

Arthropod biomass carbon stocks across vegetation density gradients in Angke Kapuk Protected Forest, Jakarta, Indonesia

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Abstract. Puspawati CA, Haneda NF, Kusmana C. 2026. Arthropod biomass carbon stocks across vegetation density gradients in Angke Kapuk Protected Forest, Jakarta, Indonesia. *Biodiversitas* 27 (1): d270128. <https://doi.org/10.13057/biodiv/d270128>. Blue carbon research has traditionally centered on vegetation and sediment reservoirs, however, the role of faunal components particularly arthropods remain underrepresented. This study examines arthropod community dynamics and their associated carbon stocks across three vegetation density classes in Angke Kapuk Protected Forest, Jakarta, Indonesia. Using a combination of yellow pan traps, light-traps, and manual collection, we estimated arthropod biomass through allometric equations to quantify biological carbon contributions. Our findings show that Diptera (Chironomidae) dominated the assemblages across all densities. Statistical analysis via one-way ANOVA indicated no significant variation in arthropod carbon stocks among the density classes ($F_{2,3} = 0.209$, $p = 0.822$), likely due to high micro-ecological variance at the plot level. However, correlation analysis revealed that carbon stocks were significantly linked to microclimatic stability, showing a strong negative relationship with light intensity ($r = -0.84$, $p < 0.05$). These results highlight that arthropod carbon distribution in urban mangroves is governed more by localized microclimatic conditions than by broad vegetation density. This study provides a refined perspective on the environmental factors governing small-scale carbon storage and suggests that maintaining structural heterogeneity is essential for sustaining faunal carbon reservoirs in urban mangrove ecosystems.

Keywords: Angke Kapuk Protected Forest, arthropod biomass, blue carbon, cover density, microclimate

INTRODUCTION

Climate change, evidenced by increasing global mean temperatures, highlights the necessity for mitigation strategies that encompass both the reduction of greenhouse gas emissions and the proactive management of ecosystem services that operate as carbon sinks. Mangrove ecosystems are widely acknowledged as highly efficient blue-carbon sinks, sequestering carbon in live biomass and organic-rich sediments at rates that often surpass those of most terrestrial forests. Recent estimations indicate that these coastal forests can absorb over $226 \text{ g C m}^{-2} \text{ yr}^{-1}$. In many regions, mangrove ecosystems can achieve a total carbon storage of approximately $1,023 \text{ Mg ha}^{-1}$, a capacity heavily influenced by dense tree populations and consistent sediment deposition. However, carbon stocks are not uniform; they fluctuate based on species composition, environmental gradients, and land-use history. For instance, mixed mangrove stands may harbor approximately 20% more organic carbon than monodominant stands, while the conversion of these habitats to aquaculture or pasture emits substantial greenhouse gases, thereby undermining their essential carbon-sink function. These trends underscore the dual significance of mangroves for global biodiversity and climate stability, as well as the vulnerability of their carbon balance to anthropogenic stresses.

The Angke Kapuk Protected Forest (AKPF) in Jakarta's coastal urban environment consists of a mangrove mosaic

that offers essential services, including carbon sequestration, air pollution mitigation, and coastal protection. However, AKPF is under significant urbanization pressure that threatens its structural integrity and ecological functionality. Urban mangrove forests experience unique environmental stressors, such as altered microclimates, habitat fragmentation, and intensified anthropogenic disturbances, which may fundamentally modify faunal community structures and associated carbon dynamics. Stressors in these areas encompass the accumulation of solid waste and plastics that impede natural regeneration, as well as shifts toward younger stand dynamics with altered size distributions. Furthermore, socio-economic factors and rising tourism may exacerbate degradation concerns in the absence of robust environmental governance. In AKPF, these urban stressors and the heterogeneity in vegetation structure are expected to alter the local microclimate. Such environmental shifts may, in turn, influence the abundance, biodiversity, and biomass-derived carbon stocks of resident arthropod communities. Differences in vegetation cover density ranging from sparse to dense act as a vital factor in microhabitat heterogeneity, particularly regarding light, temperature, and humidity, which structures faunal groups and subsequently affect the site-level carbon balance.

The significance of arthropods in carbon storage and cycling is increasingly recognized due to their direct and indirect impacts on carbon fluxes. They act as herbivores that regulate plant productivity, agents of nutrient transfer

via excreta and carcasses, and decomposers that expedite material turnover. While low-intensity herbivory may diminish canopy photosynthesis, arthropod-mediated nutrient transfers can enhance nutrient availability, thereby promoting plant growth and influencing carbon sequestration. At broader scales, biotic disturbances such as arthropod outbreaks may increase tree mortality and reduce forest carbon sequestration, particularly under warming conditions. Consequently, arthropod-related carbon must be viewed from two perspectives: as biomass-derived carbon stock and as dynamic carbon flux associated with ecological processes. However, despite their recognized functional roles, arthropods are rarely incorporated into quantitative blue-carbon assessments, which predominantly emphasize vegetation and sediment carbon pools.

The variability in vegetation density plays a critical role in determining habitat complexity, influencing not only the diversity of arthropod communities but also their contribution to carbon cycling. Despite growing recognition of arthropods as integral components of blue-carbon processes, empirical studies quantifying arthropod biomass-derived carbon stocks across vegetation density gradients while evaluating microclimatic influences in urban mangrove ecosystems remain limited. To date, no study has explicitly quantified these stocks alongside microclimatic conditions in such a localized urban context. Understanding how cover vegetation density affects arthropod abundance, biodiversity, and carbon storage is therefore essential for developing a more comprehensive framework of mangrove ecosystem functioning.

This exploratory study examines the relationships between vegetation cover density, arthropod assemblages, and biomass-derived carbon stocks in the Angke Kapuk Protected Forest. We analyzed arthropod abundance, composition, and biodiversity while quantifying carbon stocks across a density gradient. Additionally, the associations between these carbon stocks and environmental variables, such as temperature, humidity, and light intensity were

evaluated to provide an integrated understanding of faunal contributions to urban mangrove carbon dynamics.

MATERIALS AND METHODS

Study area

The research was conducted in Angke Kapuk Protected Forest, North Jakarta, Jakarta, Indonesia (Figure 1), during July-August 2025. This mangrove conservation area is managed by the Jakarta Parks and City Forest Agency and covers approximately 51.18 ha. Geographically, AKPF is located at coordinates 6°05'–6°10' S and 106°43'–106°48' E. The research was conducted in the Angke Kapuk Protected Forest, North Jakarta, Jakarta, Indonesia, during July-August 2025. This mangrove conservation area is managed by the Jakarta Parks and City Forest Agency and covers approximately 51.18 ha.

Procedures

Sampling design

Sampling plots were determined using purposive sampling based on three vegetation cover density classes (high, medium, and low) derived from Normalized Difference Vegetation Index (NDVI) analysis. Each vegetation density class was represented by two independent sampling plots, resulting in a total of six sampling plots ($n = 2$ plots per density class). Satellite imagery was obtained from Google Earth and processed to generate NDVI values following the formula proposed by Danoedoro (1996):

$$\text{NDVI} = (\text{NIR} - \text{RED}) / (\text{NIR} + \text{RED})$$

Where, NIR represents the spectral reflectance value of the near-infrared band and RED represents the spectral reflectance value of the red band.

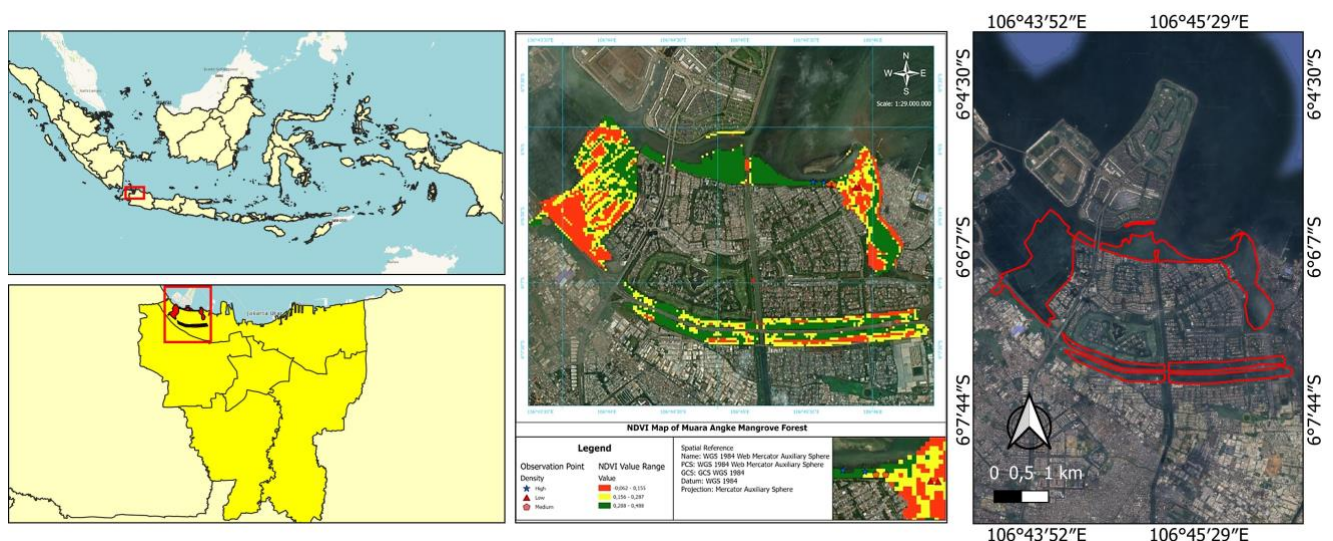


Figure 1. Location of Angke Kapuk Protected Forest, North Jakarta, Jakarta, Indonesia, showing the distribution of cover vegetation density classes (high, medium, low) and sampling plots used in this study

The resulting NDVI values were subsequently reclassified according to the Ministry of Forestry guidelines into three vegetation density classes: High (dense) = 0.36-1.00, Medium = 0.26-0.35, and Low (sparse) = -1.00-0.25 is based on the official national standards established by the Indonesian Ministry of Forestry (Regulation No. P.12/Menhut-II/2012). This regulation serves as a formal technical guideline for land cover and vegetation density analysis across various forest ecosystems in Indonesia, ensuring that the classification is consistent with national forest management protocols. A total of six sampling plots measuring 20 × 20 m were established, with two plots (n = 2) assigned to each vegetation density class (Figure 2). Although only six plots were used as independent experimental units (n = 2 per vegetation density class), sampling intensity within each plot was high, with 18 yellow pan traps deployed per plot (total = 108 traps). Trap-level data were pooled at the plot level prior to statistical analysis to avoid pseudoreplication.

Arthropods were sampled using yellow pan traps, light traps, and hand sampling within each 20 × 20 m plot, providing standardized sampling unit across all vegetation density classes. All sampling methods were applied simultaneously and with identical effort across plots to ensure comparability among vegetation density classes. Yellow pan traps were placed diagonally within each plot, light traps were operated overnight, and hand sampling was conducted systematically throughout the plot area. Arthropods were collected using three simultaneous and standardized sampling methods within each plot, with identical sampling effort applied across all plots to ensure comparability among vegetation density classes. Eighteen yellow pan traps per plot were deployed in a systematic arrangement to sample ground-dwelling and low-flying arthropods, while three light traps per plot were operated

overnight to capture nocturnal flying insects. In addition, manual hand sampling was conducted by two observers for 30 minutes per plot to collect arthropods not effectively captured by passive trapping methods. Sampling was carried out over a 48-hour period, with specimens retrieved at 24-hour intervals. All collected arthropods were preserved in 70% ethanol and transported to the laboratory for subsequent sorting, identification, and biomass analysis.

Environmental variable measurement

Environmental variables were measured at each sampling plot to characterize microclimatic conditions. Air temperature (°C, recorded to the nearest 0.1°C) and relative humidity (%) were recorded using a digital thermohygrometer (SASUMA HTC-2), while light intensity (lux) was measured using a portable lux meter (LUTRON LM-8000A). All instruments were placed beneath the canopy at the center of each plot to minimize direct solar exposure and to represent sub-canopy conditions. Measurements were conducted three times daily (morning, midday, and afternoon) over the sampling period. Mean values of each environmental variable were calculated for each plot and used in subsequent statistical analyses.

Arthropod identification

Arthropod specimens were sorted and identified to the morphospecies level for community analyses, while biomass and carbon stock estimations were conducted at the order level following Sohlström et al. (2018). Only intact adult specimens were used for body length measurements to ensure consistency in allometric calculations. Body length was measured using a digital caliper, and mean body length values for each order were applied in subsequent biomass estimations.

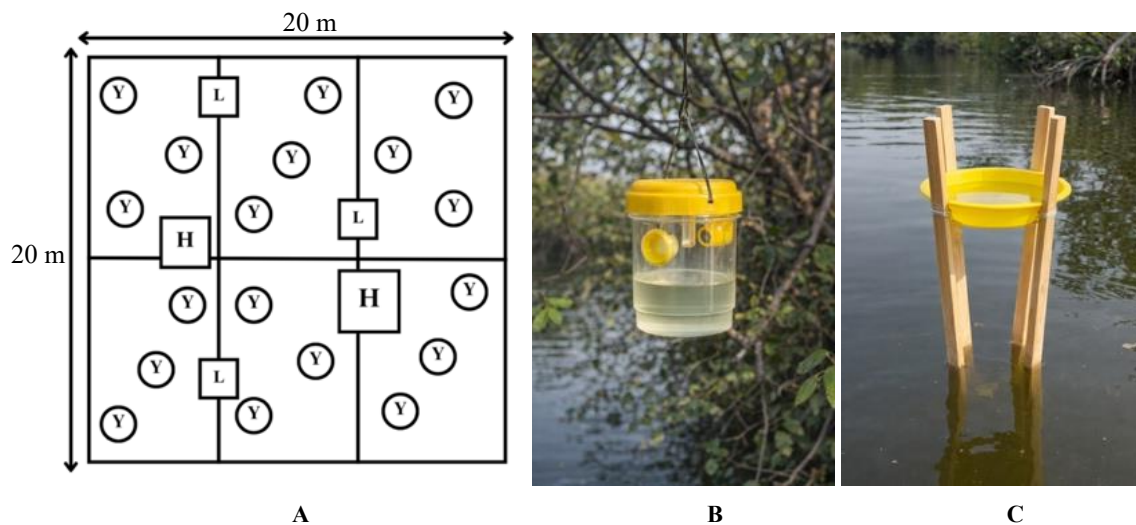


Figure 2. Arthropod sampling design and trapping equipment within the 20 × 20 m plot: A. schematic diagram showing the spatial arrangement of sampling points, B. light trap, and C. yellow pan trap used in the field (Y: yellow pan trap, L: light trap, H: hand sampling)

Biomass and carbon calculation for arthropod

Arthropod biomass was estimated using the allometric model proposed by Sohlström et al. (2018), which relates body length to body mass as follows:

$$\text{Log}_{10}(M) = a + b \times \text{log}_{10}(L)$$

Where, M is body mass (mg), L is body length (mm), and a and b are taxon-specific regression coefficients. Biomass was estimated using taxon-specific coefficients from Sohlström et al. (2018). For example, the coefficients applied for Diptera were $a = -0.973$ and $b = 2.271$, while for Araneae, $a = -0.696$ and $b = 2.301$. A dry mass fraction of 0.285 was applied as a justified constant based on previous studies by Sample et al. (1993) and Cressa (1999). Dry biomass was subsequently converted to carbon stock using a carbon fraction of 0.50 (Bar-On et al. 2018).

Data analysis

Arthropod abundance was expressed as the number of individuals per plot. Arthropod diversity was quantified using the Shannon-Wiener diversity index (H'), species richness using the Margalef index (R), and evenness using the Pielou index (E). Prior to inferential analyses, data normality was assessed using the Shapiro-Wilk test. The results indicated that the data met the assumption of normality ($p > 0.05$), supporting the use of parametric analyses.

One-way analysis of variance (ANOVA) was applied to explore differences in mean arthropod biomass and biomass-derived carbon stock among vegetation density classes (low, medium, and high). If the assumption of normality had not been met, a non-parametric alternative (Kruskal-Wallis test) would have been applied. When ANOVA results were significant ($p < 0.05$), Tukey's HSD test was used for post-hoc comparisons.

Pearson's correlation analysis was conducted to examine associations between arthropod carbon stock, arthropod abundance, and environmental variables. Pearson's correlation was applied following confirmation of data normality; otherwise, Spearman's rank correlation would have been considered as a non-parametric alternative. The level of statistical significance was set at $\alpha = 0.05$. Spatial mapping and NDVI analysis were conducted in QGIS (Quantum Geographic Information System), while statistical tests,

including ANOVA and Pearson correlation, were performed using R software (version 4.5.1).

RESULTS AND DISCUSSION

Arthropod order composition and ecological dominance across vegetation cover density classes

The general composition shows that there are clear quantitative differences between vegetation cover densities. The mean number of individuals increased from 236 in low-density stands to 367 in medium-density stands, and reached 683 in high-density stands. Diptera maintained their dominance in all vegetation classes; however, their populations experienced a substantial increase in high-density stands (206.5) and remained comparable in low (95.5 mean) and medium (93.5) density stands. The family Chironomidae was the primary driver of this trend, as their abundance increased from 69.5 (low) and 74.5 (medium) to 171.5 (high). The proportional increase in Hymenoptera was the most pronounced, with a mean of only 2.5 individuals in low-density stands, up to 47 in medium-density stands and 95.5 in high-density stands. In contrast, Araneae exhibited a more ambiguous response, increasing from 16 (low) to 40.5 (medium) but subsequently diminishing to 18.5 in high-density stands. Other orders, such as Hemiptera, Coleoptera, Orthoptera, and Thysanoptera, were present in relatively low numbers and had inconsistent trends across the density gradient (Table 1).

As indicated in Table 1, the increase in arthropod abundance with density implies that denser stands offer more abundant food resources and superior microhabitat availability. This discovery is consistent with the findings of Cavanaugh et al. (2013), who discovered a positive correlation between arthropod diversity and mangrove cover. The observed increase in arthropod abundance across the density gradient supports the premise that structural complexity in mangroves enhances niche availability and overall ecosystem productivity (Rizal 2018). He also associates mangrove ecosystems with enhanced productivity and biodiversity. Nevertheless, this ecological equilibrium is susceptible to the effects of anthropogenic pressures. Urbanization and habitat modification can disrupt arthropod populations by modifying environmental conditions, as demonstrated by Arini et al. (2022).

Table 1. Composition and abundance of arthropods communities across vegetation cover density classes in the mangrove ecosystem of Angke Kapuk Protected Forest

Order	Low		Mean	Medium		Mean	High		Mean
	1	2		1	2		1	2	
Araneae	19	13	16	61	20	40.5	13	24	18.5
Coleoptera		1	1		2	2		5	5
Diptera	116	75	95.5	89	98	93.5	127	286	206.5
Hemiptera	2		2		2	2	2	24	13
Hymenoptera	2	3	2.5	80	14	47	52	139	95.5
Orthoptera					1	1		11	11
Thysanoptera		5	5						
Total	278	194	236	460	274	367	388	978	683

The distribution of specific families was also evidently influenced by local environmental factors. The semi-aquatic family Notonectidae is a prominent example of this phenomenon, as it was exclusively observed in high-density plots (14 individuals were recorded). Their presence strongly implies that the dense vegetation in this region enhances soil moisture retention, thereby establishing specific hydrological niches. The location of the high-density plots along the shoreline, which encountered prolonged tidal flooding, further supports this observation. The distribution of arthropod habitats at a fine scale is influenced by the combination of vegetation structure and tidal proximity, as evidenced by the presence of Notonectidae.

The most acute response to vegetation density was exhibited by Hymenoptera. The total number of individuals increased from 5 in low-density stands to 94 in medium-density stands and 191 in high-density stands. The family Formicidae (ants)'s high prevalence in medium and high-density plots suggests a robust ability to exploit these intricate environments. Ant colonies and associated parasitoids are likely to be sustained by denser vegetation, which provides superior nesting locations, more stable microclimates, and consistent food supplies (Davids et al. 2024). Hymenoptera and other higher-trophic arthropods are able to thrive in the optimal conditions created by this increased vegetative complexity, which is known to promote mutualistic relationships and reduce predation pressure.

In all vegetation classes, the order Araneae (spiders) was present, albeit with a varying family composition, which included families such as Linyphiidae, Salticidae, and Tetragnathidae. Their total population increased from 32 individuals in low-density stands to 81 in medium-density stands, but it significantly decreased to 37 in high-density stands. This non-linear pattern implies that predatory species, such as spiders, may be influenced by the availability of suitable locations for web and nest construction, in addition to the density of vegetation. This hypothesis is consistent with the results of Haneda and Yuniar (2020), who found that a decrease in the number of ecologically important predatory arthropods is associated with a reduction in canopy cover. Eddy et al. (2017) have suggested that denser canopies may create more consistent microclimates, which could improve the efficacy of hunting and the survival of predators.

The distribution of arthropods families among the three vegetation cover density groups demonstrates a distinct variance in community organization. The Venn diagram reveals that eight families are present across all vegetation cover density classes low, medium, and high indicating arthropod groups with significant adaptation capability to microhabitat heterogeneity within the mangrove ecosystem (Figure 3).

As shown in the Venn diagram (Figure 3), eight families were consistently present across all strata, representing core community components with broad ecological tolerance. Conversely, families restricted to specific density classes indicate ecological specialization driven by unique microhabitat conditions, such as disparities in temperature, humidity, and light penetration (Wagner et al. 2021). While structural complexity typically fosters higher variety through

enhanced resource availability (Gobbi and Lencioni 2021), habitat homogeneity, resulting from either excessively sparse or extremely dense vegetation can diminish diversity by eliminating microhabitat variety (Debinski 2023; John et al. 2023).

In the Angke Kapuk Protected Forest, the presence of these essential families ensures ecological continuity, guaranteeing the persistence of processes such as decomposition and energy transport amid varying vegetation conditions. Within this community, Diptera emerged as the most dominant order across all density classes, with small-bodied taxa like Chironomidae being particularly widespread (Figure 4). This pattern is consistent with Haneda et al. (2023), who also reported Diptera as the prevailing group in this ecosystem. The broad distribution of Diptera likely reflects a robust tolerance to mangrove-specific stressors, including fluctuations in salinity and oxygen levels (Čerba and Hamerlík 2021).

Despite their numerical dominance, Diptera contributed less to carbon storage compared to larger-bodied arthropods. This pattern highlights a key distinction between carbon flux and carbon stock within the arthropod community: small detritivorous taxa primarily facilitate carbon cycling, whereas larger taxa, such as Araneae store proportionally more carbon due to greater body mass. Consequently, arthropod carbon storage in the Angke Kapuk Protected Forest appears to be governed more by body size distribution and allometric scaling than by abundance alone (Navarrete et al. 2023; Boix et al. 2024).

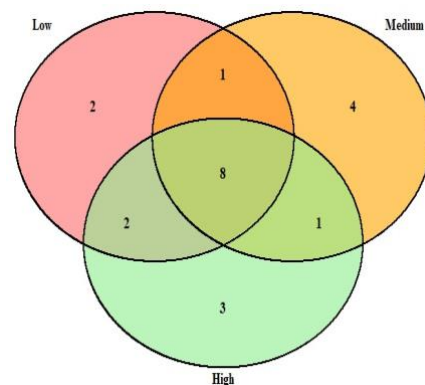


Figure 3. Venn diagram of arthropod family-level distribution across vegetation cover density classes. Values indicate the number of families recorded in each class

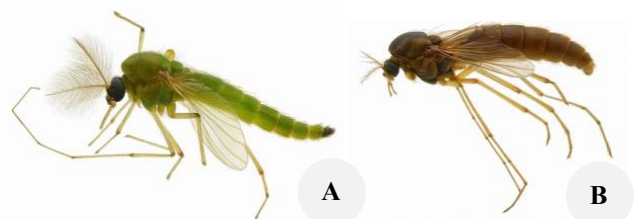


Figure 4. Adult Chironomidae (Diptera) collected from the Angke Kapuk mangrove forest. A. Male Chironomidae, and B. Female Chironomidae

Arthropod community structure and diversity

To elucidate how arthropod community structure responds to habitat change, we analyzed community composition using the Shannon-Wiener diversity (H'), Pielou's evenness (E), and Margalef's richness (R) indices (Table 2). These indices revealed a complex, non-linear relationship between vegetation density and community structure.

The Shannon diversity index (H') exhibited a clear unimodal pattern, peaking at the medium-density class ($H' = 1.83$) while showing lower values at both low ($H' = 1.50$) and high-density ($H' = 1.59$) (Figure 5). This finding strongly aligns with the Intermediate Complexity Hypothesis, which suggests that moderately complex environments often support the highest levels of biodiversity (Boudouresque et al. 2020). Such intermediate levels appear to provide a diversity of niches while potentially preventing the competitive exclusion that occur in more stable or dense systems.

This interpretation is further corroborated by Pielou's evenness index (E), which followed an identical unimodal trajectory. Evenness peaked in the medium-density class ($E = 0.71$) and was notably lower in both low ($E = 0.58$) and high-density ($E = 0.60$) classes. This decrease in evenness at high density, despite it having the highest total abundance (Figure 4), suggests community dominance by a few highly adapted families. This aligns with findings that moderate complexity levels enhance species equitability (Nishihiro et al. 2022; Hjältén et al. 2023), whereas overly homogeneous habitats often facilitate the dominance of a few successful species (Moir et al. 2011; Oliveira et al. 2020).

In contrast to the patterns for H' and E , Margalef's richness index (R) exhibited a clear negative linear trend to vegetation density. Family richness was highest in the low-density ('Jarang') class ($R = 2.20$) and declined consistently through the medium ($R = 2.03$) and high ($R = 1.99$) classes. This suggests that the more open stands may support a greater number of families by providing greater opportunities for opportunistic generalists to exploit spatially dispersed resources (Murugesan et al. 2018). These results highlight a significant ecological trade-off within the AKPF ecosystem. While the medium-density class appears to offer an optimal balance of microclimatic stability and niche variety yielding the most diverse and equitable community (H' and E) the low-density class supports the highest total family richness (R). This distinction is particularly critical in urban environments, where anthropogenic pressures often lead to habitat simplification (Nishihiro et al. 2022; Simpson et al. 2023). Consequently, preserving a mosaic of vegetation structures, rather than focusing solely on dense cover, is essential for sustaining multiple facets of arthropod diversity.

Arthropod biomass and carbon content across vegetation density classes

One-way ANOVA revealed no statistically significant differences in mean arthropod biomass or carbon stocks across the three density categories ($F = 0.209$, $p = 0.822$). As visualized in Figure 6, the intra-group variance within

each category substantially exceeded the variation between groups.

This non-significant outcome necessitates a cautious, exploratory interpretation. The primary constraint lies in limited statistical power due to the small sample size ($n = 6$), despite intensive within-plot sampling effort (18 yellow pan traps per plot; total 108 traps), which, in complex ecological systems, can obscure genuine treatment effects (Kondoh et al. 2020; Kim and Carrière 2022). Furthermore, the high internal variability observed where within group variance was nearly five times greater than between group variance suggests that small scale spatial heterogeneity plays a dominant role in these mangrove plots (Johnson-Bhola 2024).

Variations in micro-habitat characteristics, such as localized tidal gradients and salinity levels, likely exert a stronger influence on arthropod distribution than canopy density alone (Miranda et al. 2021; Hidayati et al. 2024). Additionally, the presence of specific plant species and varying degrees of localized anthropogenic disturbance may have introduced noise into the density-based classification (Gevaña et al. 2021). Consequently, while our findings do not provide statistical evidence of a density effect, they highlight the profound impact of micro-ecological patchiness on arthropod carbon reservoirs. It is important to note that the carbon quantified here represents standing biomass and should be distinguished from dynamic carbon fluxes mediated by community turnover.

Relationship between arthropods biomass and environmental conditions

The Pearson correlation analysis provides further insight into environmental variables associated with arthropod carbon distribution (Figure 7). A significant negative correlation was observed between arthropod carbon stocks and light intensity ($r = -0.84$, $p < 0.05$) suggesting that the shading provided by complex canopy structures creates a favorable environment for biomass accumulation. This is consistent with research indicating stable, shaded microclimates in mature mangrove stands reduce desiccation stress and support higher faunal productivity (Sun 2022; Lubchenco and Haugan 2023). This finding is consistent with Haneda and Yuniar (2020), who observed that canopy-mediated shading provides thermal refugia and enhances the stability of microclimates, which is essential for the biomass accumulation of larger arthropod guilds.

Table 2. Diversity indices of arthropods communities across vegetation density classes in the Angke Kapuk Mangrove Protected Forest

Vegetation density classes	Shannon-Wiener index (H')	Pielou index (E)	Margalef index (R)
Low	1.498	0.584	2.196
Medium	1.827	0.712	2.032
High	1.586	0.601	1.992

Note: Values represent mean index scores per plot at each vegetation density class

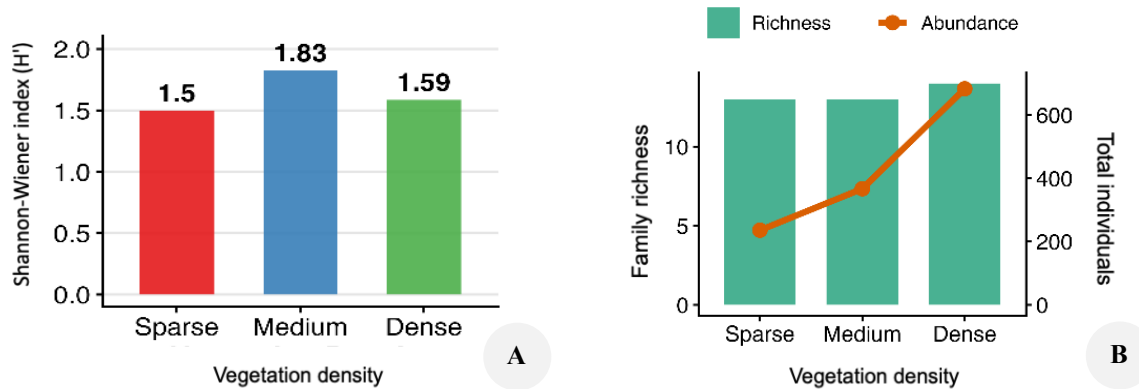


Figure 5. Insect community diversity. A. family richness, and B. total abundance across vegetation density classes in the mangrove ecosystem of Angke Kapuk Protected Forest

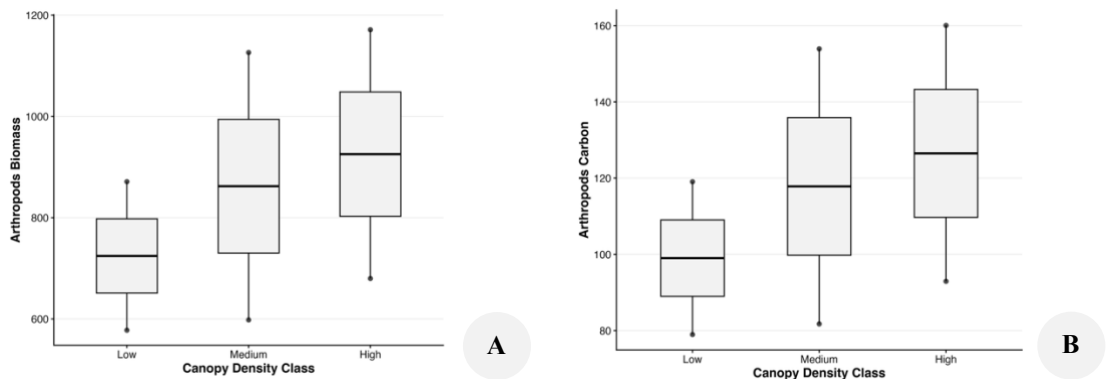


Figure 6. Comparison of arthropod biomass and carbon stock across cover density classes. A. Total arthropod biomass (g/m²) and B. total arthropod carbon stock (g C/m²). Boxes represent the interquartile range (IQR), the thick median line represents the median, and points represent individual data plots (n=2 per class)

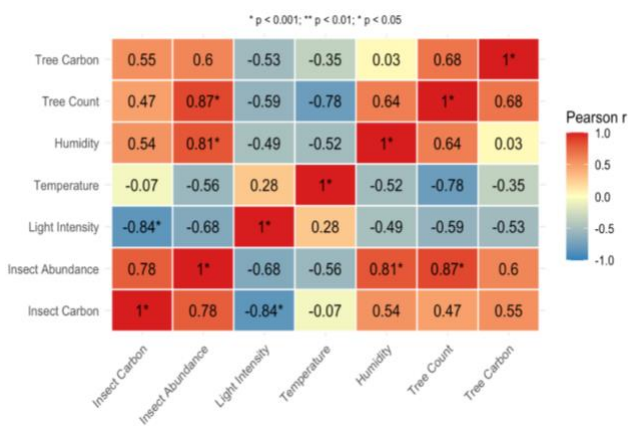


Figure 7. Pearson correlation matrix between arthropod carbon and environmental parameters in the mangrove ecosystem of Angke Kapuk Protected Forest

Interestingly, while arthropod abundance showed strong positive correlations with humidity ($r = 0.81, p < 0.05$) and tree count ($r = 0.87, p < 0.05$), these factors did not translate into statistically significant relationship with carbon stocks.

This discrepancy reinforces the functional distinction between numerical abundance and biomass reservoirs, while humid, high density stands support larger populations, the actual carbon storage is more closely tied to the presence of larger-bodied taxa favored by low-light and stable conditions. The lack of significance for other high ‘r’ values, such as the relationship between tree carbon and arthropod carbon ($r = 0.55$), may reflect limited statistical power associated with the small number of independent plots ($n = 6$) and should therefore be interpreted cautiously.

These findings imply that broad vegetation density categories may be too coarse to capture the drivers of arthropod carbon. Instead, specific micro-conditions, namely low light intensity and high humidity appear to be the primary facilitators of community structure and biomass. From a management perspective, this suggests that prioritizing canopy heterogeneity and microclimatic stability may be more effective for sustaining arthropod-mediated carbon pools in urban mangroves than focusing solely on increasing tree density. As one of the first quantitative assessments of arthropod-derived carbon in an Indonesian urban mangrove, this study highlights the need

for a refined perspective that accounts for both carbon flux and biological reservoirs in blue carbon dynamics.

In conclusion, this study demonstrates that arthropod community structure in the Angke Kapuk Protected Forest is significantly influenced by vegetation density, following a unimodal diversity pattern where medium-density stands provide optimal niche variety. Interestingly, our results reveal functional decoupling between numerical abundance and carbon storage; while high-density stands harbor the greatest abundance of small-bodied taxa, the peak carbon reservoirs are concentrated in medium-density areas favored by biomass-heavy guilds. Pearson correlation analysis identifies light intensity as the primary environmental driver, suggesting that shaded, stable microclimates are more critical for maintaining arthropod-mediated carbon stocks than vegetation density alone. Although this study is constrained by a limited sample size ($n = 6$), the findings provide a novel perspective on the role of terrestrial invertebrates in urban mangrove blue carbon dynamics. From a management standpoint, these results emphasize that preserving structural heterogeneity and microclimatic stability is essential for sustaining both biodiversity and ecosystem functionality in urban mangroves.

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