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Seasonal and habitat: influences on bees of Comoé National Park

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Abstract

Bees are major pollinators that ensure the functioning and stability of ecosystems, yet their conservation is closely linked to knowledge of their spatio-temporal distribution. This study aims to assess the influence of seasons on the distribution of bees across different habitats of Comoé National Park (CNP) in Côte d'Ivoire. Bees were sampled from December 2022 to August 2024, during both dry and rainy seasons, in four habitat types (tree savanna, shrub savanna, forest islands, and gallery forest). A total of 28 bee species were recorded, with higher species richness in the dry season than in the rainy season. Species richness did not differ significantly among habitats, although tree and shrub savannas showed higher diversity during the dry season. Diversity indices revealed a more even distribution of species in shrub savanna during the dry season and in gallery forest during the rainy season. In contrast, bee abundance varied significantly among habitats and seasons, with a marked dominance of forest islands, highlighting the role of these environments as refuge habitats. These results emphasize the importance of forest habitats in maintaining bee populations and confirm the key role of Comoé National Park in pollinator conservation. They provide essential baseline data to guide management and conservation strategies for bees and their habitats.

Keywords: Bees, diversity, seasons, habitats, Comoé National Park.

Introduction

Côte d'Ivoire (322,463 km²) has experienced severe degradation of its natural resources over recent decades, with the loss of more than 67% of its forest cover since the 1960s, mainly due to agricultural, forestry, energy, and mining activities (Cuny *et al.*, 2023) [1]. This regression of natural habitats affects wildlife and reinforces the role of protected areas as key biodiversity refuges and as tools for maintaining ecosystem services (Sue *et al.*, 2018). Comoé National Park (CNP), the largest protected area in sub-Saharan West Africa, is representative of savanna biomes in Côte d'Ivoire and is among the largest national parks in the world (Koueita *et al.*, 2018) [4]. It constitutes a major biodiversity reservoir, particularly for insect pollinators (Gernot *et al.*, 2023) [3]. Among these, bees (Hymenoptera) play a central role in the reproduction of most flowering plants and in ecosystem functioning, due to their diversity, abundance, and morphological adaptations (Tuo *et al.*, 2019) [7]. Since bee conservation is closely linked to knowledge of their distribution and spatio-temporal dynamics, this study seeks to assess the influence of seasons on bee distribution across different habitats of Comoé National Park.

Materials and Methods

Study sites

Bees were sampled during both seasons (dry and rainy) in four habitat types within Comoé National Park: tree savanna, shrub savanna, forest islands, and gallery forest (Figure 1).

Wooded savannah

Shrub savannah

Forest island

Gallery forest

Data collection

Data were collected in four habitat types of Comoé National Park (CNP)—forest islands, gallery forest, tree savanna, and shrub savanna—from December 2022 to August 2024. Bee sampling was carried out using the transect method with yellow pan traps, which are known for their high attractiveness and effectiveness in monitoring pollinator diversity (Chauvin *et al*., 1966; Leong *et al*., 1999; Campbell, 2007).

Three transects, each consisting of 80 bowls, were installed in each habitat type and for each season. The bowls were arranged in groups of four, resulting in 20 quadruplets per transect. A total of 360 quadruplets were therefore installed for each habitat type. Quadruplets were spaced 10 m apart, and a minimum distance of 150 m separated two sampling transects.

Each bowl was filled to one quarter with salted water to which a detergent was added. Insects captured were collected 48 hours after trap installation. Using a small sieve and forceps, insects were filtered and stored in vials containing 70% alcohol. They were then transported to the laboratory for mounting and identification.

Identification

Bee identification was based on morphological characteristics. Bees were sorted to separate them from other insects and pinned onto polystyrene supports to better spread body parts. Identification was carried out under an Olympus Z61 stereomicroscope at ×4 magnification using the identification keys of Eardley *et al*. (2010) and Michener (2007).

A reference bee collection available at the Lamto research station was also used to identify specimens to species level.

Data analysis

Species richness and abundance were compared using one-way ANOVA tests at a 5% significance level with Statistica version 7.1. Taxonomic composition of bees among habitats was analyzed using the Jaccard index calculated with PAST 1.0 software.

Shannon diversity and evenness indices were calculated to compare habitat diversity using PAST version 1.0.

The distribution of insects among habitats was analyzed using principal component analysis.

Results

Species richness

At the end of the study, 28 bee species were sampled. Twenty-one species were identified during the dry season and 16 during the rainy season. Regarding species diversity by habitat, tree savanna and shrub savanna were the most diverse during the dry season, each with 14 species (66.67% of recorded species). Forest islands followed with 11 species (53.38%), while gallery forest was the least diverse habitat during the dry season, with only 5 species (23.81% of the total).

During the rainy season, tree savanna remained the most diverse habitat with 9 species (56.25%). Shrub savanna followed with 8 species (50%). Gallery forest recorded 7 species (43.75%), and forest islands had 5 species (31.25%) (Figure 2).

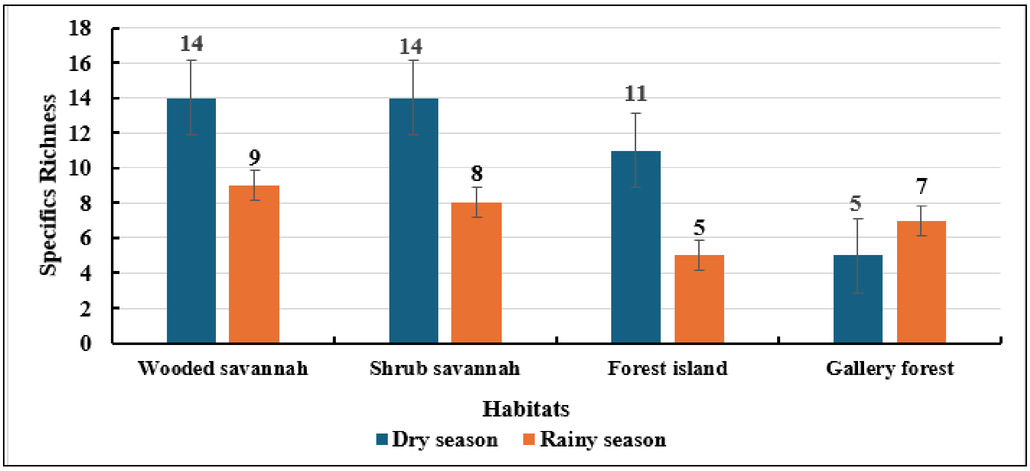

Fig 2: Bee species richness across habitats according to season

The Kruskal–Wallis test applied to dry season data showed no significant difference among habitats in species richness (H (3, N = 36) = 4.56, $p = 0.21$), indicating that variations in diversity among habitats were not statistically significant.

Regarding diversity indices, the highest values were observed in shrub savanna during the dry season, with a Shannon index H′ = 1.91 and evenness E = 0.73, indicating a more even distribution of species in this habitat. In contrast, during the rainy season, these indices were highest in gallery forest (H′ = 1.02; E = 0.70), suggesting a relatively balanced species distribution under rainy conditions (Table 1).

Table 1: Biological diversity of bees in different habitats during dry and rainy seasons

Habitats Biological diversity Indices	Wooded savannah	Shrub savannah	Forest island	Gallery forest
Dry season				
Shannon (H’)	0,91	1,92	0,74	1,02
Equitability (E)	0,34	0,73	0,31	0,63
Rainy season				
Shannon (H’)	1,3	0,84	0,95	1,46
Equitability (E)	0,57	0,38	0,53	0,7

For the rainy season, one-way ANOVA revealed no significant difference in species richness among habitats (F = 0.34; $p > 0.05$), indicating that habitat type did not significantly influence species diversity during this season.

Abundance

During the dry season, forest islands were the most abundant habitat, with 3,482 individuals, representing 84.15% of total abundance. Tree savanna ranked second with 311 individuals (7.51%), followed by gallery forest with 242 individuals (5.85%). Shrub savanna was the least abundant habitat, with only 103 individuals (2.49%).

In the rainy season, forest islands remained dominant, hosting 1,068 individuals (60.07%). Shrub savanna followed with 332 individuals (18.67%), gallery forest with 317 individuals (17.83%), while tree savanna showed the lowest abundance with only 61 individuals (3.43%) (Figure 3).

The Kruskal–Wallis test indicated significant differences in abundance among habitats during both the dry season (H (3, N = 36) = 16.16; $p < 0.05$) and the rainy season (H (3, N = 36) = 9.97; $p < 0.05$). Post-hoc tests showed that forest islands had significantly higher abundance than other habitats in both seasons, confirming their dominant role (Figures 4 and 5).

Discussion

This study highlights a relatively moderate bee species richness in Comoé National Park, with 28 species recorded over the study period. The higher richness observed during the dry season suggests increased bee activity, likely related to greater floral resource availability and climatic conditions favorable to flight and foraging, such as lower rainfall and more stable temperatures (Malika, 2010) [5].

Although differences in species richness among habitats were not statistically significant, there was a tendency toward greater diversity in tree and shrub savannas, particularly during the dry season. These habitats provide a mosaic of herbaceous and woody floral resources that favor the coexistence of bee species with varied ecological preferences (Winfree *et al.*, 2007) [8]. In contrast, gallery forest and forest islands showed lower richness, possibly due to a denser canopy limiting the availability of accessible flowers (Danforth *et al.*, 2010).

Shannon diversity and evenness indices indicated a more even species distribution in shrub savanna during the dry season and in gallery forest during the rainy season, suggesting that seasonality influences not only species richness but also community structure.

Regarding abundance, forest islands showed marked dominance in both seasons, with statistically significant differences among habitats. This high abundance may be linked to the availability of protected nesting sites and a more stable microclimate in forested environments, even during unfavorable periods. These findings indicate that forest habitats, although sometimes less species-rich, play a key role in maintaining bee populations by supporting survival and reproduction.

The significant difference in abundance between seasons highlights the major influence of climatic factors on bee communities (Malika, 2010) [5].

These results confirm the importance of protected areas, particularly Comoé National Park, in conserving bees and the pollination services they provide. However, effective management of these pollinators requires in-depth knowledge of their spatio-temporal distribution and responses to seasonal variation. This study therefore provides essential baseline data to guide conservation strategies and sustainable management of CNP habitats.

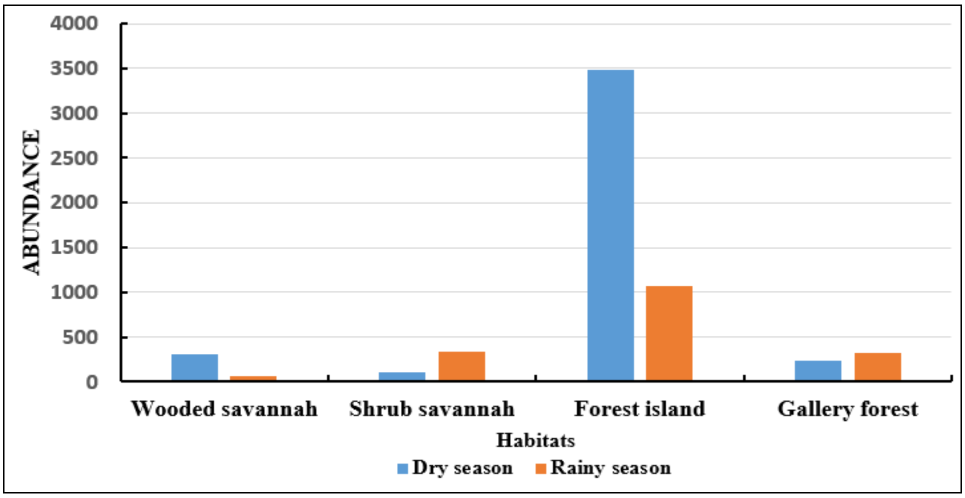

Fig 3: Bee abundance during dry and rainy seasons

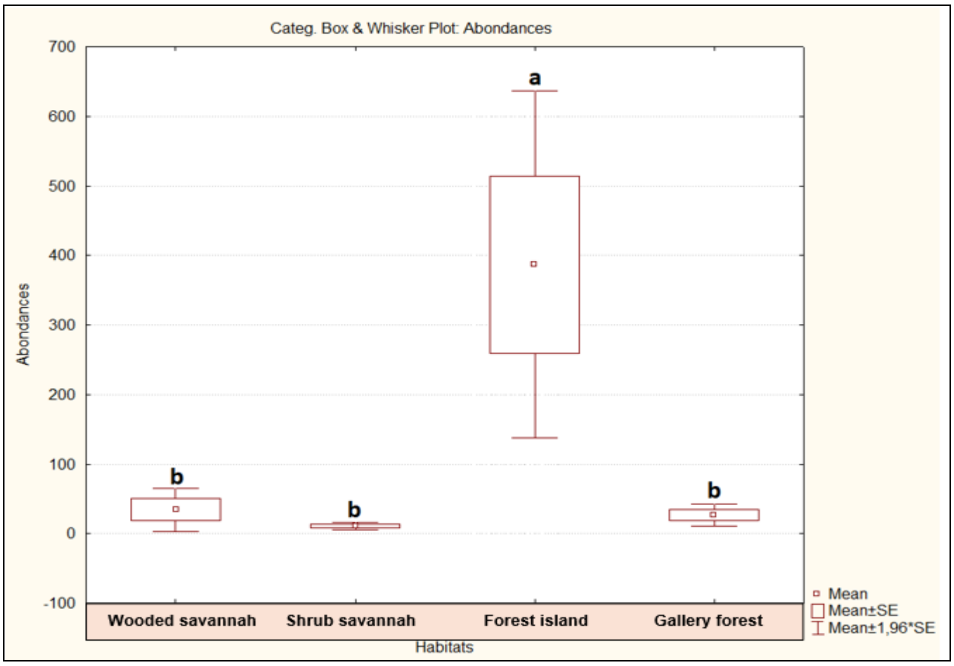

Fig 4: Bee abundance across habitats during the dry season

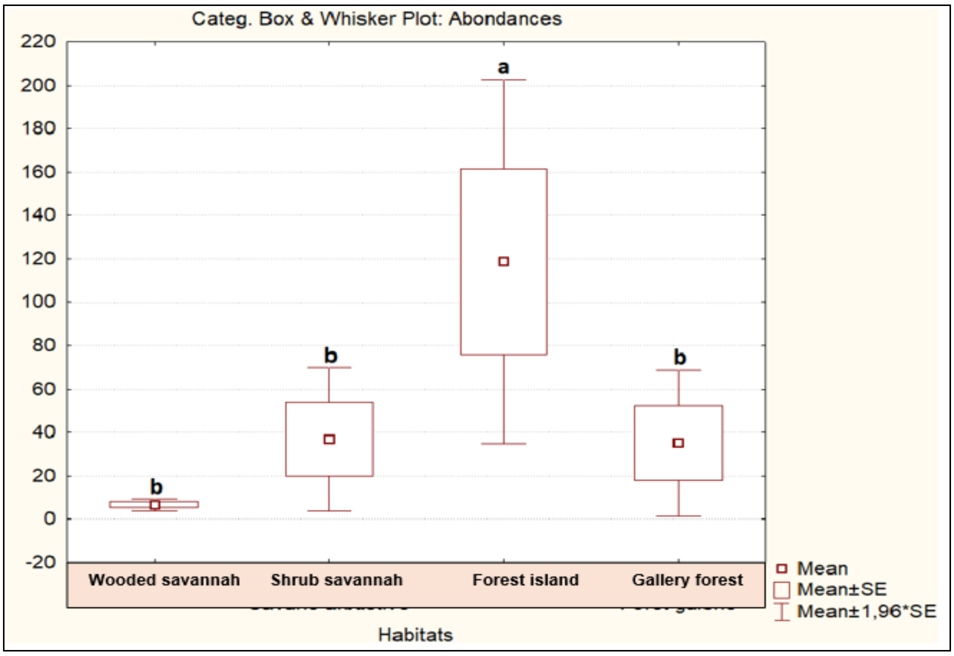

Fig 5: Bee abundance across habitats during the rainy season a = high abundance; b = low abundance

Conclusion

This study reveals marked spatio-temporal variation in bee communities within Comoé National Park, highlighting the combined influence of seasons and habitat types. The dominance observed in forest islands confirms the crucial role of these environments as refuge habitats for pollinators, particularly under climatic constraints. Differences in diversity and abundance between seasons indicate strong sensitivity of bees to environmental conditions. These findings emphasize that bee conservation in the park requires improved understanding of their ecology and provide essential scientific foundations for guiding habitat management and conservation strategies.

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