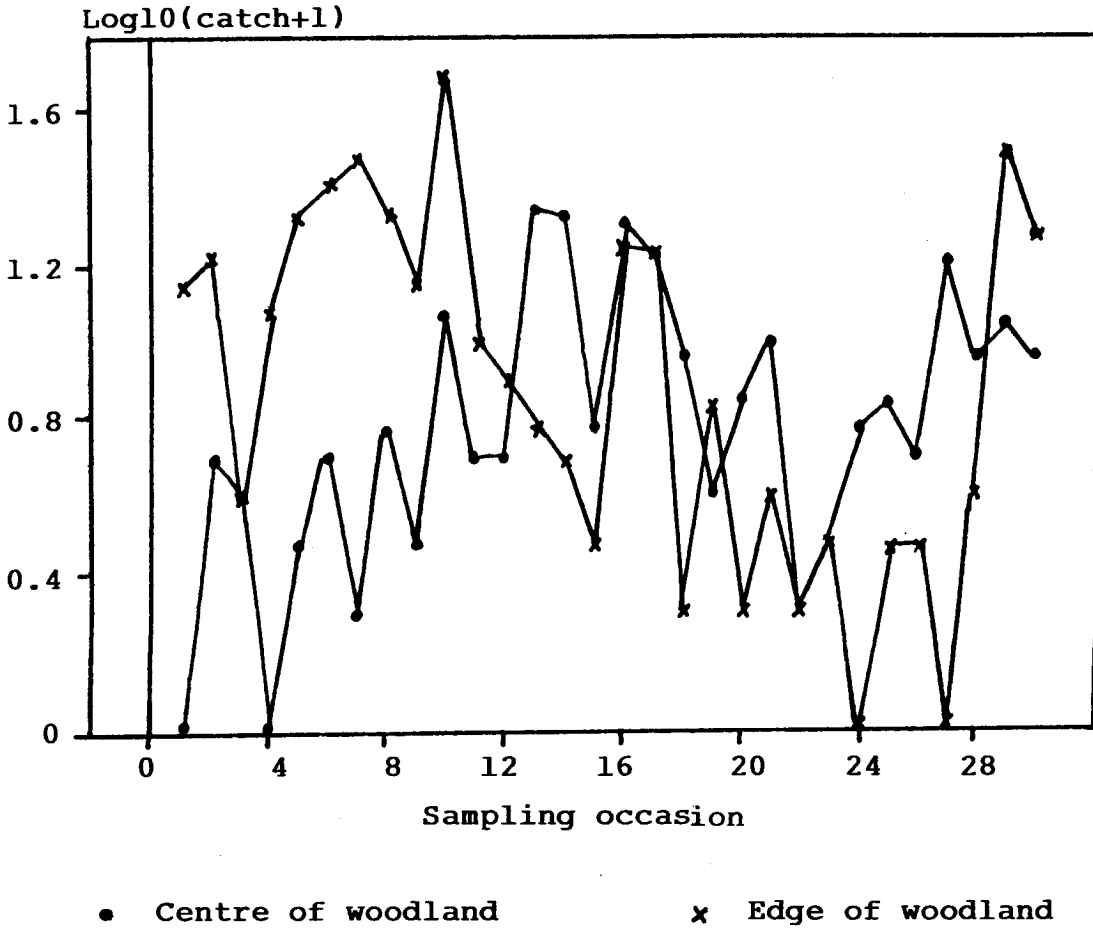


FIGURE 9.3b

Female *G. longipennis* catch in a trap in the centre of woodland and at its edge plotted against sampling occasion



study of the distribution and movement of both G. pallidipes and G. longipennis.

We have evidence to suggest that when it becomes hotter, G. pallidipes moves from the edge of the woodland to the inner woodland probably in order to avoid desiccation, and that when it starts getting cooler G. pallidipes moves towards more open areas which may be warmer than the inner woodland. At sufficiently low temperatures the tsetse flies' metabolism slows down and they become inactive and may be prone to attack by predators and fungi.

The implication of the presumed movement of G. pallidipes between the inner woodland and its edge is that at such times, the movement of the flies becomes directed and does not obey the conditions of diffusion. This partly explains the finding in the previous chapter of non-random movement of tsetse flies in certain areas of Nguruman. A different explanation is possible for the G. pallidipes curves: it could be just due to greater activity and therefore more flies trapped in the woodland where the microclimate is more congenial during the period with high temperatures. At the edge, the low