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Inventory and Abundance of Sap-Sucking Insects on Cucumber (*Cucumis sativus* L.) in a peri-urban production area of Bouaké, according to phenological stage and spatial arrangement

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Abstract

Infestation of cucumber (*Cucumis sativus* L.) by sap-sucking insects constitutes a major constraint to vegetable production in sub-Saharan Africa. This study documents, for the first time under peri-urban conditions in Bouaké, the abundance and spatial structure of three key pests, *Aphis gossypii*, *Bemisia tabaci*, and *Amrasca biguttula*, in relation to phenological stage (flowering and fruiting) and experimental block, using a completely randomized block design. Sixty plants of the Saira F1 variety, arranged in two blocks (A and B), five rows, and three plants per row, were monitored in January and February 2026. Shapiro-Wilk tests confirmed the non-normality of the distributions ($p < 0.0001$), justifying the use of non-parametric Mann-Whitney and Kruskal-Wallis tests. Jassids (*Amrasca biguttula*, 28.3% of infested plants) and whiteflies (*Bemisia tabaci*, 25.0%) dominated the pest community, while aphids (*Aphis gossypii*) remained marginal (1.7%). No significant differences were observed among phenological stages for any of the three species. However, jassid abundance was significantly higher in Block B than in Block A ($p = 0.010$), revealing spatial heterogeneity likely linked to microclimatic conditions or plot management. No significant correlation was detected between species (Spearman's test, $p > 0.05$). These findings highlight the need to strengthen monitoring of jassid population levels in vegetable crops in the peri-urban zone of Bouaké.

Keywords: *Cucumis sativus; Aphis gossypii; Bemisia tabaci; Amrasca biguttula*; Phenological stage; Côte d'Ivoire.

1. Introduction

Cucumis sativus L. (Cucurbitaceae) is one of the most widely cultivated vegetable cucurbits in West Africa, particularly in Côte d'Ivoire, where its production has expanded considerably in peri-urban areas over the past two decades [1]. This crop is nonetheless exposed to a complex of insect pests whose attacks directly affect fruit yield and marketable quality. Among sap-sucking pests, aphids (*Aphis gossypii* Glover), whiteflies (*Bemisia tabaci* Gennadius), and jassids (*Amrasca biguttula*) are regularly reported as the dominant species in sub-Saharan Africa [2,3].

These insects cause damage through direct sap withdrawal, the injection of salivary toxins, and, in the case of *B. tabaci*, through the transmission of geminiviruses, leading to yield losses of up to 80% in unprotected crops [4]. Aphids, for their part, induce marginal leaf chlorosis, known as “hopper burn,” which impairs photosynthesis and accelerates leaf senescence [5].

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Despite their agronomic importance, data on the abundance and distribution of these pests on vegetable crops in the peri-urban zone of Bouaké remain scarce. This gap limits the establishment of rational intervention thresholds within an integrated pest management (IPM) framework.

The present study aims to (i) assess the abundance and infestation frequency of *A. gossypii*, *B. tabaci*, and *Amrasca biguttula* on cucumber variety Saira F1; (ii) compare these parameters between the flowering and fruiting stages; (iii) analyze the effect of experimental block and row arrangement on pest distribution; and (iv) evaluate the associations between species.

2. Materials and methods

2.1. Study site and experimental design

Observations were conducted on a cucumber production plot located in the peri-urban zone of Bouaké, Côte d'Ivoire. The experimental design adopted was a randomized complete block design (RCBD) comprising two blocks (Block A and Block B), each organized into five rows of three plants. The observation unit was the individual plant, for a total of $n = 60$ plants (30 per block, 12 per row across the entire design).

The cultivated variety was Saira F1, a determinate-growth F1 hybrid commonly used in West African vegetable production systems for its productivity and tolerance to tropical climatic conditions. No insecticide treatment was applied during the observation period, ensuring that infestation levels reflected natural pest pressure.

2.2. Data collection

Two observation sessions were conducted, corresponding to the flowering (19 January 2026, $n = 30$ plants) and fruiting (16 February 2026, $n = 30$ plants) stages. For each plant, the number of individuals of each target pest was counted directly on the lower leaf surface (direct count method). Data were recorded in real time using the KoboCollect system on an Android tablet, ensuring traceability and time-stamping of observations.

2.3. Statistical analysis

Normality of distributions was assessed using the Shapiro-Wilk test. Given the non-normality of the count data (a discrete response variable with a high proportion of zeros), comparisons were performed using non-parametric tests: the Mann-Whitney U test for two-group comparisons (phenological stage, block), and the Kruskal-Wallis H test for comparisons involving $k = 5$ groups (row effect). Associations between pests were quantified using Spearman's correlation coefficient (ρ). The significance threshold was set at $\alpha = 0.05$. All calculations were performed using Python 3.12 (scipy 1.13 and pandas 2.2 libraries).

3. Results

3.1. Normality of distributions and descriptive statistics

The Shapiro-Wilk test revealed that all three count variables deviated significantly from normality: *A. gossypii* ($W = 0.110$, $p < 0.0001$), *B. tabaci* ($W = 0.548$, $p < 0.0001$), and *Amrasca biguttula* ($W = 0.609$, $p < 0.0001$). These results were expected for insect count data with low abundance, characterized by an overrepresentation of zero values (zero-inflated distributions).

Overall descriptive statistics are presented in Table 1. Aphids (*Aphis gossypii*) showed near-zero abundance throughout the study period (mean = 0.017 ± 0.129 individuals/plant; 1 infested plant out of 60, i.e., 1.7%). Whiteflies (*Bemisia tabaci*) and jassids (*A. biguttula*) exhibited comparable abundances (0.550 ± 1.156 and 0.483 ± 0.873 individuals/plant, respectively) but had infestation frequencies of 25.0% and 28.3%, respectively. The extremely high coefficients of variation (CVs > 180% across all species) confirmed the strong inter-plant heterogeneity characteristic of early-stage insect infestations.

Table 1 Descriptive statistics of pest populations (n = 60 plants).

Pest	n	Min	Max	Median	Mean ± SD	Frequency (%)
Aphis gossypii	60	0	1	0	0.017 ± 0.129	1.7
Bemisia tabaci	60	0	6	0	0.550 ± 1.156	25.0
Amrasca biguttula	60	0	3	0	0.483 ± 0.873	28.3

Frequency: percentage of plants exhibiting at least one individual.

3.2. Effect of phenological stage

Mean abundances by phenological stage are presented in Figure 1. At the flowering stage, jassids (*Amrasca biguttula*) were predominant with 0.667 ± 1.028 individuals/plant (11 out of 30 plants infested), followed by whiteflies (*Bemisia tabaci*) with 0.633 ± 1.377 individuals/plant. At the fruiting stage, *B. tabaci* showed a slight predominance (0.467 ± 0.900 individuals/plant) over jassids (0.300 ± 0.651 individuals/plant). Aphids (*A. gossypii*) showed only marginal presence throughout, consistent with their near-zero abundance reported in Table 1.

Mann-Whitney tests revealed no statistically significant difference between the two stages for any of the three pests: *A. gossypii* (U = 435.0; p = 0.334), *B. tabaci* (U = 446.0; p = 0.946), *A. biguttula* (U = 531.0; p = 0.133). The absence of a significant difference suggests that, over the period considered, phenological stage is not the primary determinant of pest dynamics.

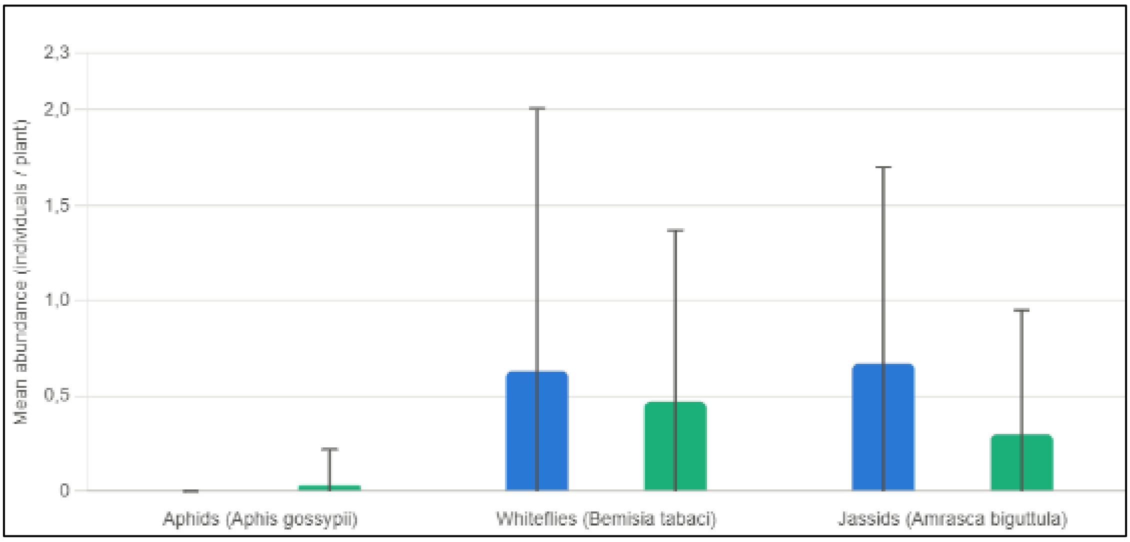

Figure 1 Mean abundance (± SD) of the three pests according to phenological stage. ns = not significant (Mann-Whitney test, α = 0.05).

3.3. Effect of experimental block

Analysis by block (Figure 2, Table 2) showed that *Aphis gossypii* and *Bemisia tabaci* had similar abundances in both blocks (Mann-Whitney test, p > 0.05). In contrast, a statistically significant difference was observed for *A. biguttula*: Block B exhibited a markedly higher mean abundance than Block A (0.767 ± 1.040 vs. 0.200 ± 0.551 individuals/plant; U = 311.0; p = 0.010).

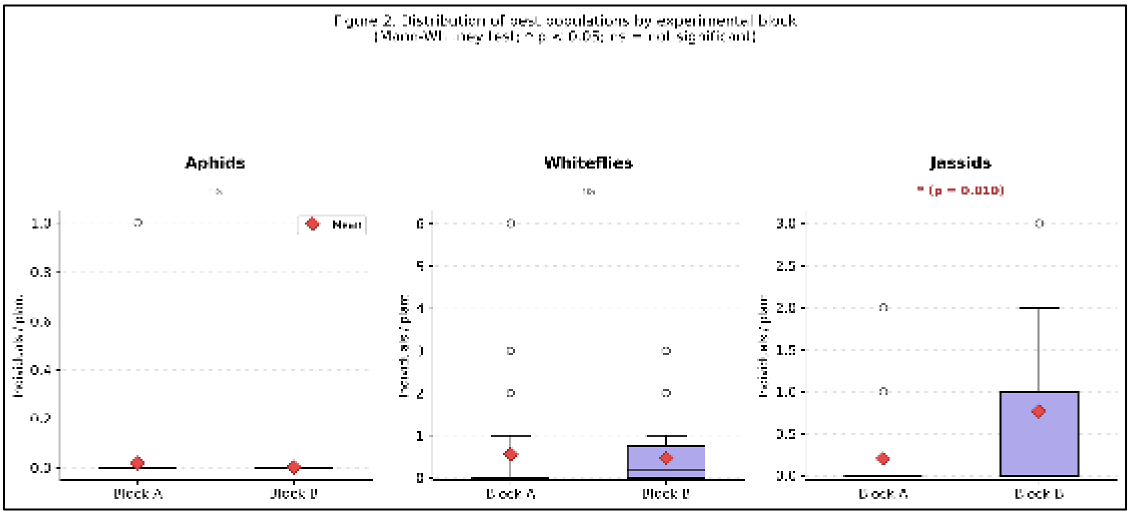

Figure 2 Distribution of pest populations by experimental block (Mann-Whitney test; * $p < 0.05$; ns = not significant).

3.4. Effect of row position

The Kruskal-Wallis test revealed no significant row effect for any of the three pests: *A. gossypii* (H = 4.000; p = 0.406), *B. tabaci* (H = 0.569; p = 0.966), *A. biguttula* (H = 2.291; p = 0.682). However, on a descriptive basis, row 5 showed the highest abundances of whiteflies (0.833 ± 1.749 individuals/plant) and aphids (0.750 ± 1.055 individuals/plant), which may indicate a gradient toward the plot edge and warrant closer monitoring in this zone.

Table 2 Results of the non-parametric statistical tests (stage, block, and row).

Pest	Stage (U / p)	Block (U / p)	Row (H / p)	Decision
Aphis gossypii	435.0 / 0.334	465.0 / 0.334	4.000 / 0.406	ns, ns, ns
Bemisia tabaci	446.0 / 0.946	436.0 / 0.793	0.569 / 0.966	ns, ns, ns
Amrasca biguttula	531.0 / 0.133	311.0 / 0.010*	2.291 / 0.682	ns, *, ns

U: Mann-Whitney statistic; H: Kruskal-Wallis statistic; ns: not significant; * $p < 0.05$.

3.5. Associations between pests

Spearman correlation coefficients between the three species were weak and non-significant (Table 3): *A. gossypii* × *B. tabaci* (ρ = -0.074; p = 0.573), *A. gossypii* × *A. biguttula* (ρ = -0.081; p = 0.540), and *B. tabaci* × *A. biguttula* (ρ = +0.149; p = 0.258). The absence of inter-specific correlation indicates that infestations occurred independently across the study plot. This independence rules out, at this stage, a direct competitive or facilitative relationship between these species, although observations over a longer period are needed to draw definitive conclusions.

Table 3 Spearman correlations between the populations of the three pests (n = 60).

Pest pair	rho (Spearman)	p-value	Interpretation
Aphis gossypii × Bemisia tabaci	-0.074	0.573	No correlation
Aphis gossypii × Amrasca biguttula	-0.081	0.540	No correlation
Bemisia tabaci × Amrasca biguttula	+0.149	0.258	No correlation

3.6. Infestation frequency and spatial distribution

Figure 3 presents the infestation frequency and the distribution of individual abundances. Jassids infested the largest number of plants (28.3%, i.e., 17/60), though with moderate counts per plant (max = 3 individuals/plant). Whiteflies were present on 25.0% of plants (15/60), with a local maximum of 6 individuals per plant (Row 5, Block B), the most intense infestation observed across the entire study. Aphid populations remained marginal (1.7%, i.e., a single plant, Block A, Row 2).

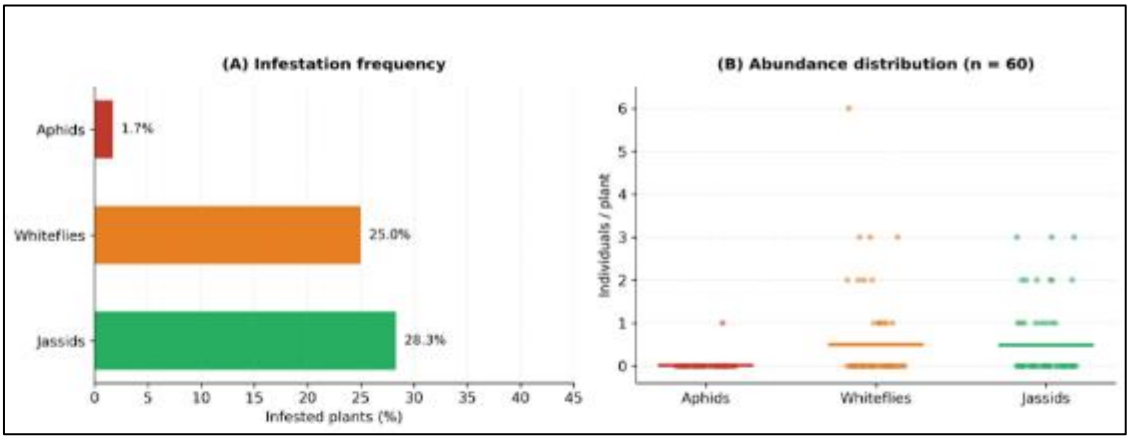

Figure 3 (A) Infestation frequency by pest (% of plants with ≥ 1 individual). (B) Distribution of individual abundances (n = 60; horizontal line = mean).

4. Discussion

The sap-sucking pest community observed on the cucumber variety Saira F1 in the peri-urban zone of Bouaké comprised three species with infestation levels generally moderate over the period considered. This result is consistent with other studies conducted at early crop stages in West Africa [3,6], where sap-sucking pest populations build up progressively from peripheral infestation sources.

The predominance of jassids (*A. biguttula*) at the flowering stage and their persistence into fruiting are noteworthy findings. *A. biguttula* is known to prefer young expanding leaves, which are abundant during flowering [7]. The slight decline in their abundance at the fruiting stage may reflect basipetal foliage aging and a redistribution of populations toward growing apices. The higher proportion of whiteflies (*B. tabaci*) at the fruiting stage (although not significant) could be explained by generational accumulation and by the increasing attractiveness of cucumber plants as leaf biomass expands.

The significant spatial heterogeneity in jassids between the two blocks ($p = 0.010$) is the most notable finding of this study. In field-based crop protection studies, this intra-plot variability is often underestimated when statistical analyses fail to distinguish block effects [8]. The fact that whiteflies and aphids did not show this pattern suggests that jassids may be more sensitive to microclimatic or structural factors varying between the two blocks. The absence of inter-specific correlation is interpreted as reflecting a random distribution of infestation sources at this early stage of the crop cycle. At the start of the season, infestations typically result from flights of these sap-sucking insects from neighboring plots or surrounding weedy vegetation [9], leading to stochastic, independent infestation patterns. Significant positive correlations could emerge at later stages if populations establish and colonize the plot in a more structured manner.

The low absolute abundances observed should not lead to an underestimation of phytosanitary risk: (i) economic intervention thresholds for *B. tabaci* on cucurbits are generally on the order of 1 to 3 adults per leaf [2], and some plants in Row 5 already reached 6 individuals/plant; (ii) *B. tabaci* is a vector of Squash leaf curl virus (SLCV) and other Begomoviruses, whose transmission requires only a very low viral load [4]; (iii) jassids (*A. biguttula*) induce irreversible "hopper burn" damage from as few as 2 to 3 individuals per leaf [5].

5. Conclusion

This study provides data on the sap-sucking pest entomofauna of cucumber in the peri-urban zone of Bouaké at two key phenological stages. Jassids (*A. biguttula*) were the most abundant sap-sucking pests. Phenological stage did not significantly influence pest abundance. However, we observed significant spatial heterogeneity of jassids between the two blocks. Given the damage that jassids (*A. biguttula*) can cause, this study recommends continued monitoring of infestation levels of this pest in vegetable crops in the peri-urban zone of Bouaké.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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