

Species Composition and Relative Abundance of Tsetse Flies along the Shabelle River, Somalia: Findings from Four Survey Rounds in Balcad and Afgooye Districts

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Abstract

Background: Contemporary information on tsetse flies in Somalia is limited, particularly along the Shabelle River. This study described tsetse catches, provisional morphological species composition, and catch patterns by district, trap type, lure, and ecological setting to provide an exploratory baseline for future surveillance. **Methods:** Four entomological survey rounds were conducted at purposively selected sites in Balcad and Afgooye districts. Twelve traps (six per district) were deployed in each round for 72 hours, producing 48 trap deployments and 144 active trap-days. In each district, one biconical and one NGU trap were paired with each of three lure treatments: cattle urine, cattle urine plus acetone, and cattle milk. Each of four ecological settings received three traps per round and contributed 36 trap-days over the survey. Captures were collected after 72 hours, recorded on field forms, and identified morphologically. Apparent density was calculated as catch divided by active trap days. **Results:** A total of 267 tsetse flies were captured over 144 trap-days (1.85 flies/trap/day [FTD]). Specimens were provisionally classified as *Glossina pallidipes* (217; 81.3%; 1.51 FTD) or *G. austeni* (50; 18.7%; 0.35 FTD). Balcad produced 217 catches over 72 trap-days (3.01 FTD), compared with 50 over 72 trap-days in Afgooye (0.69 FTD). Biconical and NGU traps produced 1.82 and 1.89 FTD, respectively. Urine plus acetone produced 3.19 FTD, urine 1.56 FTD, and milk 0.81 FTD. Dense riverine forest produced 3.11 FTD, irrigated farmland 1.61 FTD, peri-urban agriculture 1.47 FTD, and grazing corridors

1.22 FTD. **Conclusion:** Catches differed substantially between sampled deployments in Balcad and Afgooye and among the sampled ecological settings. Most specimens were provisionally identified as *G. pallidipes*. Urine plus acetone was associated with the highest unadjusted catch; however, the design did not separate lure performance from trap-location effects. Independent species verification and trap-visit-level analysis are required before causal or operational conclusions are drawn.

Keywords

African Animal Trypanosomiasis, Apparent Density, Glossina, Shabelle River, Somalia, Tsetse Surveillance

1. Introduction

African animal trypanosomiasis (AAT) is a vector-borne disease of livestock caused by *Trypanosoma* parasites and transmitted cyclically by tsetse flies (*Glossina* spp.). In affected herds, the disease can cause anaemia, weight loss, poor reproductive performance, reduced productivity, and death. These effects undermine household income and food security in communities that depend heavily on livestock [1].

Glossina pallidipes is an important vector in eastern Africa and occupies a range of savannah, woodland, and river-associated habitats. Its populations can be strongly structured across space, as shown by genetic studies in Kenya and the Serengeti ecosystem [2]. At a local level, tsetse occurrence is influenced by vegetation, moisture, host availability, and habitat connectivity. Surveys in Rwanda, Kenya, Tanzania, and Ethiopia have consequently found pronounced differences in tsetse abundance among nearby habitats and sampling sites [3]–[6].

River corridors deserve particular attention because permanent water, dense vegetation, irrigated farming, and livestock movement may create favourable conditions for fly survival and host contact. Research at human-wildlife-livestock interfaces elsewhere in Africa has shown that small-scale ecological differences can shape tsetse abundance, species composition, and trypanosome risk [7] [8]. However, recent quantitative information from Somalia is limited. Evidence from neighbouring countries cannot simply be transferred to the Shabelle corridor because tsetse distribution depends on local environmental and host conditions.

This study therefore used repeated sampling over four months to describe tsetse catches in Balcad and Afgooye districts. It aimed to establish an empirical baseline for future surveillance by comparing catches across districts, provisionally identified species, trap designs, lure treatments, and ecological site types.

2. Materials and Methods

2.1. Study Area

The survey was conducted in Balcad and Afgooye districts along the lower Sha-

belle River in southern Somalia (**Figure 1**). The sampled landscape included riverine vegetation, irrigated farmland, livestock grazing corridors, and peri-urban agricultural areas. Conditions generally became drier with increasing distance from the river. These habitats were selected because water, vegetation, farming activity, and livestock presence could support tsetse persistence and host-vector contact.

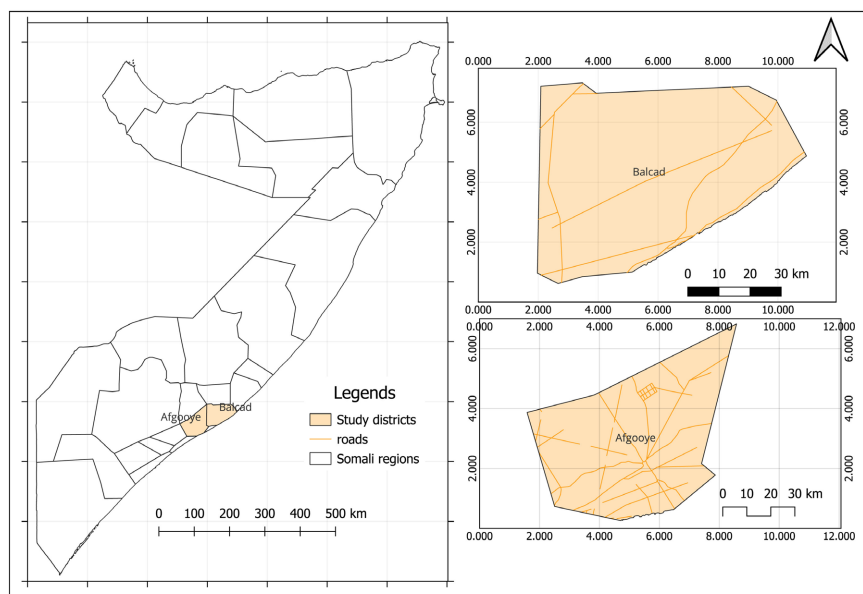


Figure 1. Location of the study sites in Balcad and Afgooye districts.

2.2. Study Design and Site Selection

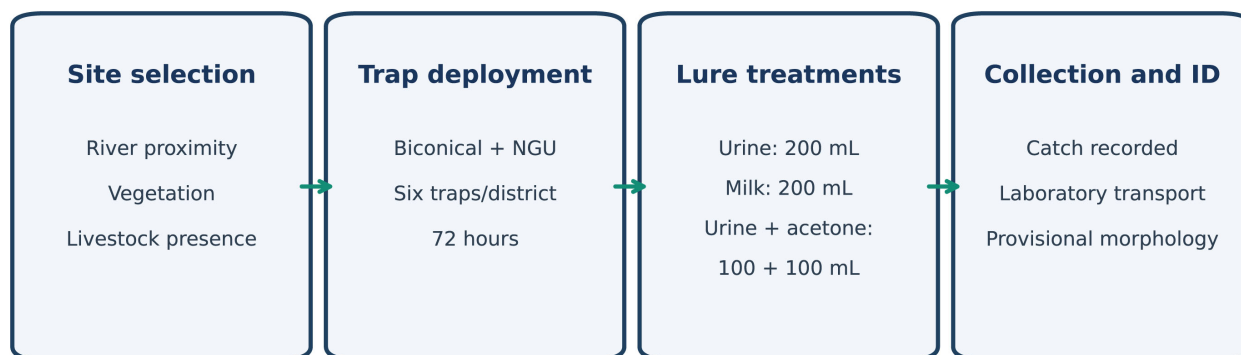
A repeated four-month longitudinal entomological survey was carried out at sites selected purposively on the basis of proximity to the river, vegetation density, livestock presence, and locally reported biting nuisance. Because the survey deliberately targeted potentially suitable habitats, the results describe relative catch in the sampled microhabitats. They should not be interpreted as a district-wide spatial average or as evidence of population dynamics.

2.3. Trap Deployment and Exposure

Two trap designs were used: biconical and NGU. Twelve traps were deployed during each monthly round, with six traps in each district. Every trap operated for 72 hours (three consecutive days), after which the catch was collected and recorded on a standardized field form. Across four rounds, total exposure was $12 \text{ traps} \times 3 \text{ days} \times 4 \text{ rounds} = 144 \text{ trap-days}$. Each district contributed 72 trap-days, each trap type 72 trap-days, each lure 48 trap-days, and each trap-lure combination 24 trap-days (**Figure 2**).

Each of the four ecological settings received three traps in every round. This gave $3 \text{ traps} \times 3 \text{ active days} \times 4 \text{ rounds} = 36 \text{ trap-days per setting}$. Exact calendar dates and complete trap-level catch records for the individual rounds were una-

available in the compiled dataset. The district-by-setting allocation could not be reconstructed beyond the verified totals of six traps per district and three traps per ecological setting in each round. District and setting patterns were therefore not treated as mutually adjusted effects.



Four survey rounds • 12 traps per round • 144 active trap-days

Figure 2. Survey workflow showing site selection, trap deployment, lure quantities, 72-hour exposure, catch collection, and provisional morphological identification.

2.4. Lure Treatments

Three lure treatments were evaluated: 200 mL of pure cattle urine, 200 mL of cattle milk, and a urine-acetone mixture containing 100 mL of cattle urine and 100 mL of acetone. For the combined treatment, the urine and acetone were mixed in a single container and placed at the trap. Within each district, one biconical and one NGU trap were allocated to every lure, producing a balanced 2×3 trap-lure arrangement. Traps were positioned approximately 200 m apart. Each trap-lure combination operated for three days per district in each round and accumulated 24 trap-days over the full survey.

The field forms recorded the collection date, trap identity, district, trap type, lure, active duration, and number captured. The available records did not fully document the source and age of the urine and milk, the lure-container specifications, or whether the lures were replaced during the 72-hour deployment. Lure-specific results are therefore presented descriptively and should not be treated as controlled efficacy estimates.

2.5. Specimen Handling and Identification

Captured flies were transported to the National Malaria Control Programme laboratory and identified morphologically using the approach described by [9]. Identification considered wing venation and folding, body colour and markings, and, where applicable, the male hypopygium (**Figure 3**). No independent taxonomic review or molecular confirmation was undertaken. Species names are therefore reported as provisional, with particular caution applied to the *G. austeni* record.

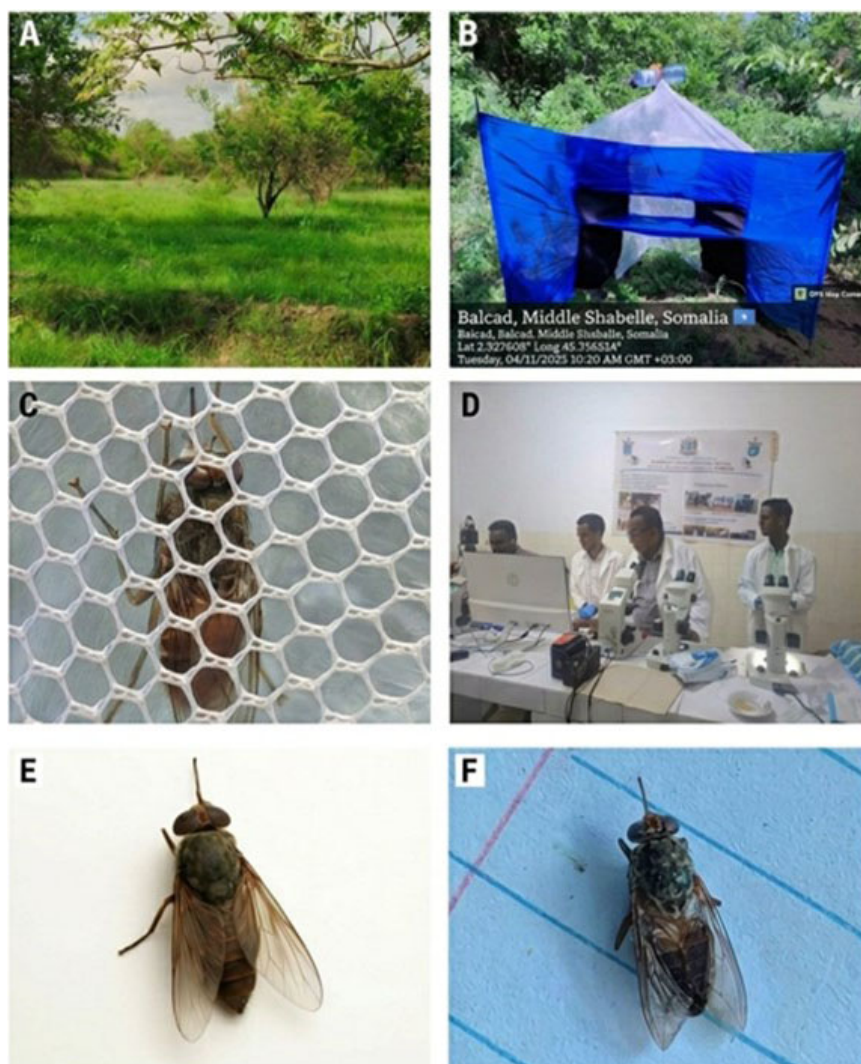


Figure 3. Field collection and identification of tsetse flies. (A) Riverine trapping habitat in Balcad district; (B) Field trap deployment; (C) Captured tsetse fly in collection mesh; (D) Laboratory morphological confirmation; (E) *Glossina pallidipes*; and (F) *Glossina austeni*.

2.6. Data Analysis

Apparent density was calculated as $FTD = \text{total number of tsetse captured} \div \text{verified active trap-days}$. Denominators were 144 trap-days overall, 72 per district, 72 per trap type, 48 per lure, and 24 per trap-lure combination. Frequencies, percentages, and FTD were summarized by district, provisional species, trap type, lure, and ecological site.

The compiled dataset available for this manuscript did not contain the complete trap-visit-level repeated-measures records required for adjusted regression or interaction testing. Pooled chi-square tests and unverified interaction estimates were therefore not used. A confirmatory analysis should apply a Poisson or negative-binomial mixed-effects model, include log (active trap-days) as an offset, and account for repeated observations at trap or site level.

2.7. Ethical Considerations

The study involved non-invasive trapping of wild tsetse flies and did not include human participants or invasive procedures on animals. Community members and land users were informed about the survey, and verbal permission was obtained before traps were placed.

3. Results

3.1. Overall Catch and District Distribution

The survey captured 267 tsetse flies during 144 active trap-days, giving an overall apparent density of 1.85 FTD. Balcad accounted for 217 captures (81.3%) and had an apparent density of 3.01 FTD. Afgooye accounted for 50 captures (18.7%) and had an apparent density of 0.69 FTD. Thus, the observed catch rate in Balcad was more than four times that in Afgooye, although the purposive site selection prevents a district-wide causal comparison (**Table 1**).

Table 1. Tsetse catch by district and provisional species identification.

District	<i>G. pallidipes</i>	<i>G. austeni</i>	Total	% of total	FTD
Balcad	172	45	217	81.3	3.01
Afgooye	45	5	50	18.7	0.69
Total	217	50	267	100.0	1.85

3.2. Provisional Species Composition

Tsetse flies were collected in riverine areas of both study districts (**Figure 4**). Morphological examination provisionally classified 217 flies as *G. pallidipes* (81.3%) and 50 as *G. austeni* (18.7%) (**Figure 5**). Using the full exposure denominator, their apparent densities were 1.51 and 0.35 FTD, respectively. Within Balcad, *G. pallidipes* comprised 79.3% of the district catch and *G. austeni* 20.7%; the corresponding proportions in Afgooye were 90.0% and 10.0% (**Figure 6**).

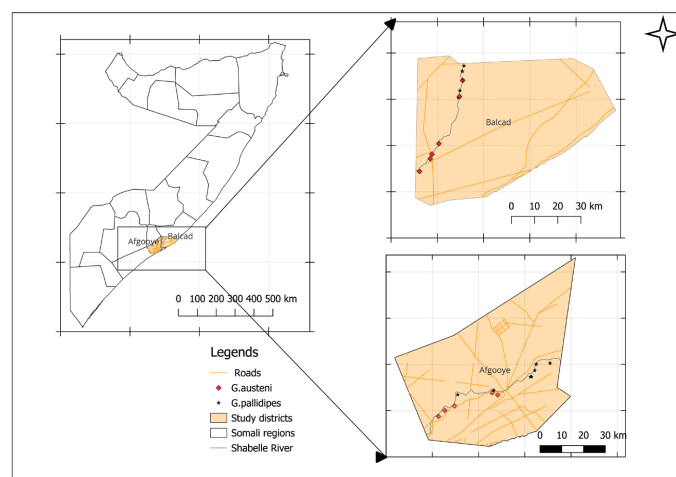


Figure 4. Provisional species-wise distribution in the study districts.

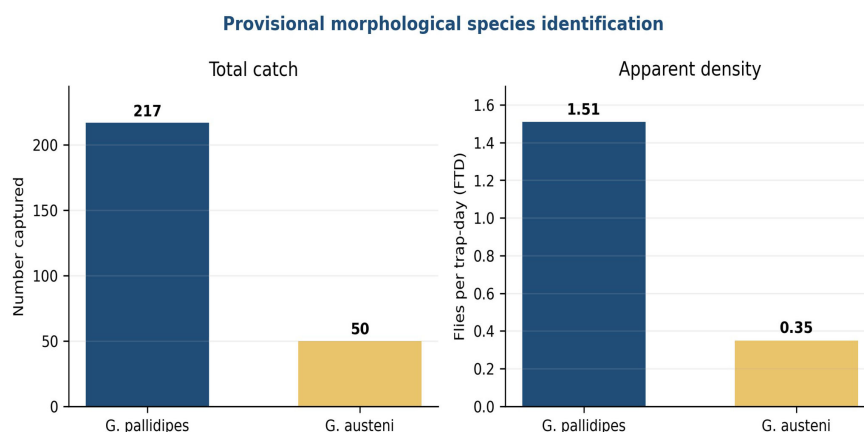


Figure 5. Total catch and apparent density by provisionally identified species. FTD denominator = 144 active trap-days.

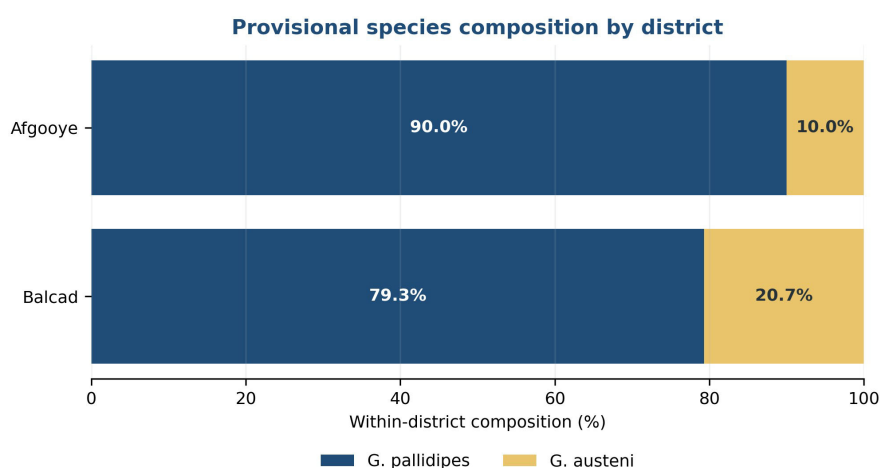


Figure 6. District-level provisional species composition based on the counts reported in Table 1.

3.3. Trap Type and Lure

Biconical traps captured 131 flies over 72 trap-days (1.82 FTD), whereas NGU traps captured 136 flies over 72 trap-days (1.89 FTD). Their descriptive catch rates were therefore similar (Table 2). Across lure treatments, urine plus acetone produced 153 captures over 48 trap-days (3.19 FTD), urine produced 75 (1.56 FTD), and milk produced 39 (0.81 FTD). At the trap-lure level, apparent density ranged from 0.58 FTD for NGU traps baited with milk to 3.50 FTD for NGU traps baited with urine plus acetone.

Table 2. Tsetse catch and apparent density by trap type and lure.

Trap type	Lure	<i>G. pallidipes</i>	<i>G. austeni</i>	Total	FTD
Biconical	Urine	28	9	37	1.54
Biconical	Urine + acetone	54	15	69	2.88
Biconical	Milk	17	8	25	1.04

Continued

NGU	Urine	31	7	38	1.58
NGU	Urine + acetone	74	10	84	3.50
NGU	Milk	13	1	14	0.58
Overall	—	217	50	267	1.85

These values are exposure-standardized descriptive estimates. The available aggregate data do not support adjusted estimates of trap type, lure effects, or trap-by-lure interaction.

3.4. Ecological Site Types

Each ecological setting contributed 36 active trap-days. Dense riverine forest produced 112 catches (3.11 FTD), followed by irrigated farmland with 58 (1.61 FTD), peri-urban agriculture with 53 (1.47 FTD), and grazing corridors with 44 (1.22 FTD) (**Table 3**). These exposure-standardized differences describe the sampled deployments. Purposive site selection and unmeasured environmental factors prevent them from being interpreted as independent habitat effects.

Table 3. Exposure-standardized catch by ecological setting. Each setting received three traps per round for three days across four rounds.

Ecological setting	Traps/ round	Days/ round	Rounds	Trap- days	Catch	FTD
Dense riverine forest	3	3	4	36	112	3.11
Irrigated farmland	3	3	4	36	58	1.61
Peri-urban agriculture	3	3	4	36	53	1.47
Grazing corridors	3	3	4	36	44	1.22
Total	12	—	4	144	267	1.85

4. Discussion

The survey recorded a relatively simple provisional species assemblage dominated by *G. pallidipes* (**Table 1**; **Figure 5** and **Figure 6**). Similar dominance has been reported in parts of eastern Africa, including the Akagera landscape in Rwanda and the Shimba Hills interface in Kenya [5] [7]. However, species composition varies substantially across tsetse ecosystems. By [6], for example, found *G. morsitans morsitans* slightly more abundant than *G. pallidipes* in their Tanzanian study area, while surveys in Cameroon and Congo-Brazzaville have emphasized palpalis-group species [8] [10] [11]. These contrasts reinforce the need for local surveillance rather than assuming that regional patterns apply uniformly to Somalia.

The provisional identification of *G. austeni* deserves particular caution. The species is known from eastern Africa, but a contemporary record from the Shabelle corridor would be important and should not rest on morphology alone. Representative specimens should be re-examined by an experienced tsetse taxonomist

and confirmed with a suitable molecular marker before the record is presented as definitive.

Balcad produced 217 catches compared with 50 in Afgooye despite equal recorded trap exposure (**Table 1**). This difference points to strong spatial heterogeneity within the surveyed corridor. Comparable clustering has been reported in Tanzania, Kenya, Rwanda, and Ethiopia, where local variation in vegetation, host availability, moisture, and habitat continuity produced large differences among sampling sites [3]-[6].

The present data cannot identify the factor responsible for the Balcad-Afgooye contrast. Site selection was purposive, and vegetation structure, livestock density, wildlife presence, weather, and river conditions were not measured in a way that allowed their separate effects to be estimated. The result is therefore evidence of a catch difference among sampled sites, not proof that Balcad as a whole has a higher tsetse population or that any single environmental variable caused the difference.

Biconical and NGU traps produced nearly identical overall densities, at 1.82 and 1.89 FTD (**Table 2**). This small descriptive difference is not sufficient to claim that the two trap designs are equivalent. Trap performance can depend on species, habitat, odour bait, position, and weather, and the aggregate data do not account for repeated measurements or site effects [12].

Urine plus acetone clearly produced the highest unadjusted lure-specific density (**Table 2**). Odour-baited traps are well established in tsetse surveillance, including for *G. pallidipes* [12] [13]. Even so, the current finding should be treated as a signal for a better controlled trial. Trap positions should be randomized or rotated, lure preparation and release should be standardized, and catch should be analyzed at the trap-visit level before operational superiority is claimed.

Dense riverine forest produced 3.11 FTD, compared with 1.61 in irrigated farmland, 1.47 in peri-urban agriculture, and 1.22 in grazing corridors (**Table 3**). Shade, moisture, and vegetation structure may have contributed to this pattern, but these factors were not measured independently. The exposure-standardized differences should therefore guide confirmatory sampling rather than be treated as causal habitat effects. Irrigated farmland and peri-urban agriculture also produced substantial catches, indicating that surveillance should extend beyond intact riverine vegetation to working agricultural landscapes where livestock and people may encounter flies.

Both provisionally identified species can transmit animal trypanosomes. The survey did not test flies or livestock for infection, so it cannot estimate AAT prevalence or transmission intensity. Nevertheless, the presence of tsetse in livestock-associated habitats justifies integrated follow-up. Entomological surveillance should be paired with parasitological or molecular testing of flies and livestock to establish whether high-catch sites are also active transmission sites [3] [7] [14].

Implications for Surveillance and Control

The findings support confirmatory surveillance rather than immediate area-wide

vector control. Balcad and dense riverine sites should receive priority, but Afgooye should remain in the surveillance network because both provisional species were recorded there. A stronger design would use fixed georeferenced sites, randomized or rotated trap-lure assignments, complete visit-level records, year-round sampling, and documented environmental measurements. These changes would allow the programme to distinguish persistent hotspots from short-term catch variation and to estimate adjusted effects with appropriate count models.

5. Limitations

The sites were purposively selected, limiting generalization beyond the sampled microhabitats. Exact calendar dates, month-specific totals, complete trap-level repeated-measures data, environmental measurements, lure-source details, lure age, container specifications, and replacement schedules were unavailable in the compiled records. Although each ecological setting contributed 36 trap-days, the district-by-setting allocation could not be reconstructed, so district and setting effects may be confounded. Randomization or rotation of trap-lure assignments could not be verified, meaning treatment effects may also be confounded with position. The FTD values are descriptive point estimates without confidence intervals. Species identifications were not independently or molecularly confirmed, sex-specific data were unavailable, and four survey rounds were insufficient for inference about seasonality or population dynamics.

6. Conclusions

This repeated four-month survey provides an exposure-standardized baseline for tsetse catches in selected Shabelle River microhabitats. A total of 267 flies were captured during 144 trap-days, corresponding to an overall density of 1.85 FTD. The catch was provisionally composed of *G. pallidipes* (217; 1.51 FTD) and *G. austeni* (50; 0.35 FTD), although the latter record requires independent confirmation.

Balcad produced a substantially higher descriptive catch rate than Afgooye (3.01 versus 0.69 FTD). Biconical and NGU traps performed similarly in the pooled comparison, while urine plus acetone produced the highest unadjusted lure-specific density. Dense riverine forest produced the highest setting-specific apparent density (3.11 FTD). Overall, the results identify priorities for better designed confirmatory surveillance; they do not provide adjusted causal estimates of district, ecological setting, trap, or lure effects.

Recommendations

- Prioritize Balcad and dense riverine sites for balanced confirmatory surveillance while maintaining sentinel sampling in Afgooye.
- Randomize or rotate trap-lure assignments and record trap identity, coordinates, deployment and collection times, downtime, lure source, age, volume, release rate, and replacement schedule.

- Extend sampling across a full year and link each trap visit to documented rain-fall, river level, temperature, vegetation, and livestock data.
- Independently re-identify representative specimens and use molecular confirmation, especially for the provisional *G. austeni* record.
- Test tsetse and livestock for Trypanosoma infection so that entomological hotspots can be linked to actual transmission risk.
- Analyze complete visit-level counts with a Poisson or negative-binomial mixed-effects model using log(active trap-days) as an offset.

Ethical Approval and Consent to Participate

The study involved entomological trapping of wild tsetse flies and no invasive sampling of humans or livestock. Verbal permission for trap placement was obtained from community land users before fieldwork.

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Data Availability

The data generated or analysed during this study are available from the corresponding authors on reasonable request.

Author Contributions

Jeilani Busuri Mio: conceptualization, methodology, supervision, writing; **Yusuf Oyow Osman:** field surveillance, trapping, specimen collection; **Hassan Mohammed Jimcale Mohamed:** specimen collection, identification; **Juweiria Abdikadir Mohamud:** field data, data entry; **Suleiman Abdwahid Sheikh:** trapping, specimen handling; **Adan Mohamed Ali:** field surveillance, logistics; **Moktar Omer Sheikh Mohamed:** methodology, interpretation, review; **Zakariye Abdifatah Ahmed:** data curation, analysis, validation, review; **Mohamed Dhayib Abubakar:** field surveillance, trapping, specimen collection. All authors reviewed and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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