RAINFOREST VEGETATION TYPE: A LEVERAGE TO PANGOLIN HABITAT ENHANCEMENT IN DENG-DENG NATIONAL PARK, EASTERN REGION, CAMEROON

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Received June 2024; Accepted July 2024; Published August 2024;

DOI: https://doi.org/10.31407/ijees14.307

ABSTRACT

Rainforest vegetation type plays a critical role in providing suitable habitat and resources for pangolins, and understanding the relationship between rainforest vegetation and pangolin ecology is essential for conservation efforts. This study is aimed on assessing the influence of rainforest vegetation type on the enhancement of pangolin habitat within deng-deng national park. However, the research methodology involved conducting field surveys to collect data on pangolin distribution across different forest vegetation within the park. Also, habitat assessment was carried out to evaluate the structural characteristics, vegetation composition, and microhabitats available in each forest vegetation type. Data analysis techniques, included chi-square (X^2) and correlation statistical models were employed to identify association between forest vegetation type and pangolin ecology. The forest vegetation type demonstrated a significant association on wildlife species X^2=10.002 df=12 P<0.05, presence of human activity X^2=18.806 df=9 P=0.027, and forest vegetation canopy X^2=6.183 df=6 P<0.05 respectively. Forest vegetation types determine the composition and diversity of wildlife communities, including species that may interact with pangolins. The study also recorded liana-rich vegetation 38% and dense forest vegetation 32% as highest, while marshy forest 17% and open forest vegetation 13% as least respectively. The rainforest vegetation undergrowth recorded a significant correlation association on the vegetation type r=0.398 P=0.000. More so, the rainforest vegetation visibility showed a significant association on forest type X^2=6.552 df=11 P<0.05. Additionally, forest vegetation landscape and forest type showed a significant association r=0.240 P=0.038. The findings of this study contributes to our understanding of the importance of rainforest vegetation in shaping the sustainability of pangolin populations. Different forest vegetation types offer varying levels of resources, microhabitats, and ecological interactions that influence pangolin behavior and population dynamics. The implications of this study are crucial for pangolin conservation and management strategies. By identifying the forest vegetation types that support thriving pangolin populations, conservation efforts would focus on protecting and restoring these habitats. Finally, by integrating this knowledge into conservation plans and forest management practices, we would effectively safeguard pangolin populations and contribute to the overall biodiversity conservation in the national park.

Keywords: Rainforest vegetation, Pangolin ecology, Conservation efforts, Microhabitats

INTRODUCTION

Habitat heterogeneity, referring to the horizontal variation or patchiness in habitat physiognomy (August 1983), is of paramount importance for determining species habitat relationship. It is sometimes referred to as habitat diversity or habitat complexity, and considered an important mechanism influencing diversity patterns in spatially structured habitats (Tews et al. 2004). In spite of the importance of habitat to species, habitats around the globe and in Cameroon in particular are currently experiencing alterations and transformation (Alemagi and Kozak 2010, Ndoye 2000, Gartlan 1992) that in turn threatens the large mammal species that live in them. Maintaining habitat heterogeneity has been proposed as a means of conserving species diversity in habitats threatened by human activities (Cramer and Willig 2005). However, spatial heterogeneity is not static and can change along temporal scales, but any change in habitat composition or structure whether in small or large scale, slow or rapid, needs to be understood in order to advance actions that may lead to conservation. Increase in habitat heterogeneity is assumed will increase species diversity by providing more niches in a unit of space for new species to colonize (Augustus 1983). However, the extent to which habitat heterogeneity influences the diversity and abundance of large mammals and the understanding of how conservation of wildlife can be fully effected in heterogeneous environment remains less clear. Among deng-deng national park's diverse wildlife, pangolins, as the world's most trafficked mammal, stand out as a species of significant conservation concern. Understanding the factors that influence pangolin ecology and promoting their sustainable habitat enhancement is crucial for their long-term survival. One such factor that plays a pivotal role in shaping pangolin ecosystems is forest vegetation.
The term `habitat‟, refers to an ecological area or environment where plants, animals and other organisms live (Tagliapietra and Sigovin 2010, Krausman 1999, Hall et al. 1997, Block and Brennan 1993). Habitat as defined by Tews et al. (2004) is a vegetation formation. Various vegetation formations occur around the globe and even within small areas resulting to heterogeneity in landscapes. The heterogeneity of a landscape is viewed as an environmental mosaic or the horizontal arrangement of diverse vegetation formations in space within a landscape (Forman and Godron 1986, August 1983). Complex interactions among many factors including human activities and natural processes (e.g. climatic variation and variation in landscape topography) are responsible for heterogeneity of landscape at different scales (Colligne 2010, Turner 2005, Fischer et al. 2004). Forests are essential habitats for pangolins, providing them with shelter, food resources, and suitable microhabitats. Different forest types exhibit distinct structural characteristics, vegetation composition, and ecological dynamics, which can significantly influence the availability of resources and ecological interactions for pangolins. Therefore, investigating the relationship between forest type and pangolin ecology is fundamental for effective conservation and management strategies within deng-deng national park. The dynamic nature of natural landscapes has attracted a lot of interest with ecologists seeking to understand the importance of landscape dynamics and its associated significances on flora and fauna communities (Smith et al. 2011, McGarigal 2010, Schultz and Crone 2008, Fischer and Lindenmayer 2007, Turner 2005, Fischer et al. 2004, Tews et al. 2004, Fischer and Lindenmayer 2002, Kerr and Packer 1997). While efforts are being made, the term landscape itself is perceived from different perspectives and has remained a dilemma to natural resource managers. The diverse views on landscape have made it even more complicated for managers to establish reliable policies that could address all elements in a landscape. The definitions of landscape (Box 1) however, consistently include an area of land with mosaic of heterogeneous patches or landscape elements (McGarigal 2010, Turner et al. 2001, Dunning et al. 1992, Forman and Godron 1986). Landscapes occupy spatial scale (Dunning et al. 1992) and are also defined based on scale. Landscape scale ranging from a few kilometres to 300 km or any higher value has been suggested by Fischer and Lindenmayer (2007) and Forman and Godron (1986) but a landscape may be termed homogenous at one scale and heterogeneous at another (Biswas and Wagner 2012, Antwi 2009). Therefore, a clear definition of the landscape perspective under management is relevant to the understanding of the processes that occur within them. Box 1 presents some views of proponents, on the term „landscape‟. Furthermore, this study contributes to the broader field of biodiversity conservation by highlighting the significance of forest vegetation types in shaping the sustainability of pangolin habitat enhancement. It emphasized the need for comprehensive approaches that integrate ecological knowledge into conservation planning and forest management practices, ensuring the long-term viability of pangolins and the preservation of their unique ecosystems within deng-deng national park. By understanding the significance of forest vegetation type and incorporating this knowledge into conservation and management strategies, we would effectively protect pangolins and promote the overall biodiversity conservation within the park. Understanding which forest vegetation supports thriving pangolin

population distribution and offer optimal resources and microhabitats is crucial for targeted conservation efforts. The results would guide the development of effective management strategies, including habitat restoration, protection, and sustainable forest management practices that prioritize the ecological requirements of pangolins.

MATERIALS AND METHODS

Description of Study Area. The Deng Deng National Park is located in the East Region of Cameroon, precisely in the Lom-et-Djerem division (Fig. 1). The park covers an area of about 523 km and lies between latitude 13° 23 to 13° 34 East and longitude 05° 5 to 05° 25 North, in the North-Eastern part of the lower Guinean forest (Mercy, 2015). The Park is bounded by the Lom-Pangar River to the east, a segment of the Cameroon railway line and settlement (villages) to the west, by a continuous stretch of natural forest and savanna mosaic to the north and by roads and settlement to the south. Deng deng national park covers the least area among the protected areas in the east region, but one with high priority for conservation as it is situated within a zone where social and economic operations from logging, construction of petrol pipeline and hydroelectricity dam, are exerting enormous pressure on the landscape (Mercy, 2015). The biophysical environment of deng deng national park is described by its characteristics climate, relief, vegetation types and hydrology. Annual rainfall in the park ranged from 1500 mm to 1600 mm (COTCO 2011, GVC 2007). The park area features a typical equatorial and humid climate (Fotso et al. 2002) defined by the rainfall regime in this area. Seasonal pattern in the park area is characterized by distinct but unequal dry and wet season periods. Heavy wet season starts from August to November, a light wet season from April to June, a long dry season from December to March and a short dry season from July to mid-August. With a mean annual temperature of 23° C, annual minimum and maximum temperatures within the park area ranged from 15° C and 31° C (COTCO 2011, Fotso et al. 2002). The park consists largely of flat and gently undulating terrain. Elevation within the park varies from 100 m in the south to 920 m above sea level in the north.

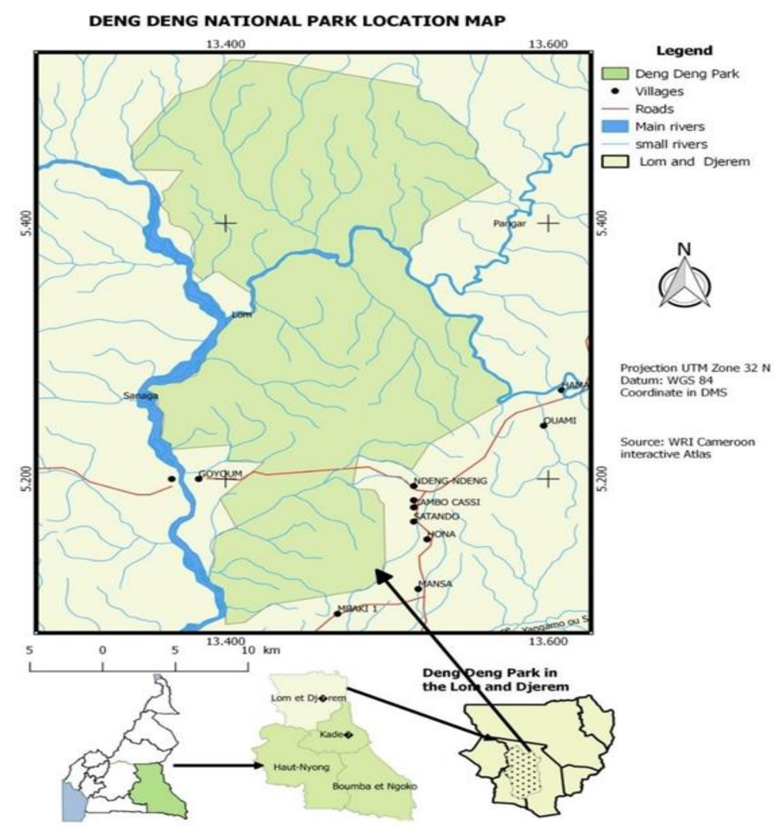

Figure 1. Map of Deng-deng National Park (Source: Mercy 2015).

Research Data Collection Method

Exploring the relationship between forest vegetation types and pangolin habitat enhancement in deng-deng national park, a comprehensive data collection method was employed. The research methodology involved a combination of field surveys, habitat assessments, and data analysis techniques. More so, field surveys were conducted to determine the presence of pangolins within different forest vegetation types. This involved systematic camera trapping, and direct observations of pangolins. During this process, pangolin signs such as trails, burrows, and feeding evidence were recorded. Additionally, forest vegetation types were classified based on their structural characteristics, vegetation composition, and dominant tree species. This was achieved through a combination of field measurements, canopy vegetation cover, landscape and some environmental variables like sunshine and rainfall were recorded as well.

Data Analysis Techniques

Statistical analyses, such as chi-square tests (X^2), and correlation (r) models were applied to examine the relationships between pangolin presence and different forest vegetation types. These analyses identified significant associations, and quantified the effects of forest vegetation type on pangolin populations.

RESULTS

The forest vegetation type demonstrated a significant association on wildlife species X^2=10.002 df=12 P<0.05 (fig.2), presence of human activity X^2=18.806 df=9 P=0.027(fig.3), and X^2=6.183 df=6 P<0.05 forest vegetation canopy (fig.4) respectively. Forest vegetation types determine the composition and diversity of wildlife communities, including species that may interact with pangolins. Different forest types support a variety of mammal, bird, reptile, and amphibian species that can have ecological relationships with pangolins. For example, certain bird species may engage in mutualistic interactions with pangolins by aiding in seed dispersal or providing early warning signals of potential threats. The presence of specific forest types shape the ecological dynamics and interactions between pangolins and other wildlife species. Furthermore, forest types vary in their accessibility and proximity to human settlements, infrastructure, and economic activities. Forests that are closer to human populations or have better accessibility are more likely to exhibit higher levels of human sign. For example, forest types near agricultural areas, roads, or urban centers may experience greater human presence, resulting in increased signs such as footpaths, clearings, or trash. Different forest types exhibit variations in vegetation composition, including the types of tree species present. Certain forest types may be dominated by specific tree species or plant communities that offer different resources to pangolins. For example, forests with a high abundance of ant or termite species preferred by pangolins as prey can provide a more suitable foraging environment. The presence of specific plant species also influences factors such as shelter availability, food resources, and nesting sites for pangolins.

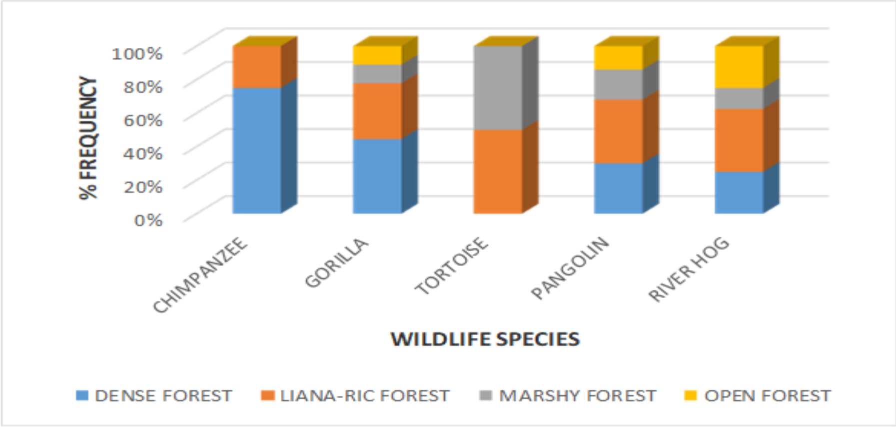

Figure 2. Forest vegetation types and wildlife species.

Understanding the relationship between forest vegetation types and wildlife species, including pangolins, is essential for designing effective conservation strategies. Conservation efforts should consider the specific habitat requirements of pangolins and the forest types that support their populations. Protecting and managing different forest types, including intact forests, secondary forests, and agroforestry systems, contribute to maintaining diverse and healthy wildlife communities, including pangolins. More so, forest type has a significant impact on the presence, distribution, and ecological dynamics of wildlife species, including pangolins. Conservation initiatives would need to consider the importance of different forest types in supporting pangolin populations and prioritize the protection and sustainable management of these habitats. Forest type plays a significant role in shaping the wildlife species found in the pangolin environment. Different forest types have distinct characteristics, including vegetation composition, structure, and ecological processes, which influence the diversity and abundance of wildlife species, including pangolins.

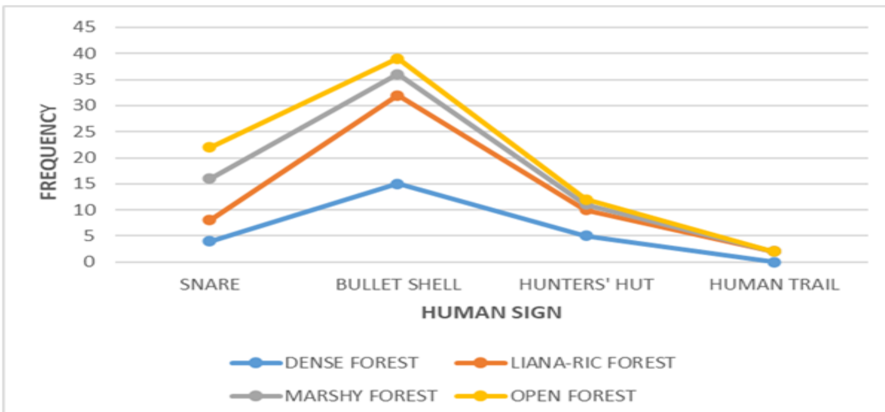

Figure 3. Forest vegetation type and signs of human activity.

The presence of human sign in the pangolin ecosystem is also influenced by conservation efforts and protected areas. Forest types that are designated as protected areas or managed for conservation purposes may exhibit signs of human activities related to conservation efforts, such as ranger patrols, research stations, or ecotourism infrastructure. Understanding the role of forest types in human sign is crucial for assessing and managing the impacts of human activities on pangolin populations and their habitats. Conservation strategies should take into account the specific forest types that are more vulnerable to human disturbances and prioritize efforts to mitigate negative impacts, such as through effective law enforcement, community engagement, and sustainable land-use practices.

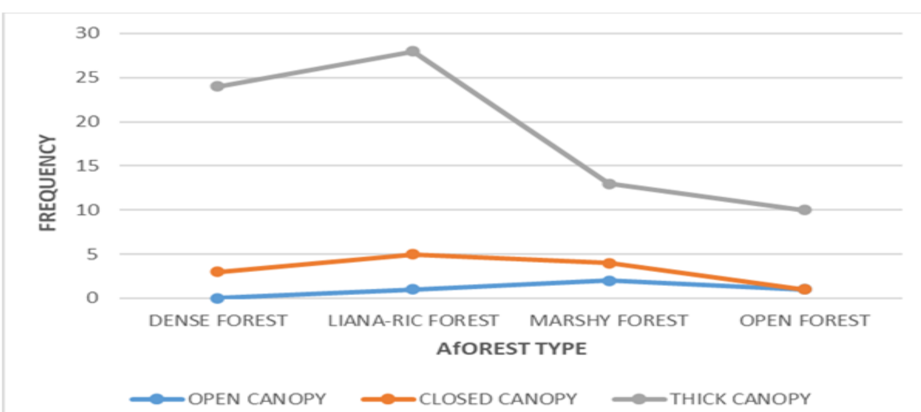

Figure 4. Forest vegetation type and vegetation canopy structure.

Conserving a range of forest types is essential for maintaining a diverse and suitable vegetation canopy for pangolins. Protecting intact forests, promoting forest restoration efforts, and implementing sustainable land-use practices are crucial for preserving the complex vegetation structure and composition that support pangolin populations. Effective conservation strategies should consider the specific habitat requirements of pangolins and the role of different forest types in providing the necessary resources for their survival and well-being. Forest types vary in terms of canopy height and density. Some forest types, such as mature or old-growth forests, tend to have tall trees with a dense canopy cover, creating a more closed and shaded environment. Other forest types, such as secondary forests or open woodlands, may have a shorter canopy height and a more open canopy structure. These variations in canopy height and density influence the amount of sunlight reaching the forest floor, which in turn affects the understory vegetation and microhabitats available to pangolins.

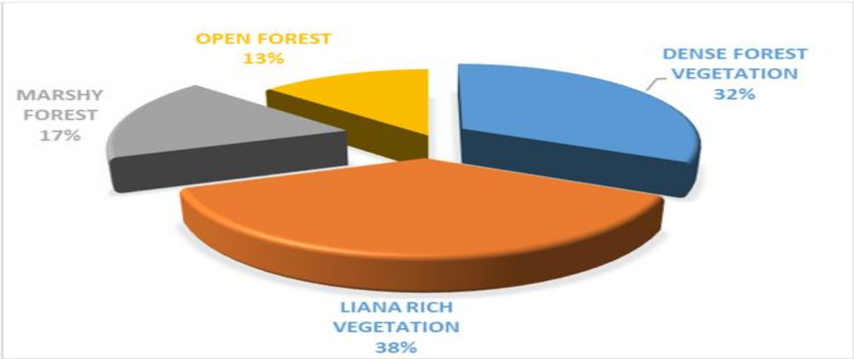

Figure 5. Rainforest vegetation type

The study recorded liana-rich vegetation 38% and dense forest vegetation 32% as highest, while marshy forest 17% and open forest vegetation 13% as least (fig.5) respectively. Rainforest vegetation type influences the level of human disturbance and the conservation status of pangolin populations. Certain forest vegetation types may be more susceptible to anthropogenic activities such as deforestation, habitat fragmentation, or illegal wildlife trade. For instance, tropical rainforests are often subject to high levels of deforestation and habitat loss due to agriculture, logging, or infrastructure development. The loss and degradation of these forest types can have severe consequences for pangolins, leading to habitat fragmentation, decreased food availability, and increased vulnerability to poaching. Understanding the specific threats and conservation needs associated with different forest types is essential for effective pangolin conservation efforts. Different forest types have varying vegetation compositions, which directly influence the availability of food resources for pangolins. Pangolins primarily feed on ants and termites, but the abundance and diversity of these prey species can vary depending on the forest type. For example, tropical rainforests often have high species diversity and support a wide range of ant and termite species, providing abundant food sources for pangolins. In contrast, other forest types, such as savannas or dry forests, may have different ant and termite communities, affecting the availability of suitable prey for pangolins.

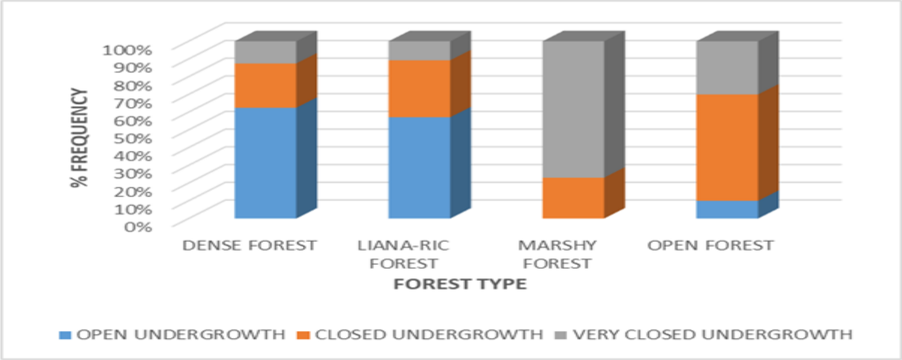

Figure 6. Rainforest undergrowth and forest vegetation type.

The rainforest vegetation undergrowth recorded a significant correlation association on the vegetation type r=0.398 P=0.000 (fig.6). Different forest types exhibit variations in the composition of undergrowth vegetation. The types of tree species present, as well as the presence of specific shrubs, herbs, ferns, and grasses, contribute to the diversity and structure of the undergrowth. Forest types with a higher diversity of plant species often support a more diverse undergrowth community, providing varied food resources, shelter, and microhabitats for pangolins and other wildlife. Forest types influence the availability of microhabitats within the undergrowth vegetation. Microhabitats include features like fallen logs, leaf litter, dense vegetation patches, and rock crevices that provide important resources for pangolins, such as nesting sites, shelter, and foraging opportunities. Forest types with a diverse and complex undergrowth structure offer a greater variety of microhabitats, enhancing the habitat suitability for pangolins. Conserving a range of forest types is crucial for maintaining a diverse and suitable undergrowth vegetation for pangolins. Protecting intact forests, promoting forest restoration efforts, and implementing sustainable land-use practices are essential for preserving the complex undergrowth structure and composition that support pangolin populations. Effective conservation strategies should consider the specific habitat requirements of pangolins and the role of different forest types in providing the necessary resources for their survival and well-being.

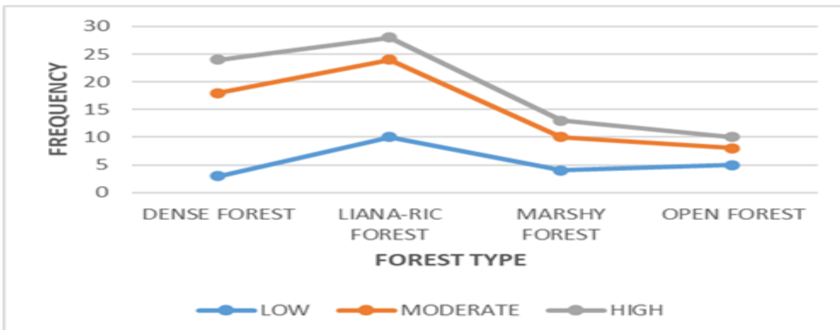

Figure7. Forest vegetation visibility and forest type.

The rainforest vegetation visibility showed a significant association on forest type X^2=6.552 df=11 P<0.05 (fig. 7). Forest types vary in terms of canopy density, which affects the amount of sunlight that reaches the forest floor and the degree of shade present. Forests with a dense canopy, such as mature or old-growth forests, tend to have limited visibility due to the reduced penetration of sunlight and the presence of a thick overhead canopy. This can create a darker and more visually obstructed environment. In contrast, forest types with a more open canopy structure, such as secondary forests or woodlands, allow more sunlight to reach the forest floor, resulting in better visibility. It's important to note that pangolins are adapted to forest environments with varying levels of visibility. Some pangolin species have adapted to low-visibility environments by relying on their other senses, such as their acute sense of smell and hearing, to navigate and locate food. Conservation efforts should consider the specific habitat requirements of pangolins, including the visibility conditions of different forest types, to ensure the preservation of suitable habitats for these unique creatures.

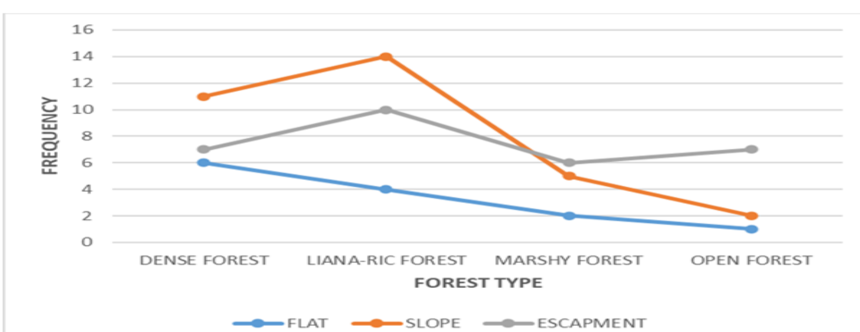

Figure 8. Rainforest landscape and forest vegetation type.

The forest vegetation landscape and forest type showed a significant association r=0.240 P=0.038 (fig.8). Forest types can be associated with specific topographic features, such as hills, valleys, slopes, or flat terrain. The topography of the forest landscape influences factors such as water drainage, soil characteristics, and microhabitats. Forests situated on steep slopes or in mountainous regions may exhibit a more rugged and undulating landscape, while forests in flat areas may have a more uniform and level landscape. These variations in topography contribute to the spatial heterogeneity of the forest ecosystem. Understanding the role of forest type in shaping the forest landscape is essential for effective conservation and management of pangolin habitats. Conservation strategies should consider the specific landscape characteristics of different forest types, including the connectivity of habitat patches, spatial arrangement of resources, and the preservation of key landscape features. Maintaining a diverse range of forest types and managing their spatial configuration is important for supporting pangolin populations and promoting overall ecosystem health.

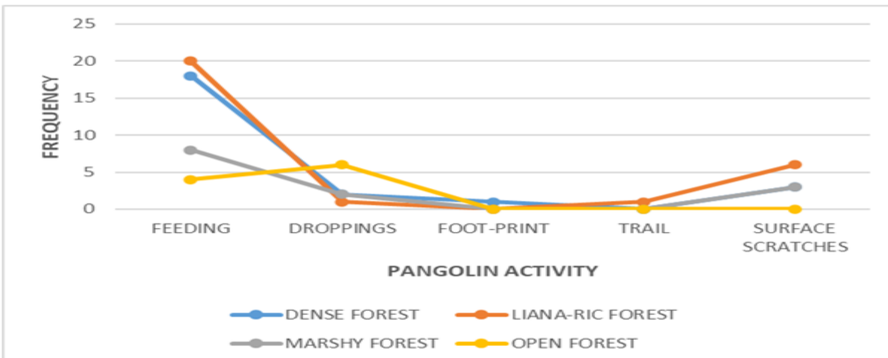

Figure 10. The significance of pangolin activity and vegetation type.

Pangolin-activity significance showed an association on vegetation type X^2=24.996 Df12 P=0.015 (fig.10). The density and composition of vegetation in different forest types can impact the visibility of pangolin signs. Forests with a dense canopy and understory vegetation may make it more difficult to spot pangolin tracks or burrows on the forest floor. On the other hand, forest types with sparse vegetation or open areas, such as grasslands or savannas, may offer better visibility and make it easier to identify signs of pangolin activity. Forest types that exhibit greater habitat heterogeneity, including variations in vegetation structure, tree composition, and microhabitats, may support a wider range of pangolin signs. Such habitat diversity can create a mosaic of different ecological niches within the forest, providing opportunities for pangolins to engage in various activities and leave behind different types of signs. Some pangolin species are arboreal and may utilize trees for shelter, nesting, or foraging. The presence of specific tree species preferred by pangolins can influence the occurrence and visibility of pangolin signs. Forest types with abundant food sources or suitable tree species for pangolins may exhibit signs such as feeding marks on tree trunks, disturbed foliage, or nests. Observing these signs can provide insights into the presence and activity of pangolins.

Discussion

Cameroon is well-known for its rich biodiversity and encompasses unique and diverse flora, fauna and ecosystems (GFW 2000, Fomete and Tchanou 1998, Cheek et al. 1996, MINEF 1995, Vivien 1991). These rich biodiversity is unfortunately experiencing pressures from national socio-economic development actions and mainly from the country's ever increasing and dynamic human population that have continued to penetrate natural and remote ecosystems to satisfy social and economic needs, thereby threatening biodiversity. Forest degradation, habitat fragmentation, habitat loss and overexploitation of wildlife through hunting are some of the consequences (GFW 2000). Forest fragmentation, which involves the division of continuous forest areas into smaller patches, can have significant implications for pangolins. Fragmented landscapes with increased edge-to-interior ratios can expose pangolins to edge effects, including increased human disturbance, predation risks, and changes in microclimate. Moreover, the fragmentation of forested areas can disrupt movement corridors, hindering the natural dispersal and gene flow of pangolin populations. Maintaining landscape connectivity through the conservation and creation of forest corridors is crucial for maintaining the long-term viability of pangolin populations. More so, different forest types exhibited varying degrees of suitability for pangolins, based on their structural characteristics, vegetation composition, and microhabitat availability.

Nonetheless, diverse land use and fragmentation from illegal hunting, Grazing, agricultural extension, gathering for subsistence and complete conversion of areas to meet settlement and other developmental needs, such as railway, oil pipeline and hydroelectricity dam construction are evident in the Deng Deng National Park even though it is a category II protected area that prohibits consumptive use of resources. Environmental Impact Assessments (EIA) conducted for the construction of a portion of the Chad-Cameroon oil pipeline crossing through the park (Poncelet et al. 2011, Dames and Moore 1999) and a hydroelectricity dam, i.e. Lom-Pangar Dam (COTCO 2011, IR and GVC 2005, WB 2005), adjacent the park did marginalize important habitats and wildlife in this area. Large area constituting habitat for flora and fauna in and adjacent this park has been clear-cut, dug up and flooded for the realization of these projects. Other contrary uses that followed these major projects has been the clearing and opening of large forest tracks for the construction of roads to facilitate transportation of project equipment and the construction of settlement camps for workers at the detriment of biodiversity. The forest landscape provides the primary habitat for pangolins, particularly in tropical and subtropical regions. The presence of suitable forested areas, including both primary and secondary forests, is essential for the survival and well-being of pangolins.

The selection and use of habitat by individual animal species in a heterogeneous landscape is influenced by several interacting factors including the provision of adequate habitat requirement such as shelter, cover, nesting site, and foraging grounds (Kruasman 1999, Litvaitis et al. 1994), and the special social systems, and dispersal patterns of animals (Yackulic et al. 2011). Altering landscapes and habitats therefore may influence the persistence of species in a given habitat and may affect the supply of basic requirements for species the lack of which may lead to species decline, isolation or extirpation (Yackulic et al. 2011, Bennett and Saunders 2010, Kadmon and Allouche 2007).

Species however, vary in their tolerance for different habitat types, and for exogenous , endogenous and stochastic factors defining habitats and species (Fischer and Lindenmayer 2007, Morrison et al. 2006). While some species show preference reflected by their presence, high abundances and continuous distribution patterns, others are restricted in their distribution and may rather decline or become locally extirpated or extinct (Bennett and Saunders 2010, Fischer and Lindenmayer 2007, Freckleton et al. 2005). However, forest succession, the process by which forests undergo change and development over time, can influence the pangolin environment. Different successional stages within the forest landscape provide varied microhabitats and resource availability. Pangolins may exhibit preferences for certain successional stages, depending on factors such as vegetation structure, prey availability, and nesting opportunities. Maintaining a mix of early successional and mature forest habitats within the landscape can support a range of ecological requirements for pangolins.

Trends in wildlife population has followed changes associated with human interventions such as expanding urbanization (McKinney 2002), extraction from logging (Struhsaker 1997), land conversion to agriculture (Gordon 2009, Bulte and Horan 2003) and hunting of species (Corlett 2007, Willcox and Nambu 2007). Typically human interference on wildlife habitats and the exploitation of wildlife species has rendered large mammal species vulnerable (Erb et al. 2012, Brashares et al. 2004, Milner-Gulland and Bennett 2003, Auzel and Wilkie 2000). Effective forest conservation and management practices are vital for maintaining suitable pangolin environments. Protected areas, national parks, and forest reserves play a critical role in safeguarding large intact forest landscapes that provide essential habitats for pangolins. Sustainable forest management practices that consider the ecological needs of pangolins, such as regulating logging, minimizing habitat fragmentation, and promoting forest regeneration, are crucial for their long-term survival.

CONCLUSION

The study demonstrates the significance of maintaining diverse forest habitats and specific microhabitats within the national park to promote the long-term survival and ecological success of pangolins. Also, the identification of preferred rainforest vegetation types and key microhabitats has important implications for pangolin conservation and management strategies. Protecting and restoring these forest vegetation types would create suitable habitats and ensure the availability of resources necessary for pangolin populations to thrive. More so, pangolins exhibited preferences for rainforest vegetation types characterized by dense canopy cover, greater tree diversity, and an abundance of microhabitats such as fallen logs and termite mounds. These forest vegetation types provided optimal conditions, including suitable prey species and shelter, contributing to the enhanced ecological success of pangolins. Maintaining diverse forest habitats is crucial for supporting thriving pangolin populations. Additionally, sustainable forest management practices that consider the ecological requirements of pangolins, such as selective logging and the creation of artificial microhabitats, should be integrated into conservation plans. Furthermore, by incorporating ecological knowledge into conservation planning, practitioners would make informed decisions regarding protected area design, habitat restoration, and land-use planning. This holistic approach to pangolin conservation ensures the preservation of their unique ecosystems while contributing to broader biodiversity conservation goals within deng-deng national park. By integrating these findings into conservation strategies and sustainable forest management practices, we would effectively protect pangolins and contribute to the preservation of biodiversity within the park. Continued research and monitoring efforts are essential to further our understanding of the complex interactions between pangolins, forest vegetation types, and other environmental factors, ensuring the long-term viability of pangolin populations in the region.

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