ARACHNID DIVERSITY AND COMMUNITY COMPOSITION AS INDICATORS OF LAND-USE CHANGE IN GHANA

TECHNICAL REPORT

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AUTHORS: *Harriet Kibvu Kinga[1], Debrah Kwame Daniel[2], Obed Owusu Adai[3], Jeffrey Gabriel Sumboh[4], Frederick Gyasi Damptey[5]*

[1]Brandenburg University of Technology, Department of Ecology. Cottbus-Senftenberg, Germany

[2]CSIR-Forest Research Institute of Ghana. Kumasi, Ghana

[3]Eco-care Ghana. Accra, Ghana

[4]Noguchi Memorial Institute for Medical Research. Accra, Ghana

[5]Forest Aid Ghana. Accra, Ghana

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SUMMARY

Ghana loses its forest resources at a rate higher than other countries in West Africa. With the limited conservation and restoration efforts being implemented, there is a need to monitor the progress to determine the success of restoration. Spiders are being introduced as an alternative to vegetation parameters for monitoring the progress of restoration trajectories in a forest under restoration, primary forest, agroforestry plantation and degraded area. Simultaneously, documentation of the spider diversity in these land-uses to provide a checklist of spiders. Spiders and other arachnids were sampled from three micro-habitats including; tree trunks, branches and soil using visual searching, beating and pitfall trap techniques respectively. A total of 2262 arachnid individuals were sampled from the pitfall traps and visual searching sampling methods which include Araneae (2099 spiders), Opiliones (68), Acari (71), Pseudoscorpiones (20), Schidomida (3), and Scorpiones (1). The spider composition of the four land-uses is highly diverse and though we recognized some families that can serve as indicators of habitat change and monitoring tools for restoration successes, further study is needed to bridge the gap between the individual spider groups to understand their ecological roles at the species level.

2. INTRODUCTION

Continuous degradation of Ghana's natural habitats through mining, agriculture, logging, and infrastructural development (Kwawuvi et al., 2021) threatens biodiversity (Boafo et al., 2019; Kyere-Boateng & Marek, 2021), including arachnid species (spiders, scorpions, and their kin) that provide vital ecosystem functions, although very little is still known about this fauna. Disturbed or fragmented forests are generally diminished in species diversity and fail to provide critical ecosystem services (Liebke et al., 2021). As top predators, spiders react sensitively to local changes in forest food webs and prey composition (Diehl et al., 2013; Nelson & Jackson, 2011); hence they are excellent indicators of overall biome health (Ramos et al., 2022). Unfortunately, the arachnid fauna of Western Africa is largely unexplored compared to other regions in the tropics, and limited data are available on the arachnids in this region (Harms, 2018). The sensitivity of spiders to ecological changes, like deforestation due to logging or mining (Potapov et al., 2020), threatens several species with extinction. Still, limited taxonomic knowledge of spider communities in Western Africa often prevents their use as bioindicators in conservation initiatives of individual species.

This study aimed to investigate changes in abundance, taxonomic and functional diversity of spiders in three major habitats of spiders in tropical forests: soil, shrub and tree trunks. Comparatively, analyze these changes across land-use to identify restoration trajectories using spiders as indicators for conservation effects on arthropod community composition in the study area.

3. METHODOLOGY

3.1 STUDY AREA

The study sites are located in the Upper Guinean forests of Ghana (Figure 1) which are amongst the most critically threatened forests in the world (30). Arachnid communities were sampled in the Tain II Forest Reserve referred to as a restored forest (RF), located in the Ahafo Region of Ghana. Most sections of the Tain II Forest Reserve were degraded by logging and frequent wildfire incidences. The company Form Ghana Ltd has reforested most areas of Tain II Forest reserves with indigenous and non-native tree species to provide ecological benefits and habitat restoration. In addition to the restored forest, a natural forest, agroforestry plantation and degraded area will be sampled. The Asukese Forest Reserve (natural forest (NF)) is located in the Moist Semi-Deciduous North-West Forest zone at latitude 7°8.469' N and longitude 2°31.107'W (Blay, Dominic, Francis K. Dwomoh, 2009), the agroforestry (AF) plantation located in the Bosomkese Forest Reserve at latitude 7°6.338'N and longitude 2°14.782'W within the semi-deciduous South-East Forest zone, and an open area close to the restored forest which after being logged in 2013, was affected by wildfires and other human activities that resulted in degradation, was sampled as succession treatments in the study. Sampling was carried out after access was negotiated with the Forestry Commission in Ghana and Form Ghana Ltd, and the necessary permits were obtained for fieldwork in these four land-use types.

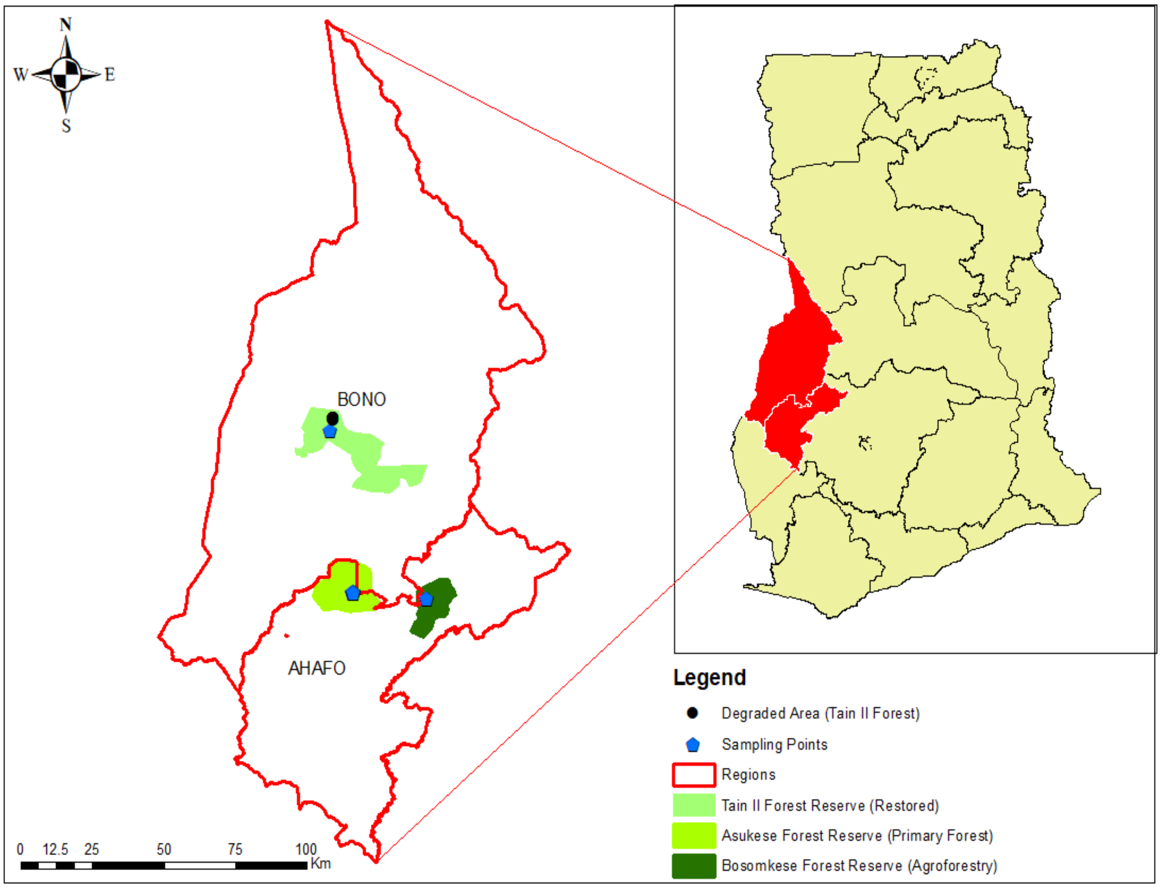

Fig 1: Map of Ghana showing the location of sampling sites

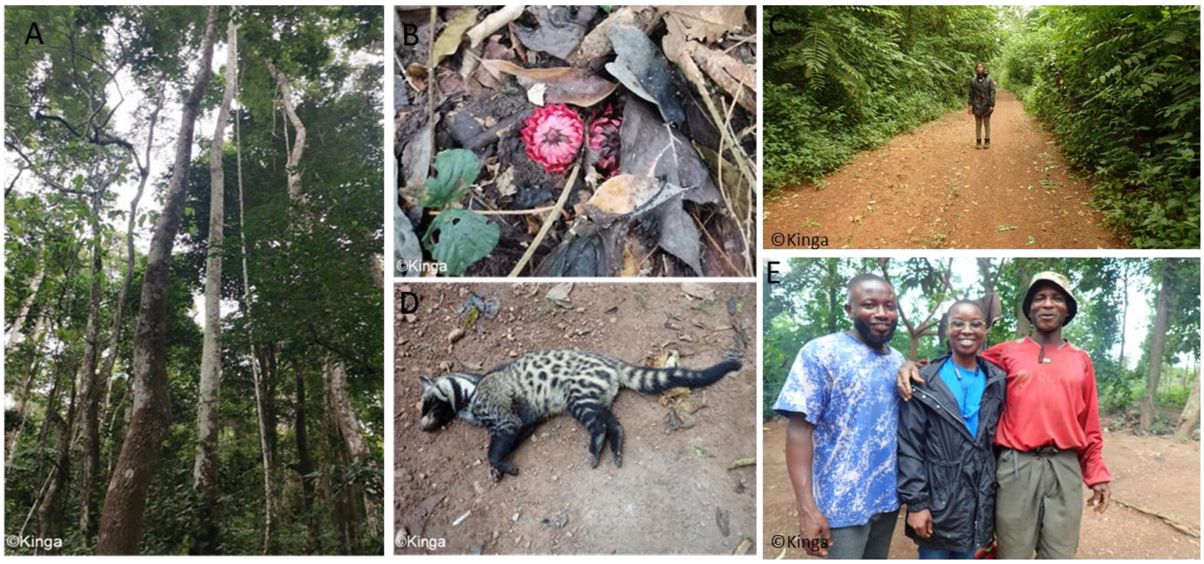

Fig 2: As seen in Asukese forest reserve. A: Current state of the primary forest, B: Thonningia sanguinea indigenous to West Africa, C: Main road through the forest. D: African Civet hunted from the primary forest. E: Forest guides from the primary forest.

Fig 3: Agroforestry plantation, Bosomkese forest reserve. A: On the way to sampling plots. B: current state of the agroforestry plantation. C: Forest guide, Student and plantation owner assisting in establishing sampling plots.

Fig 4: Restored forest in Tain II forest reserved. A: Current state of the restored area. B: Ant mount located on the restored plot. C: Forest guide and Form Ghana worker measuring vegetation parameters of trees.

Fig 4: Degraded area overrun by weeds and shrubs

3.1 Sampling Design and Methods

After surveying each land-use type, appropriate areas to be sampled were decided, followed by eight (8) plots of 20m x 20m in each site. Pitfall traps, beating, and visual searches were employed to sample spiders and other arachnids from the ground, shrubs and tree trunks. Each plot was subdivided into three (3) transects on which beating and visual searches were conducted during the day. Pitfall traps, beating, and visual searches were employed to sample spiders and other arachnids from the ground, shrubs and tree trunks with more emphasis made to sampling spiders and only sampling the other arachnid orders when seen or captured in the pitfalls and beating sheets.

I. Pitfall Trapping

Three traps per plot were set with 200ml propylene glycol solution for a duration of five days for four weeks. Pitfall traps were covered with roofs to prevent rainwater from diluting the preservative or flooding the traps and to prevent vertebrate bycatch or disturbance by large animals. The traps were evenly spaced along three transects within each quadrat to ensure reproducibility.

Fig 5: Pitfall traps adapted with roofs to prevent dilution of preservative and flooding by rain.

II. Beating

Beating was done on all four land-use types with each transect sampled during the first and third weeks of the sampling period, respectively. Beating was done on random branches and shrubs along three (3) 5m transects with ten branches per transect beaten three times on each subplot.

Fig 6: Beating branches and shrubs to dislodge spiders and other arthropods.

III. Visual Searching

Visual search was carried out during the second and fourth weeks of sampling, respectively. This included checking for spiders on webs, leaves, tree trunks and ground. The duration of visual search on each plot lasted 30 minutes with the timer paused when collecting samples into collection vials. Searching was done along three 5m transects on all subplots.

Fig 7: Visually searching spiders and other arachnids into a tube containing 95% ethanol using a pooter.

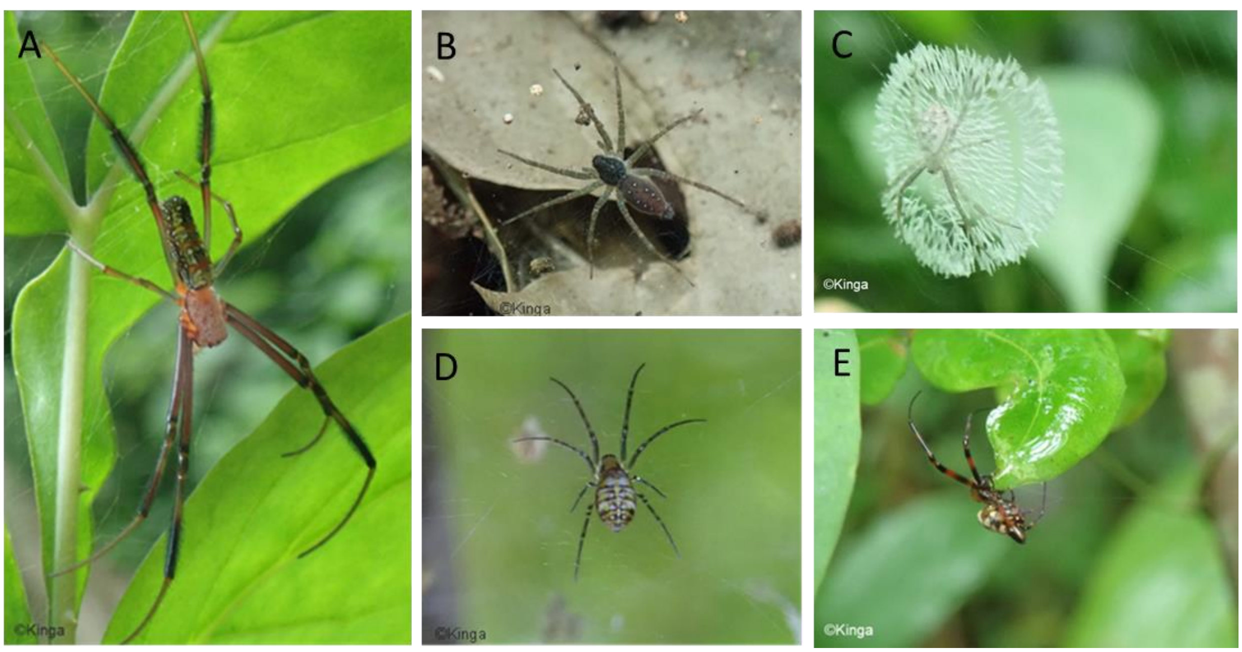

Fig 8: Some spiders caught on webs and leaves. A: Tetragnathidae, B: Agelenidae, C: Araneidae, D: Araneidae, E: Uloboridae.

3.2 Sample Identification

A total of 384 samples was collected from pitfall traps, 64 samples from visual searches and 64 samples from beating. Spider samples, including other sampled arachnids, were identified to order, and family, with ongoing further identification to genus and when possible, to species level using appropriate identification keys on African Spiders (Dippenaar-Shoeman and Jocque., 1997), and other relevant literature/keys from the World Spider Catalogue (online at https://wsc.nmbe.ch/), Les araignées de Belgique et de France (http://arachno.piwigo.com/), and araneae spiders of Europe (https://araneae.nmbe.ch/). Insect bycatch from the pitfall traps are being identified to order using appropriate identification keys.

Fig 9: A: Sorting of pitfall trapped samples, B: Identification of arachnids.

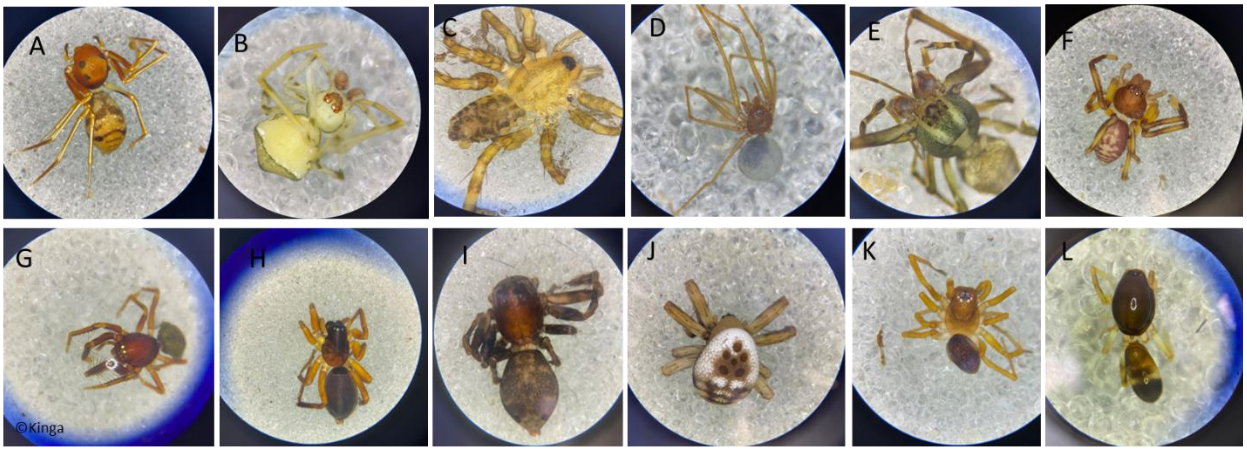

Fig 10: Some identified families of spiders A: Thomisidae, B: Theridiidae, C: Miturgidae, D: Tetrablemidae, E: Uloboridae, F: Clubionidae, G: Trachelidae, H: Coriniidae, I: Salticidae, J: Araneidae, K: Zodariidae, L: Oonopidae.

4. RESULTS

4.1 Arachnid Composition Across Sampling Location

A total of 2262 arachnid individuals were sampled from the pitfall traps and visual searching sampling methods (Table 1), which includes Araneae (2099 spiders), Opiliones (68), Acari (71), Pseudoscorpiones (20), Schidomida (3), and Scorpiones (1). Arachnids sampled from pitfall traps contributed to the highest activity density of the total sampled arachnids (1258).

Table 1: Activity density of arachnids sampled from the four land-use types with the three employed sampling methods of beating, Pitfall Trap, and visual searching. Showing Araneae, Opiliones and Acari as having the most activity density.

Sampling method	Araneae	Opiliones	Acari	Pseudoscorpiones	Schidomida	Scorpiones
Pitfall Trap	1253	52	69	15	3	1
Visual Search	846	16	2	5	0	0
Total	**2099**	**68**	**71**	**20**	**3**	**1**

4.2 Abundance of Spiders Across Land-use Types

Primary forest accounted for 37% of the total activity density of spiders (1184 spiders), while 25% was accounted for by the agroforestry plantation (794 spiders), 19% by the restored forest (607 spiders), and 18% by the degraded area (577 spiders) (Figure: 11).

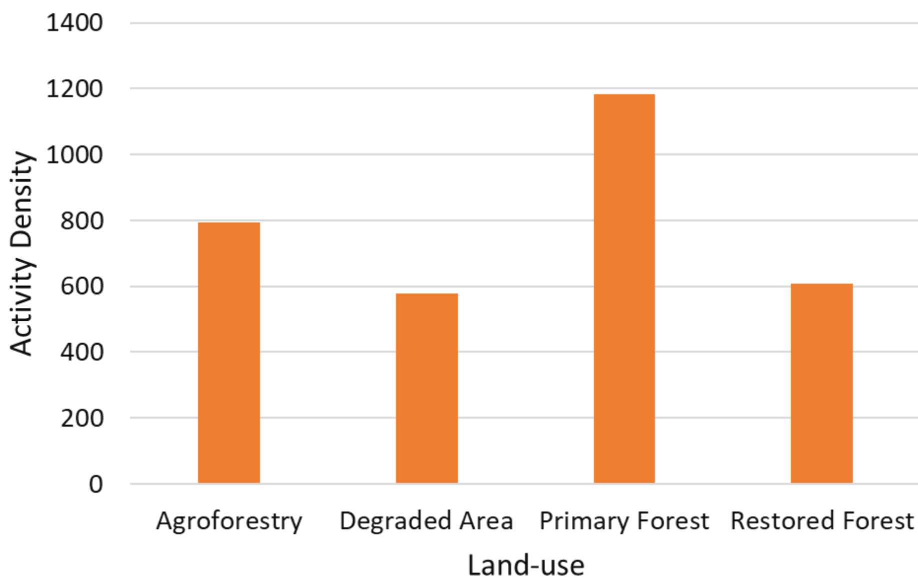

Fig 11: Bar plot of activity density across land-use types.

4.3 Family Composition of Spiders in the Various Land-use Types

In total, 35 families of spiders have been identified so far with pitfall sampling and visual searching from the four land-use types. These included two families from the order Mygalomorphae (Cyrtauchenidae, and Dipluridae), and thirty-three (33) from the order Araneomorphae (Figure: 12). Lycosidae, Zodariidae, Ctenidae, and Salticidae made up the majority of the Araneomorphae (Figure:13).

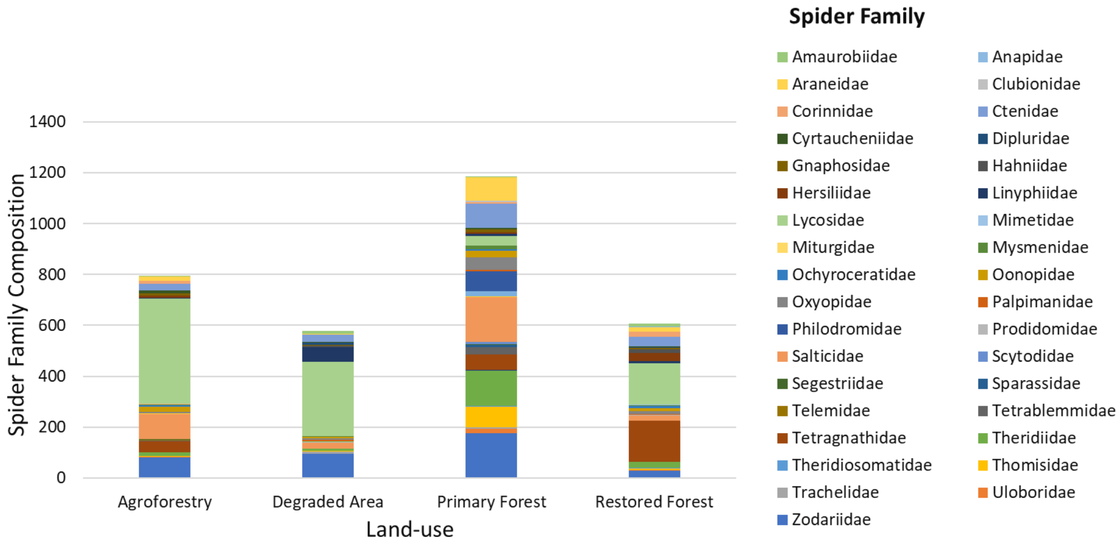

Fig 12: Bar Plot of spider family composition from pitfall sampling and visual searching across land-use types.

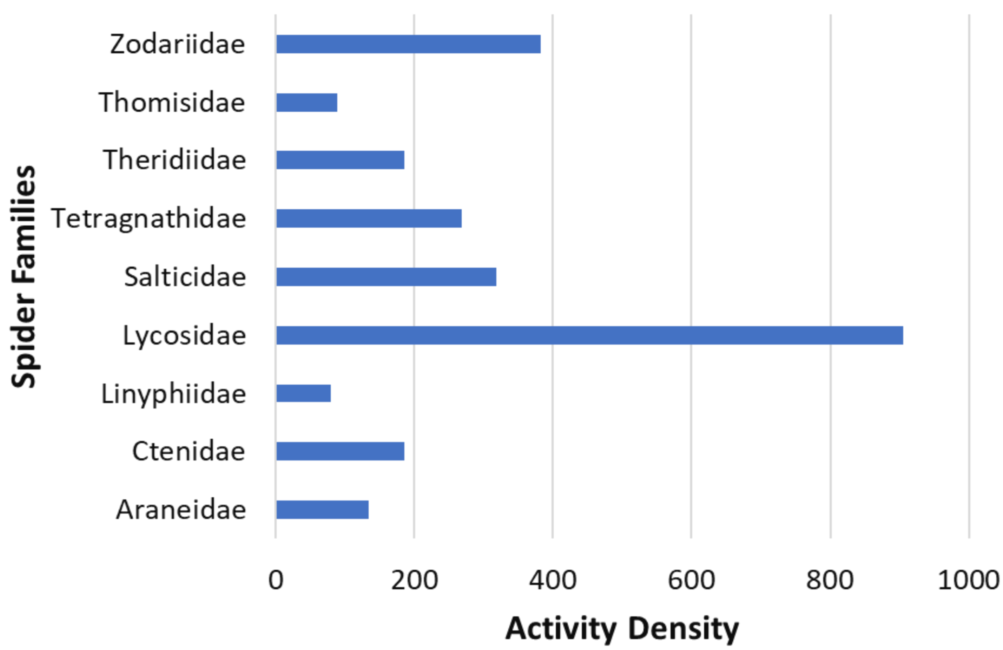

Fig 13: Bar plot of most abundant spider families across land-use.

4.4 Spider Family Composition Across Land-use Types

To determine the variation of spider family composition sampled with pitfall traps, a Bray Curtis similarity was done. A PCO plot was generated to visualize the variation across land-use types, considering the X-axis because it explained up to 26% of the total variation (Figure 14). The primary forest and degraded area had more spider families only found in their respective land-use types. The agroforestry plantation and restored forest had most of the spider families common to the two while also sharing some families with the primary forest and degraded area (Figure:14).

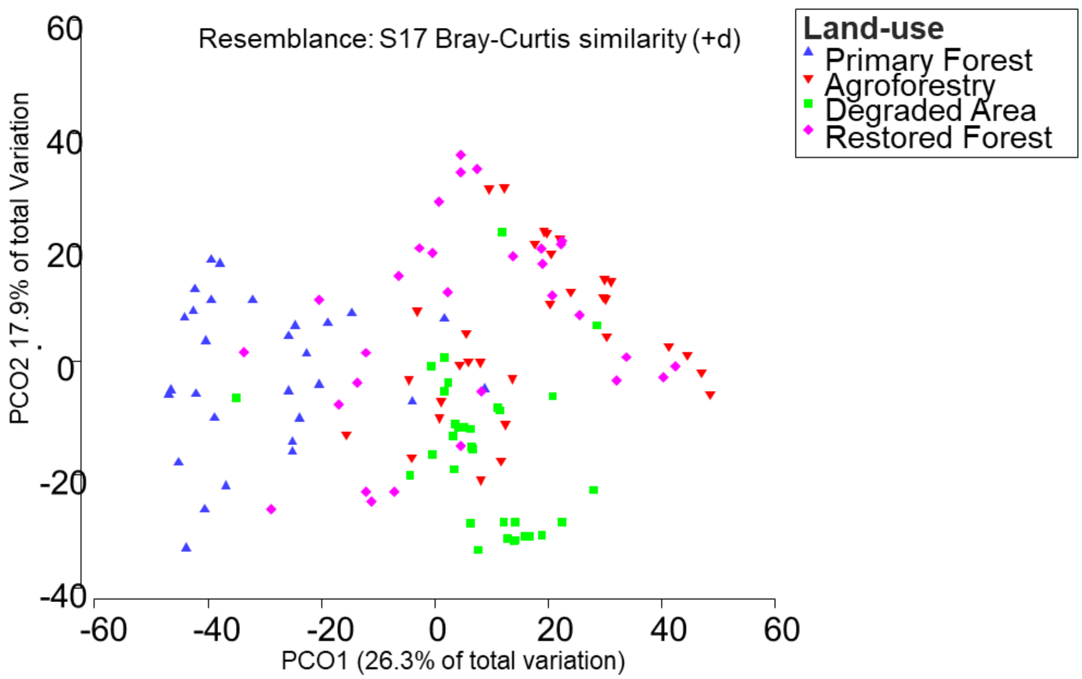

Fig 14: PCO plot of spiders sampled from pitfall showing similarity of spider family composition across land-use.

4.5 Activity Density of Other Sampled Arachnids

There was a low activity density of other arachnids sampled. Opilliones and Acari made up the most while Pseudoscorpiones and Schizomida were scarce and just one scorpion was sampled ().

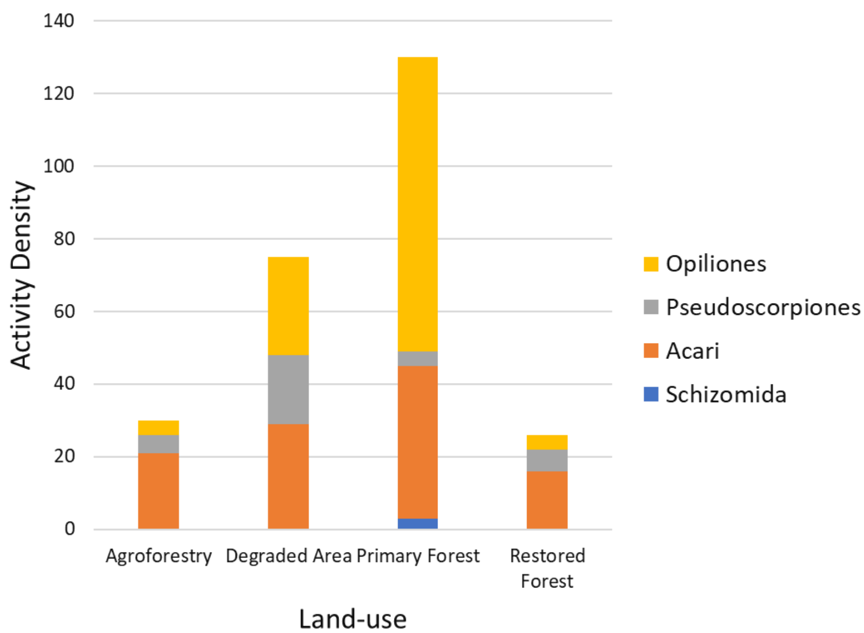

Fig 15: Bar plot of Opiliones, Pseudoscorpions, Acari and Schizomida activity density across land-use.

Fig 16: Other sampled arachnids; A: Acari, B: Pseudoscorpiones, C: Opilliones, D: Scorpiones, and E: Schizomida.

5. DISCUSSION

To assess the role of spiders and other arachnids as alternative tools for evaluating habitat health and restoration trajectory of logged and degraded forests as replacement of vegetation parameters, it is crucial to establish the composition of this taxon in the various land-use types. Land-use change from natural forest to alternative land-use systems has been associated with a high species loss and turnover in arachnid communities, with less than 20% of forest species being found in agricultural land-use types, irrespective of the collection method (Potapov et al., 2020). Canopy structure and tree diversity have previously been identified as determining factors of canopy spider communities (Ramos et al., 2022). Spider diversity is reduced in disturbed, isolated forest patches with more open canopies compared to the less disturbed regenerated forest. For example, orb-weaver (Araneidae) and crab spider (Thomisidae) richness were correlated to shrub canopy and ground herb cover, constituting vegetation complexity (Floren & Deeleman, 2005; Jiménez-Valverde & Lobo, 2007). Nocturnal hunters (Ctenidae) are associated with intact forests while wolf spiders (Lycosidae) are associated with disturbed forests and degraded land (Jocqué & Alderweireldt, 2005).

In this study, ground-dwelling spiders and web builders were used to establish the composition of four strata (tree trunk dwellers, lower branches spiders, ground spiders, and soil spiders), to identify indicator groups that can be suitable as monitoring tools for habitat health.

Sampling from the four land-use revealed a high activity density of spiders ranging from the primary forest, agroforestry plantation, restored forest, and degraded area. This reduction across habitat gradient can be explained by the decline in woody areas (Meyfroidt, P. and Lambin, 2011; Tscharntke et al., 2005, 2012), fluctuating resource availability(Eggenberger et al., 2019; Merckx et al., 2018), loss of environmental heterogeneity and reduced availability of microclimatic conditions(Martínez-Núñez et al., 2024) and can potentially influence functional filtering (Correa-Carmona et al., 2022). Functional filtering results in the loss of species less adapted to disturbed areas and an increase in species that have evolved to survive and thrive in areas that are affected by progressive degradation over time(Nyffeler & Birkhofer, 2017; Potapov et al., 2020). Spider composition differed in all the land-use types with wide variations observed in the primary forest and degraded area. This shows that landscape context can effectively shape spider communities in different land-use types (Tscharntke et al., 2005, 2012). This results in spider communities with vulnerability and environmental adaptation to better thrive in areas with fewer resources.

Ctenidae and Lycosidae were more abundant across land-use. These two families of spiders have a high capacity as indicator species due to their cryptic nature in the rainforest.

The variation in family composition of spiders increasing in the primary forest, to the restored forest, agroforestry, and degraded area, agreed with the expected trajectory of restoration where areas undergoing restoration are expected to increase their species composition to resemble that of primary forest status though not same. They are not only a higher species composition than agroforestry but less species composition of a primary forest. The restored forest was also seen to have a community composition intermediate between the primary forest and agroforestry implying it is progressively being restored to a primary forest state.

Due to the cryptic nature of psuedoscorpions, scorpions, opillionids, and schidomids, there are very few studies done to document the biodiversity of these arachnids from this region. Apart from some scorpion and mite species, most arachnids in Ghana are poorly studied and very limited literature is available to identify them.

6. CONCLUSION

Spiders and arachnids in general from Ghana and most West African countries have received very little attention to date despite their important role as bioindicators, pest controllers, and potential monitoring tools. This study has highlighted possible groups that can be used for habitat monitoring and assessment. This information coupled with the knowledge of other arthropods are major reasons to consider the conservation of existing natural habitats in Ghana such as forests that are being extensively exploited due to logging, mining, agriculture, and infrastructural development.

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