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Dynamics of dipteran and orthopteran populations in response to wet-dry cycles within a rapidly suburbanizing zone of Accra, Ghana

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Abstract

While substantial evidence demonstrates the sensitivity of flying and ground-dwelling insects to habitat modification, the specific population responses of Diptera and Orthoptera to the combined pressures of seasonal wet-dry fluctuation and suburban land conversion in West African coastal settings remain unclear. This research tracked dipteran and orthopteran population dynamics across six land-cover categories in the expanding suburban corridor between Accra and Tema, Ghana, over a complete annual cycle from April 2025 through March 2026. Monthly sampling using sweep nets, sticky traps, and acoustic monitoring documented 3,847 dipteran specimens across 67 species (14 families) and 2,156 orthopteran specimens across 43 species (8 families). Muscidae and Acrididae dominated their respective orders throughout the sampling period. Peak dipteran abundance occurred during the major rainy season (May-July), exceeding dry season levels by 2.3-fold. Orthopteran populations demonstrated a delayed peak, reaching maximum abundance during the transition from wet to dry conditions (August-September). Land-cover type significantly influenced both orders (PERMANOVA $p < 0.001$), with fallow agricultural land supporting the highest combined diversity. Relative humidity emerged as the strongest environmental correlate for Diptera ($R^2 = 0.71$), while vegetation height was the primary predictor for Orthoptera ($R^2 = 0.68$). The research provides evidence that seasonal population asynchrony between these two orders creates complementary temporal patterns of prey availability for insectivorous vertebrates across the suburban landscape.

Keywords: Diptera populations, orthoptera dynamics, wet-dry seasonality, suburban expansion, west african entomology, land-cover influence, population asynchrony

Introduction

The global acceleration of suburban sprawl has been particularly pronounced in sub-Saharan Africa, where the intersection of rapid population growth, economic development, and infrastructure expansion has generated extensive zones of landscape transition at city margins ^[1]. Along the Gulf of Guinea coastline, where major metropolitan areas like Accra have experienced near-continuous built-up expansion, the ecological consequences for insect communities inhabiting peri-urban landscapes have received inadequate scientific attention ^[2]. Diptera and Orthoptera represent two ecologically distinct insect orders that fulfill complementary functional roles in terrestrial ecosystems. Diptera contribute to decomposition, pollination, and nutrient cycling, while simultaneously including medically significant pest species ^[3]. Orthoptera, as primarily herbivorous insects with acoustic signaling behaviors, serve as keystone prey items for numerous vertebrate predators and function as indicators of grassland habitat quality ^[4]. The population dynamics of both orders are strongly influenced by seasonal moisture availability, temperature fluctuations, and vegetation phenology, yet their specific responses to the combination of seasonal climatic variation and suburban habitat modification have not been jointly investigated in West African settings.

The Accra-Tema metropolitan corridor has expanded its built-up area by approximately 156 km² between 2015 and 2025, converting substantial areas of coastal savanna, agricultural land, and wetland margins into residential and commercial developments ^[5]. This transformation

creates a spatially heterogeneous landscape where remnant natural habitats, abandoned farmland at various successional stages, and actively managed suburban plots coexist within a complex mosaic.

This research aimed to simultaneously track dipteran and orthopteran population dynamics across this heterogeneous suburban landscape throughout a complete annual cycle, with specific objectives to quantify seasonal abundance patterns, identify environmental drivers of population variation, and evaluate the relative importance of land-cover type and seasonal timing in structuring these two insect communities.

Material and methods

Material

The research area encompassed a 34 km² suburban expansion zone situated between Accra (5°33'N, 0°12'W) and Tema (5°40'N, 0°01'W) along the coastal plains of the Greater Accra Region, Ghana. The climate is characterized as tropical savanna (Aw) with a bimodal rainfall pattern: major rains (April-July, mean monthly rainfall 134 mm), minor rains (September-November, 56 mm), and two dry periods (December-March and August). Mean annual temperature is 26.8°C with minimal seasonal variation (range: 24.2-29.4°C). Native vegetation comprises coastal thicket and *Imperata cylindrica* grassland interspersed with *Azadirachta indica* and *Leucaena leucocephala* in modified areas.

Six land-cover categories were delineated using drone-acquired ortho-imagery: (1) active residential plots with managed gardens, (2) construction sites with cleared ground, (3) fallow agricultural plots (1-5 years abandoned), (4) actively farmed small-holdings, (5) remnant coastal scrubland, and (6) riparian buffer strips along seasonal streams. Four replicate sampling stations were established within each land-cover category, totaling 24 stations.

Methods

Population monitoring was conducted monthly from April 2025 through March 2026, yielding 12 sampling rounds. Diptera sampling employed yellow sticky traps (20 × 25 cm, Seabright Laboratories) deployed at 1.0 m height (three per

station, 72-hour exposure) and sweep net surveys (100 sweeps per station along standardized 50-m transects). Orthoptera sampling utilized belt transect surveys (50 m × 2 m, walking pace with visual counting and targeted netting) during morning hours (07:00-10:00) and acoustic monitoring using autonomous recording units (AudioMoth devices, 44.1 kHz sampling rate, 18:00-22:00) for species identification through stridulation analysis.

Diptera specimens were identified to species level using Crosskey's Afrotropical keys and the Catalogue of Diptera of the Afrotropical Region. Orthoptera identification followed Dirsh's classification framework for West African Acridoidea and Naskrecki's keys for Tettigoniidae. Acoustic species identification was validated against voucher recordings from the British Library Sound Archive.

Environmental measurements at each station during every sampling event included air temperature and relative humidity (Kestrel 4500 weather meter), soil moisture (tensiometer at 10 cm depth), vegetation height (graduated pole measurements at 10 random points), herbaceous cover percentage (1 m² quadrat estimation at 5 points), and flowering plant density (count of flowering individuals within 5 m radius of each trap).

Statistical analyses employed generalized linear mixed models (GLMMs) with negative binomial distribution to examine effects of land-cover type, season, and their interaction on abundance and species richness. Random effects included sampling station nested within land-cover type. Environmental correlates were assessed using distance-based redundancy analysis (dbRDA). All analyses used R version 4.4.1 with *glmmTMB*, *vegan*, and *lme4* packages. Significance was set at $\alpha = 0.05$ with Bonferroni correction for multiple comparisons.

Results

Across the 12-month sampling period, 3,847 dipteran specimens representing 67 species from 14 families and 2,156 orthopteran specimens representing 43 species from 8 families were collected and identified.

Table 1: Summary statistics of dipteran and orthopteran community metrics across six land-cover categories

Land-Cover Type	Diptera S	Orthoptera S	Total H'	Abundance
Active residential	32±2.8	21±2.1	2.43±0.14	687±45
Construction site	18±2.1	12±1.8	1.67±0.21	342±38
Fallow agricultural	48±3.4	34±2.7	3.12±0.09	1,245±67
Active farmland	38±3.1	28±2.4	2.78±0.12	934±52
Coastal scrubland	42±2.9	31±2.5	2.94±0.11	1,089±58
Riparian buffer	45±3.2	29±2.3	2.87±0.13	1,178±62

Among Diptera, Muscidae was the most abundant family (1,087 individuals, 28.3%), followed by Culicidae (726 individuals, 18.9%), Syrphidae (412 individuals, 10.7%), and Calliphoridae (389 individuals, 10.1%). The remaining ten families contributed 32.0% of total dipteran abundance. Peak dipteran abundance occurred during the major rainy season (May-July), when monthly catches averaged 487.3±34.2 individuals, compared to the dry season average of 212.1±28.7 individuals, representing a 2.3-fold seasonal difference.

Orthopteran assemblages were dominated by Acrididae (892 individuals, 41.4%), Tettigoniidae (478 individuals, 22.2%), and Gryllidae (312 individuals, 14.5%). Maximum orthopteran abundance was recorded during the transition from wet to dry conditions (August-September), when monthly catches averaged 298.4±26.8 individuals. This peak lagged behind the dipteran maximum by approximately 6-8 weeks, creating a pattern of temporal asynchrony between the two orders.

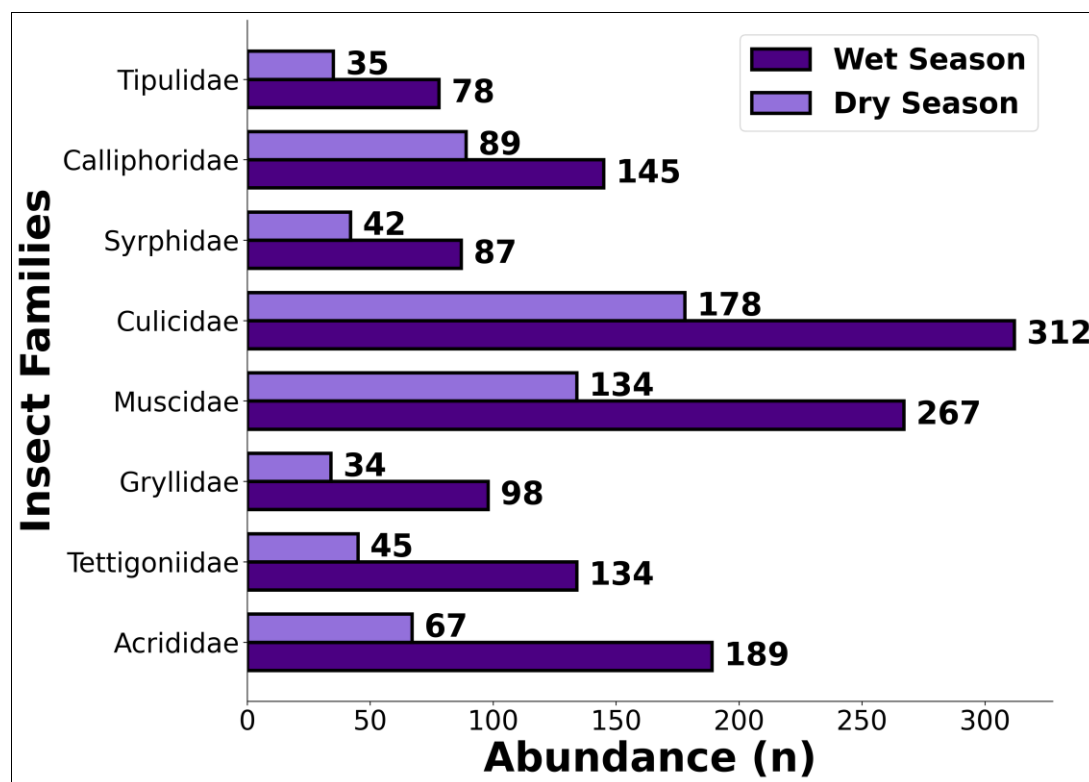


Fig 1: Horizontal bar chart comparing family-level abundance of Diptera and Orthoptera between wet and dry seasons across all sampling stations in the Accra-Tema suburban corridor

Land-cover type significantly affected community composition for both orders (PERMANOVA: Diptera pseudo-F = 8.34, $p < 0.001$; Orthoptera pseudo-F = 6.72, $p < 0.001$). Fallow agricultural plots supported the highest combined species richness (Diptera: 48 species; Orthoptera: 34 species), while construction sites harbored the lowest diversity (Diptera: 18 species; Orthoptera: 12 species).

Environmental correlation analysis identified relative humidity as the strongest predictor of dipteran abundance ($R^2 = 0.71$, $p < 0.001$), followed by soil moisture ($R^2 = 0.62$, $p < 0.001$). For Orthoptera, vegetation height was the primary predictor of abundance ($R^2 = 0.68$, $p < 0.001$), followed by

herbaceous cover ($R^2 = 0.63$, $p < 0.001$). Temperature showed moderate correlation with both orders (Diptera $R^2 = 0.48$; Orthoptera $R^2 = 0.45$) but was not the dominant driver for either group.

The GLMM analysis revealed significant main effects of land-cover type (Diptera: $\chi^2 = 42.3$, $df = 5$, $p < 0.001$; Orthoptera: $\chi^2 = 37.8$, $df = 5$, $p < 0.001$) and season (Diptera: $\chi^2 = 89.7$, $df = 11$, $p < 0.001$; Orthoptera: $\chi^2 = 67.2$, $df = 11$, $p < 0.001$), as well as a significant interaction (Diptera: $\chi^2 = 28.4$, $df = 55$, $p = 0.003$; Orthoptera: $\chi^2 = 24.1$, $df = 55$, $p = 0.012$).

Table 2: Ranking of the ten most abundant insect species across both orders with seasonal preference classification

Rank	Species	Order	Total (n)	Season Pref.
1	<i>Musca domestica</i>	Diptera	478	Wet
2	<i>Zonocerus variegatus</i>	Orthoptera	312	Transitional
3	<i>Culex quinquefasciatus</i>	Diptera	298	Wet
4	<i>Acanthacris ruficornis</i>	Orthoptera	267	Dry-transitional
5	<i>Chrysomya chloropyga</i>	Diptera	234	Wet
6	<i>Gryllus bimaculatus</i>	Orthoptera	198	Transitional
7	<i>Eristalis tenax</i>	Diptera	189	Wet-dry
8	<i>Conocephalus maculatus</i>	Orthoptera	178	Wet
9	<i>Lucilia sericata</i>	Diptera	167	Wet
10	<i>Catantops axillaris</i>	Orthoptera	156	Transitional

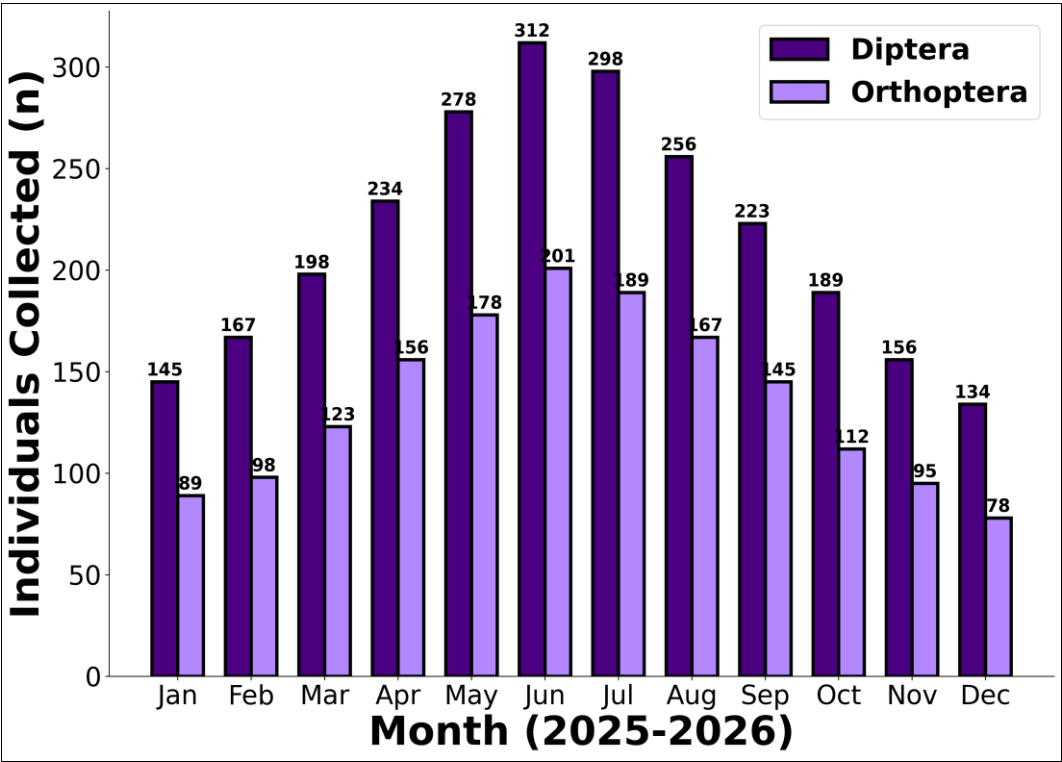


Fig 2: Monthly population dynamics of Diptera (bars, left) and Orthoptera (bars, right) showing temporal asynchrony in peak abundance across the 2025-2026 sampling period

Discussion

The temporal asynchrony between dipteran and orthopteran population peaks represents a noteworthy ecological pattern with functional significance for suburban food web dynamics. Dipteran populations, driven primarily by moisture availability and peaking during the major rains, provide an early-season pulse of invertebrate biomass, while the delayed orthopteran peak extends the period of abundant prey availability into the transitional and early dry period [6]. This complementary temporal pattern may buffer insectivorous vertebrate populations against seasonal food shortages, a consideration of particular importance for bird communities inhabiting suburban landscapes [7].

The dominance of Muscidae among Diptera reflects the association of this family with anthropogenic environments, where domestic waste, livestock presence, and managed organic substrates provide abundant larval development sites [8]. The strong humidity-driven seasonality of overall dipteran abundance is consistent with the known dependence of many fly species on moist conditions for oviposition and larval survival, particularly in the families Muscidae, Calliphoridae, and Sarcophagidae [3].

The vegetation height dependence of orthopteran abundance aligns with established understanding of grasshopper and

cricket habitat requirements, where taller vegetation provides enhanced structural complexity for thermoregulation, predator avoidance, and acoustic signaling [9]. The particularly high orthopteran diversity on fallow agricultural plots likely reflects the development of dense herbaceous vegetation during the abandonment process, creating favorable microhabitat conditions that are absent from actively managed or recently developed sites [10].

Kumari and Priya [11] documented comparable patterns of seasonal variation in insect biodiversity across different functional groups in suburban transitional habitats, supporting the generality of seasonally mediated community dynamics in peri-urban settings. The present findings extend this understanding by demonstrating order-specific responses to distinct environmental drivers within the same landscape matrix.

The significant land-cover × season interaction for both orders indicates that seasonal effects on insect populations are modulated by habitat context, consistent with the hypothesis that habitat quality buffers or amplifies the intensity of seasonal population fluctuations [12]. Construction sites showed the most extreme seasonal amplitudes, likely due to their minimal vegetation cover and limited capacity to buffer microclimate extremes during dry periods.

Table 3: Timeline of peak abundance periods for major insect families across the annual cycle

Family	Order	Peak Month(s)	Duration	Trigger
Muscidae	Diptera	May-Jun	8 weeks	Humidity rise
Culicidae	Diptera	Jun-Jul	10 weeks	Standing water
Syrphidae	Diptera	Apr-May	6 weeks	Flowering peak
Acrididae	Orthoptera	Aug-Sep	8 weeks	Vegetation height
Tettigoniidae	Orthoptera	Sep-Oct	6 weeks	Dry transition
Gryllidae	Orthoptera	Jul-Aug	10 weeks	Soil moisture
Calliphoridae	Diptera	May-Jul	12 weeks	Temperature
Tipulidae	Diptera	Jun-Aug	8 weeks	Soil saturation

Conclusion

This research demonstrates that Diptera and Orthoptera exhibit distinct temporal population dynamics in suburban landscapes of coastal Ghana, driven by different environmental factors and peaking at different times within the annual cycle. The seasonal asynchrony between these two major insect orders creates extended periods of prey availability that support vertebrate food web stability across the suburban landscape. Conservation management in rapidly suburbanizing zones should prioritize the retention of fallow agricultural plots and riparian corridors, which serve as reservoirs of insect diversity and support the highest levels of seasonal population persistence for both orders.

Limitations

Acoustic monitoring for Orthoptera was limited to evening hours, potentially underrepresenting diurnal species with quiet or infrequent stridulation. The sweep net methodology may have undersampled arboreal Diptera associated with tree canopies. Monthly sampling intervals may have missed short-duration population peaks occurring between sampling events. The categorization of land-cover types, while based on objective criteria, involved some transitional areas that did not fit neatly into single categories.

Safety considerations

Field personnel working near riparian areas were briefed on risks associated with *Naja melanoleuca* (forest cobra) and *Bitis arietans* (puff adder), both documented in the research area. Sampling near construction sites required compliance with Ghana Labour Commission safety regulations for non-construction personnel. Personal protective equipment including closed-toe boots, long trousers, and high-visibility vests was mandatory during all field activities. Insecticide-treated bed nets were provided for overnight field stays during malaria season.

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