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RESEARCH ARTICLE

CONSERVATION STATUS OF ENDANGERED WILDLIFE: THE CASE OF THE PANGOLIN IN A COMMUNITY FOREST AND TWO CLASSIFIED FORESTS IN THE TONKPI REGION, WESTERN CÔTE D'IVOIRE

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Abstract

Wildlife is an essential component of global biodiversity. Among the animal species most threatened with extinction is the pangolin. This insectivorous mammal belongs to the order Pholidota. It is considered the most illegally trafficked mammal in the world due to the growing demand for its meat and scales. This study aims to assess the conservation status of the pangolin in three forests in western Côte d'Ivoire, in order to better understand its distribution, preferred habitats, and the threats facing this animal species. Ethnozological surveys and reconnaissance walks (RECCE) were conducted to inventory pangolin species in the field. This study was carried out in four habitat types: humid dense forests, mountain dense forests, dry dense forests, and anthropogenically modified forests. The pangolin species identified during this study were Phataginus tetradactyla and Phataginus tricuspis. Pangolin species could be detected directly or indirectly. Direct observations included any visual contact with the animals during our fieldwork. Indirect observations encompassed all indirect indicators that could definitively confirm the presence of pangolins at the study site. During the study, 89 pangolin signs were recorded, including 66 (74.16%) signs of Phataginus tricuspis and 23 (25.84%) signs of Phataginus tetradactyla. These two pangolin species have essentially the same distribution ranges. They are generally observed in forest habitats,particularly in mountainous areas.The sustainable conservation of these mammals in western Côte d'Ivoire is threatened by human activities, including agriculture, hunting, logging, and bushfires.

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Introduction:-

Wildlife is an essential component of global biodiversity. It plays a fundamental role in maintaining the ecological balance of forest ecosystems (Archer et al., 2021). This biodiversity is currentlyexperiencing an unprecedented crisis, marked by an alarming rate of animal species extinction, largelyattributable to human activities (Heinrich et al., 2017; Kouassi et al., 2023). Among the most threatened animal species is the pangolin. This insectivorous mammal belongs to the order Pholidota (Gaubert et al., 2016). It is considered the most illegallytrafficked mammal in the world due to the growingdemand for its meat and scales(Challender et al., 2015; Heinrich et al., 2017).Itsscales are used in some traditional Asian and African pharmacopoeias(Zanvo et al., 2021). The pangolin is listed in the appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Challender & Waterman, 2017) and classified as Vulnerable, Endangered, or Critically Endangered on the IUCN Red List of Threatened Species. In sub-Saharan Africa, and more specifically in Côte d'Ivoire, the pressure exerted on forest ecosystems by extensive agriculture, logging, and poaching directlythreatens the pangolin's natural habitats (Sidibé et al., 2020).

Although the COVID-19 pandemicin 2020 caused a temporary disruption to urban wildlife supply networks, the bushmeat trade remains a major threat contributing to the decline of its populations (Gossé et al., 2023). The Tonkpi region, located in western Côte d'Ivoire, is an important but highly fragmented biodiversity refuge where the pangolin population is declining, particularly in community and classified forests. Forest management in this region is heterogeneous, fluctuating between "classified forests" under state control and "community forests" managed through customary practices (Kadet, 2015). Although the pangolin is protected by international conventions (CITES) and Ivorian legislation, scientific data on its actual conservation status in Tonkpi remains limited. The central issue, therefore, lies in assessing the impact of protection status on the persistence of pangolin populations in a fragmentedlandscape. However, weak monitoring measures, the use of non-selective hunting tools, and the uncontrolled exploitation of natural resources severelyjeopardize the survival of animal populations, especially the pangolin. In light of this situation, our study aims to assess the conservation status of the pangolin in these three forests of the Tonkpi region, (i) in order to better understand its distribution, (ii) its preferred habitats, and (iii) the threats facing this animal species. Our study will contribute to the improvement of appropriate sustainable wildlife management policies in this forest region.

Methodology:-

Study site:-

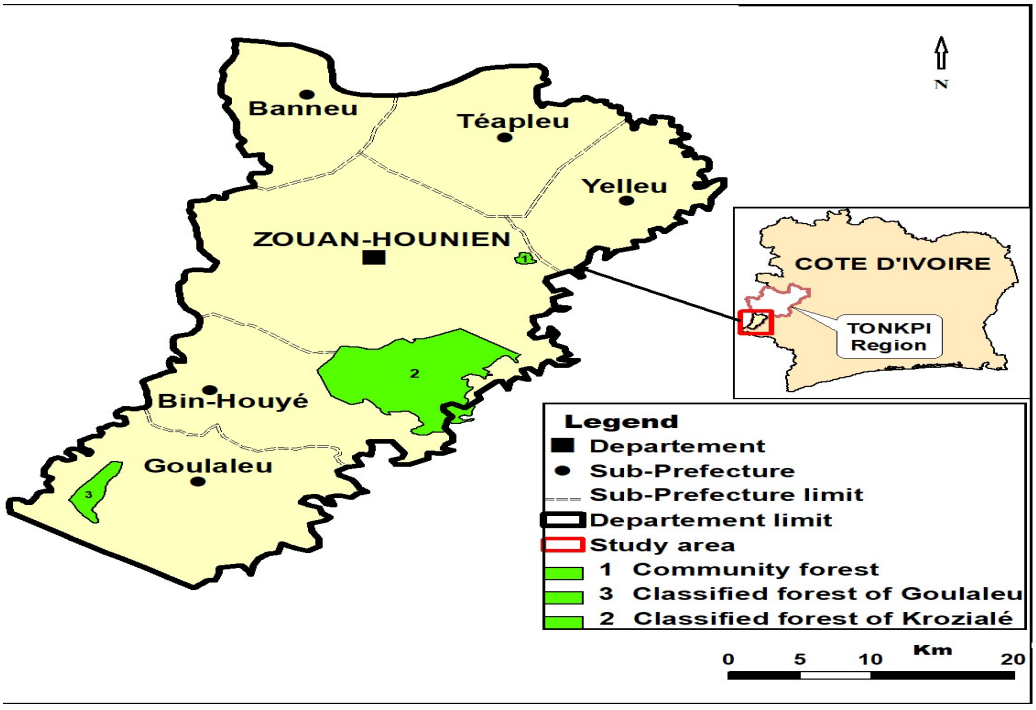


Figure 1 : Geographical location of the study area

Data Collection Methods:-

Investigation:-

An ethnozoologicalsurvey(Din et al., 2022) was conducted among local communities with proven knowledge of mammalian wildlife in general, and the pangolin in particular, in the villages surrounding the three studied forests. During the survey, we showed a pre-selectedsample of different pangolin species likely to be present in the Tonkpi region. Several other pangolin images (Ingram et al., 2019; Morton et al., 2021) not known in Côte d'Ivoire were also presented to the participants to assess the reliability of identification based on the photographs. The survey first allowed us to compile a list of pangolin species that could be encountered, and then to identify the forests that mightstillharbor these wild animals.

Foot prospecting:-

In classified forests and the community forest, foot surveys were conducted at night. A single foot survey method was used, employing torches and machetes to facilitate movement (Din et al., 2022). This method was the reconnaissance walk method (RECCE) (Kadjo et al., 2014; Hoppe-Dominik et al., 2011). This method was applied to increase sampling efforts and cover areas of potentially high diversity and density, as well as to increase our chances of detecting multiple pangolin individuals. During the reconnaissance walks, we followed a predetermined route, but one that allowed for deviations during the foot surveys. RECCE had the advantage of allowing the team to cover more areas in a short period of time, while minimizing environmental impact(Walsh and White, 1999). Using GPS and a compass, we walked slowly at a speed of 0.5 to 1 km/h to collect data on the presence of pangolins. Pangolin species could be detected directly or indirectly. Direct observations included any visual contact with the animals during our movements. Indirect observations encompassed all indirect indicators that could definitivelyconfirm the presence of pangolins at the study site. Whenever evidence of pangolin presence was found, the inventory team stopped to characterize it and record its geographic coordinates. During the walking surveys, we also recorded evidence of human activities such as agriculture, logging, hunting, and bushfires. All observations were recorded on a walking inventory form to facilitate data analysis.

Data analysis:-

Two software programs, PAST (2.17c) and QGIS (2.14.7), were used for data analysis. PAST (2.17c) was used to perform correspondence analyses to identify preferred pangolin habitats. QGIS (2.14.7) was used to create maps of the spatial distribution of pangolin species in the Daapleu community forest, the Goulaleu classified forest, and the Krozialé classified forest. Excel was used to analyze the frequency of human threats to pangolin individuals.

Results:-

A total of 89 pangolin presence indicators were recorded in the three forests, including 70 indirect indicators (78.66%) and 19 directindicators (21.34%). The indicators of presence were primarily feeding sites, burrows, and visual observations. The Krozialé classified forest recorded the highest number of indicators (60.67%; N = 54), followed by the Goulaleu classified forest (25.85%; N = 23), and then the Daapleu community forest (13.48%; N = 12).

Figure 1. Illustration of the Pangolin (*Phataginus tricuspis*) in the studied forests, Ivory Coast

Spatial distribution of the pangolin in the studiedforests:-

✓ **Krozialé Classified Forest:-**

In the Krozialé classified forest, 57 signs of Pangolin presence were recorded in this forest during our study. During the collection of data on Pangolins in the classified forest of Krozialé, there were 43 indirect observations (75.44%) and 14 direct observations (24.56%). The Krozialé classified forest, with an area of 9,300 hectares, contains individuals of Pangolin. These Pangolin individuals belong to two species. These are the species Phataginus tetradactyla (Figure 2) and the species Phataginus tricuspis (Figure 3). The species Phataginus tetradactyla is observed in the east, south and west of the forest. However, its observation frequency is higher to the east of the forest. As for Phataginus tricuspis, it is observed in the East, South, Center and West of the forest. Its observation frequency is also higher to the east of the forest. Although having approximately the same distribution areas, Phataginus tricuspis has a higher observation frequency compared to that of Phataginus tetradactyla which has not been observed in the center of the Krozialé classified forest.

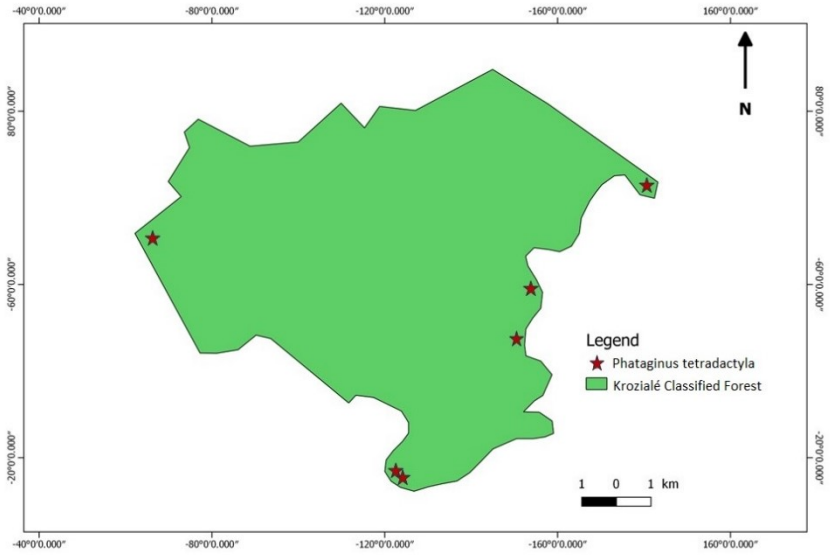


Figure2. Spatial distribution of *Phataginus tetradactyla* in the classified forest of Krozialé, Côte d'Ivoire

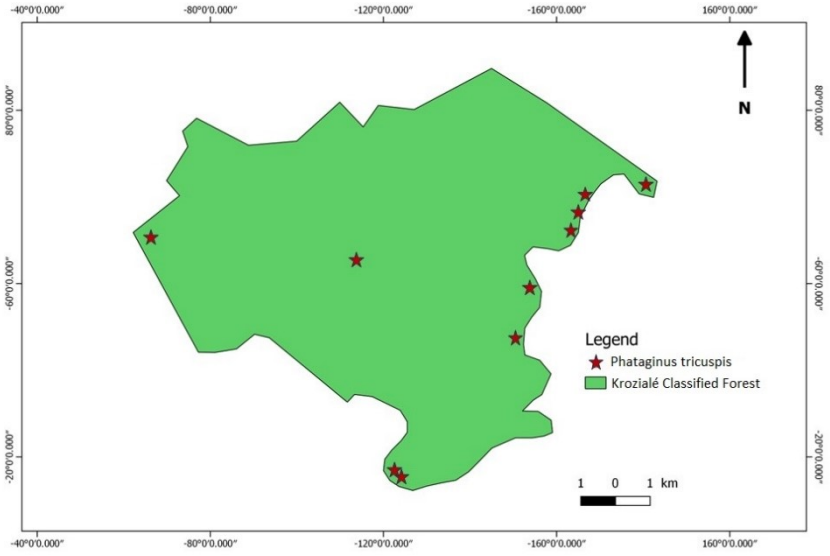


Figure3. Spatial distribution of *Phataginus tricuspis* in the classified forest of Krozialé, Côte d'Ivoire

✓ **Goulaleu Classified Forest:-**

Within the Goulaleu Classified Forest, 23 pangolin presence indicators were recorded during our study. During data collection on pangolins in the Goulaleu Classified Forest, there were 18 indirect observations (78.26%) and 5 direct observations (21.74%). The Goulaleu Classified Forest, covering an area of 950 hectares, is home to several pangolin individuals. These pangolins belong to two species: Phataginus tetradactyla (Figure 4) and Phataginus tricuspis (Figure 5). These two mammal species have virtually the same distribution. However, in terms of specificity, Phataginus tetradactyla is observed in the north and west of the Goulaleu Classified Forest, while Phataginus tricuspis is observed in the north, west, and south of the forest. These two species of Pangolin are observed further west of the classified forest of Goulaleu.

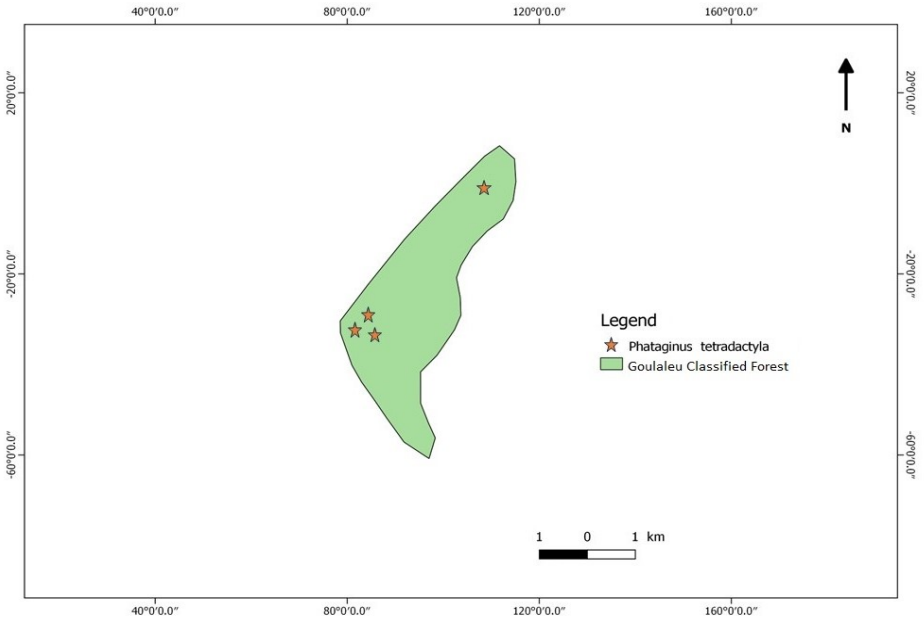


Figure 4.Spatial distribution of *Phataginus tetradactyla* in the classified forest of Goulaleu, Côte d'Ivoire

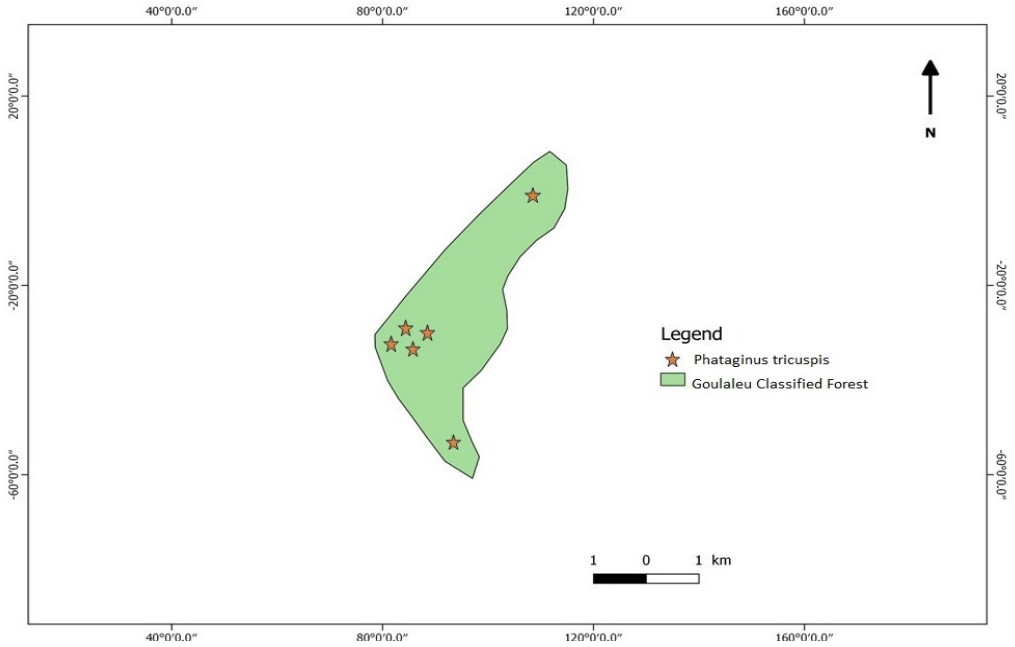


Figure 5. Spatial distribution of *Phataginus tricuspis* in the classified forest of Goulaleu, Côte d'Ivoire

✓ **Daapleu Community Forest:-**

In the Daapleu community forest, 12 pangolin presence indicators were recorded during the study. Data collection on pangolins in the Daapleu community forest revealed 9 indirect observations (75%) and 3 direct observations (25%). The Daapleu community forest, covering an area of 170 hectares, contains pangolins belonging to two species: Phataginus tetradactyla (Figure 6) and Phataginus tricuspis (Figure 7). Phataginus tetradactyla is found in the northeast, east, and southwest of the Daapleu community forest. Phataginus tricuspis is found only in the northern part of the forest.

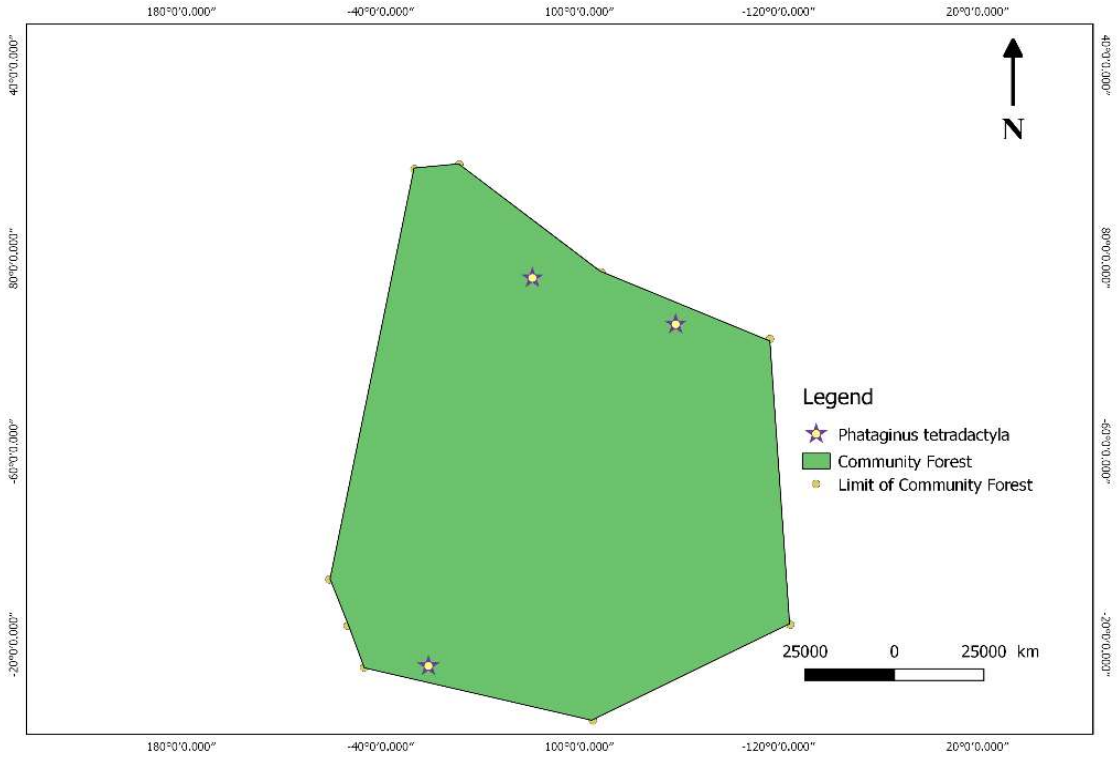


Figure 6.Spatial distribution of *Phataginus tetradactyla* in the Daapleu community forest, Côte d'Ivoire

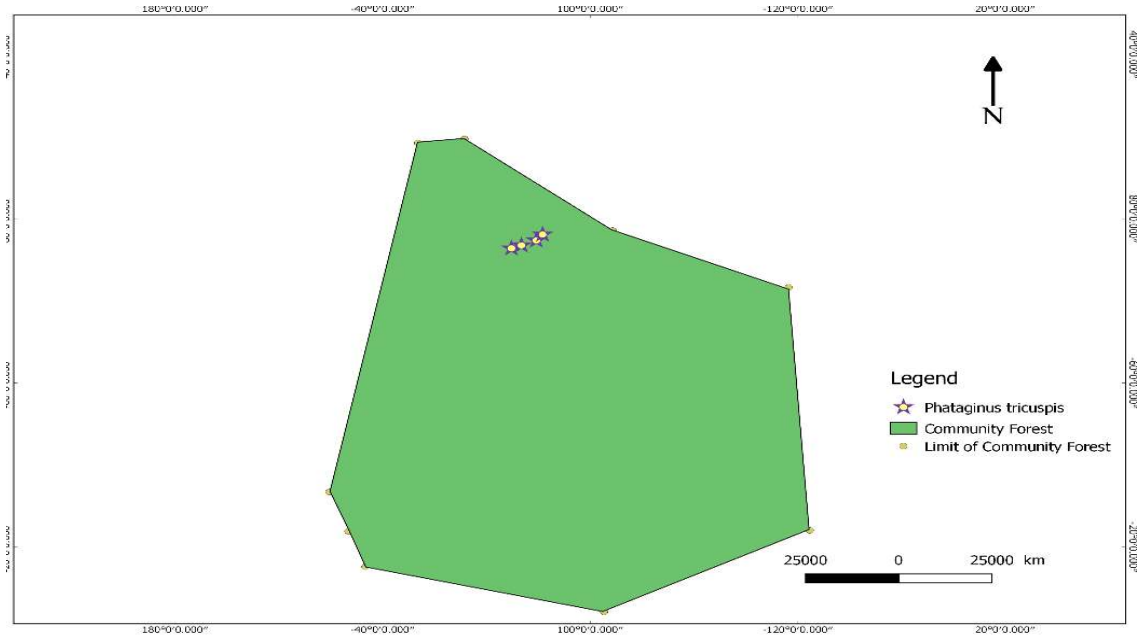


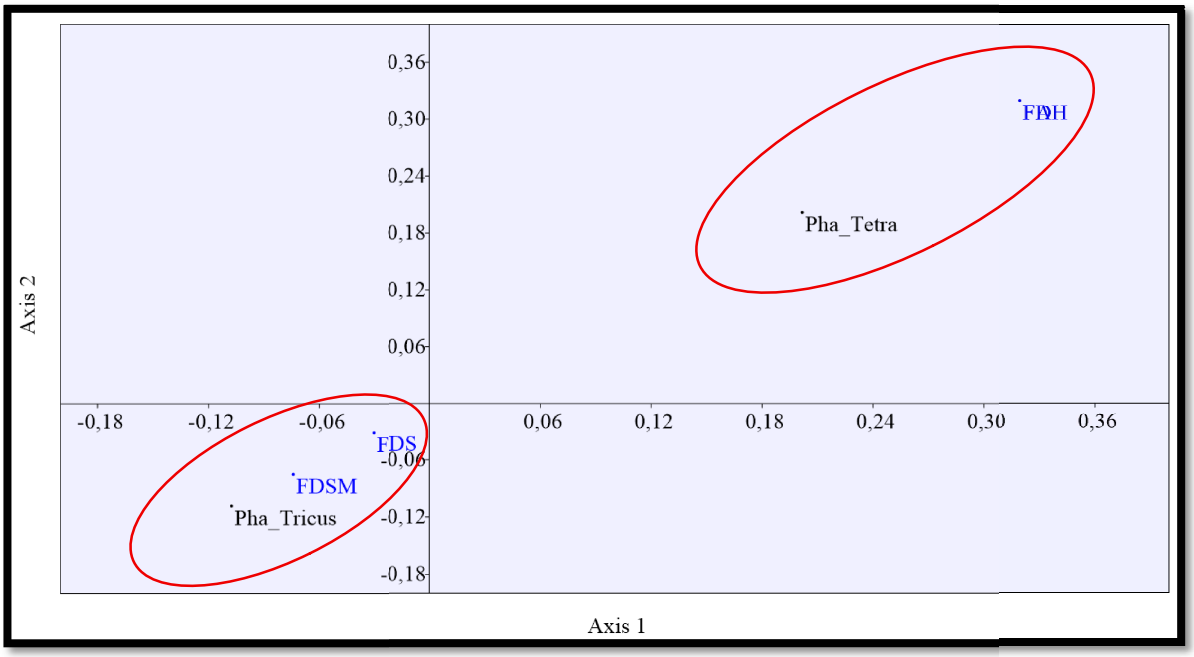
Figure 7. Spatial distribution of *Phataginus tricuspis* in the Daapleu community forest, Côte d'Ivoire

Distribution of the pangolin in forests according to habitats:-

During our study in the Krozialé and Goulaleu classified forests, and later in the Daapleu community forest, four different habitat types were identified : Dense Humid Forest (DHF), Dense Mountain Forest (DMF), Dense Dry Forest (DDF), and Anthropogenic Forest (AF). At least one pangolin individual was identified in each of these habitats.

✓ **Krozialé Classified Forest:-**

In the Krozialé classified forest, the species Phataginus tricuspis is found in both Dense Mountain Forest (DFSF) and Dense Dry Forest (DDF). However, it is more commonly found in the Dense Mountain Forest (DFSF) habitat. As for Phataginus tetradactyla, it is found in both Dense Humid Forest (DHF) and Anthropogenic Forest habitats within the Krozialé classified forest (Figure 8).

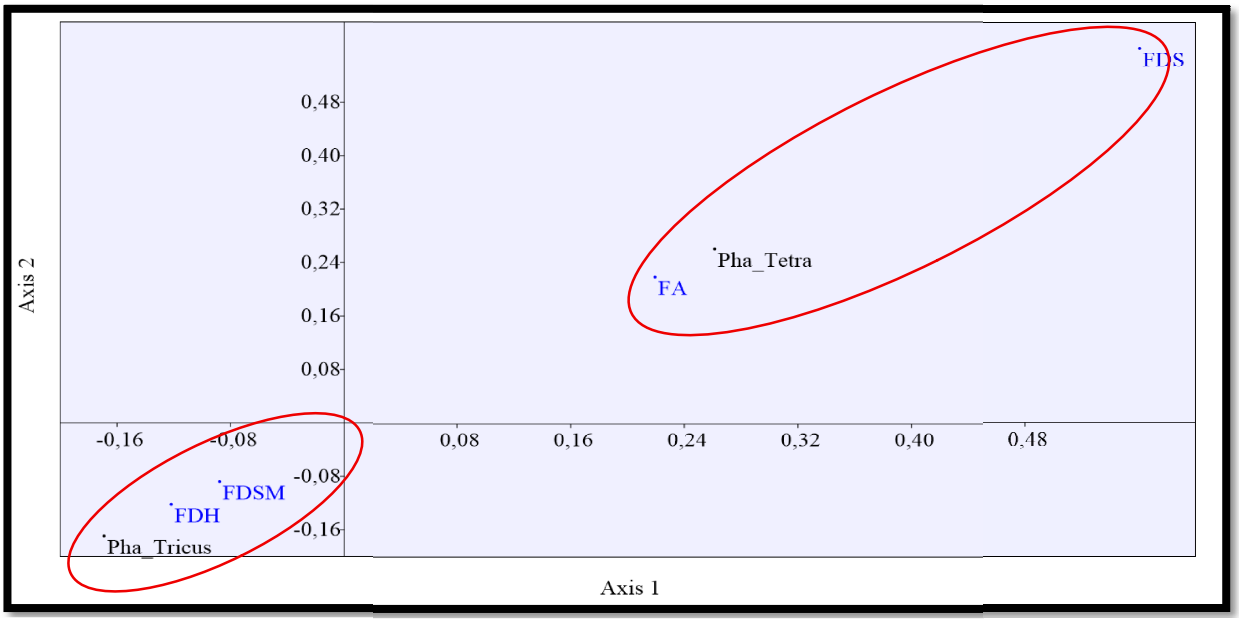


FDH = Dense Humid Forest; FDSM = Dense Mountain Forest; FDS = Dense Dry Forest; FA = Anthropogenic Forest; Pha_Tricus = Phataginus tricuspis; Pha_Tetra = Phataginus tetradactyla

Figure 8.Distribution of the Pangolin in the Krozialé classified forest according to habitats,Côte d'Ivoire

✓ **Goulaleu Classified Forest:-**

In the Goulaleu classified forest, the species Phataginus tricuspis is found in the Dense Mountain Forest (FDSM) and Dense Humid Forest (FDH) habitats. However, the species is more frequently observed in the Dense Mountain Forest (FDSM) habitat. As for Phataginus tetradactyla, it is found in the Dense Dry Forest (FDS) and Anthropogenic Forest (FA) habitats. The species Phataginus tetradactyla is more frequently observed in the Anthropogenic Forest (FA) habitat within the Goulaleu classified forest (Figure 9).

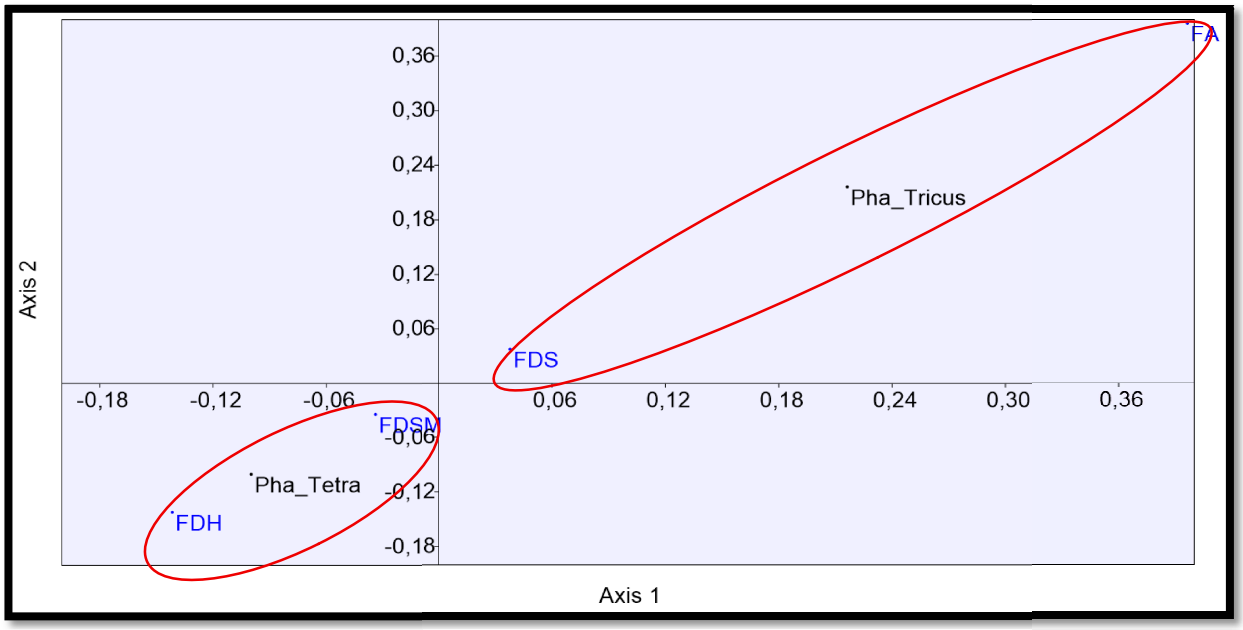


FDH = Dense Humid Forest; FDSM = Dense Mountain Forest; FDS = Dense Dry Forest; FA = Anthropogenic Forest; Pha_Tricus = Phataginus tricuspis; Pha_Tetra = Phataginus tetradactyla

Figure 9.Distribution of the Pangolin in the classified forest of Goulaleu according to habitats, Côte d'Ivoire

✓ **Daapleu Community Forest:-**

Regarding the Daapleu community forest, the pangolin's habitat distribution differs from that of the Krozialé and Goulaleu classified forests. In the Daapleu community forest, the species Phataginus tricuspis is observed in both the Dry Dense Forest (DDF) and Anthropogenic Forest (AF) habitats. Its observation frequency is identical in these two habitat types. Phataginus tetradactyla, on the other hand, is observed in the Mountain Dense Forest (MDDF) and Humid Dense Forest (HDF) habitats. However, this mammal is more frequently observed in the Humid Dense Forest (HDF) habitat of the Daapleu community forest (Figure 10).



FDH = Dense Humid Forest; FDSM = Dense Mountain Forest; FDS = Dense Dry Forest; FA = Anthropogenic Forest; Pha_Tricus = Phataginus tricuspis; Pha_Tetra = Phataginus tetradactyla

Figure 10.Distribution of the Pangolin in the Daapleu community forest according to habitats, Côte d'Ivoire

Human-induced threats to pangolin conservation in the studiedforests:-

The threats to the sustainable conservation of the pangolin in the Krozialé and Goulaleu classified forests and the Daapleu community forest are anthropogenic. These include agriculture, hunting, logging, and bushfires (Figure 11), (Figure 12), and (Figure 13). In the three forests studied, agriculture is the primary threat to pangolin species. Its frequency varies according to the forest studied: Krozialé classified forest (74.60%; N = 235), Goulaleu classified forest (60.63%; N = 134), and Daapleu community forest (60.34%; N = 73). Hunting is the second most significant threat after agriculture. Hunting rates in the Krozialé classified forest were 20.01% (N = 63) compared to 26.70% (N = 59) in the Goulaleu classified forest. Hunting rates were 21.48% (N = 26) in the Daapleu community forest (Figure 14). Logging poses a threat to pangolin species in the studied forests. Its frequency was 14.05% (N = 17) in the Daapleu community forest, 11.31% (N = 25) in the Goulaleu classified forest, and 4.76% (N = 15) in the Krozialé classified forest. Bushfires were rarely observed. Their frequencies are 4.13% (N = 5) in the Daapleu community forest, 1.36% (N = 3) in the Goulaleu classified forest and 0.63% (N = 2) in the Krozialé classified forest.

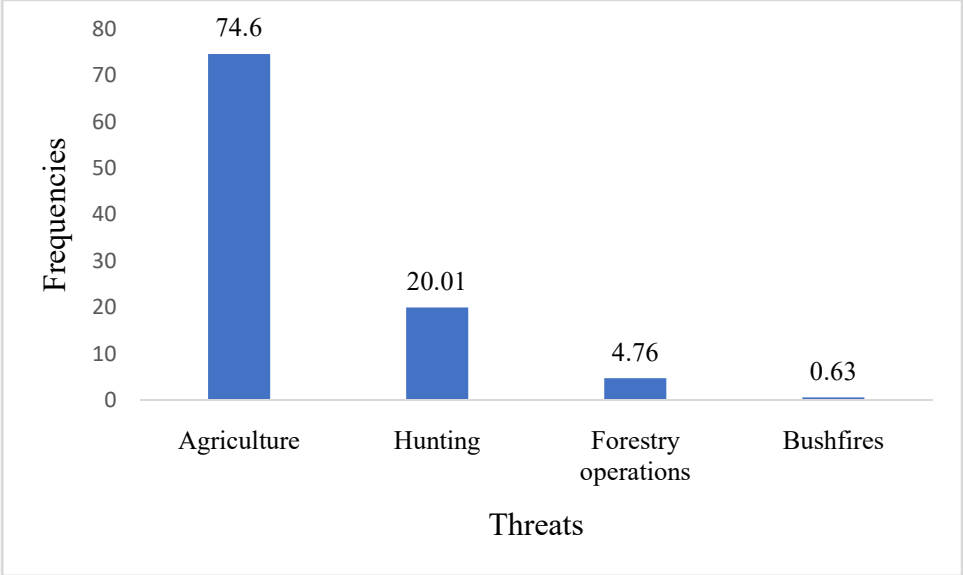


Figure 11.Threats to the sustainable conservation of the Pangolin in the Krozialé classified forest, Côte d'Ivoire

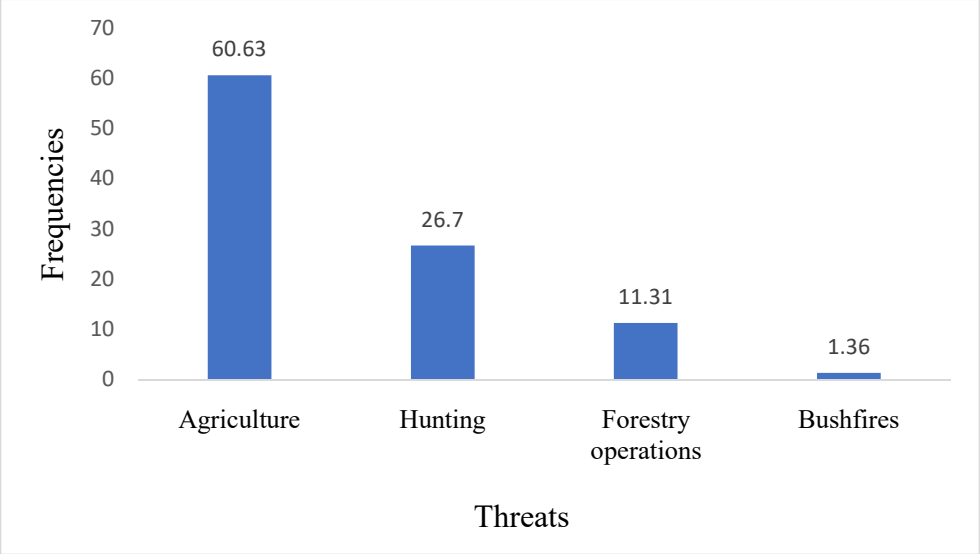


Figure 12.Threats to the sustainable conservation of the Pangolin in the Goulaleu classified forest, Côte d'Ivoire

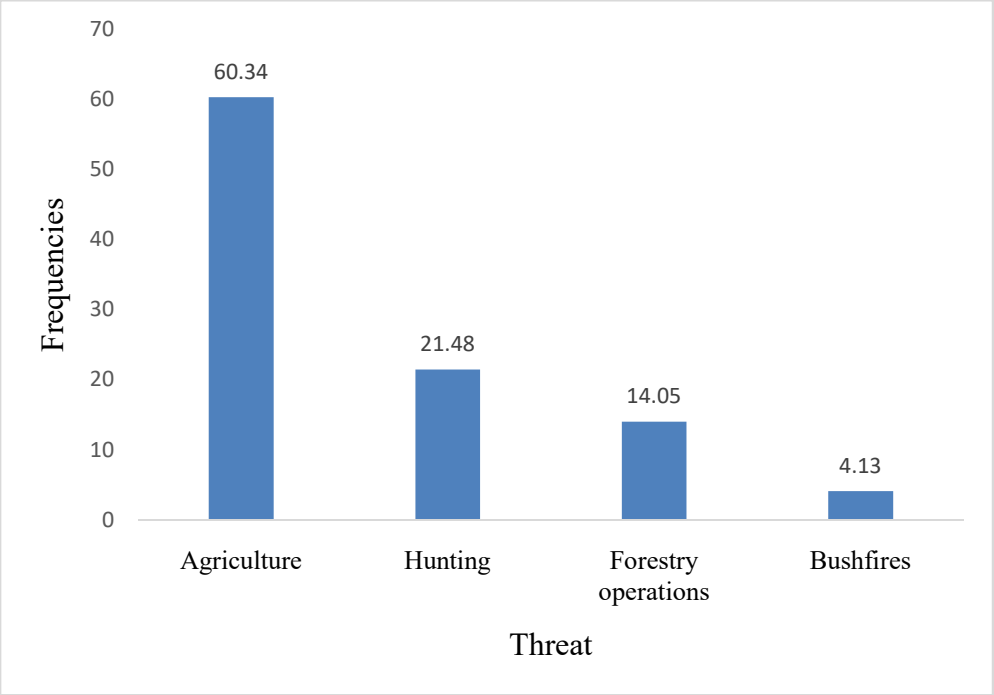


Figure 13.Threats to the sustainable conservation of the pangolin in the Daapleu community forest, Côte d'Ivoire

Figure 14. Illustration of the threat of hunting to the sustainable conservation of the Pangolin in the classified forests of Krozialé, Goulaleu and the Daapleu community forest,Côte d'Ivoire

Discussion:-

A total of 89 pangolin presence indicators were recorded across the three forests. Of these, 70 were indirect and 19 were direct. Visual sightings, feeding sites, and burrows were more frequently recorded in the Krozialé Classified Forest. The higher number of presence indicators in this forest is likely due to its larger size compared to the Goulaleu Classified Forest and the Daapleu Community Forest. This could also be explained by the fact that the Krozialé Classified Forest provides habitats and food sources essential for the sustainable conservation of wildlife. Indeed, the pangolin is a mammal species that is not restricted to all habitat types (Bhandari et al., 2014; Chao et al., 2020). The presence of pangolins in the Daapleu community forest proves that these types of forest relicts play an

important role in the sustainable conservation of endangered species like the pangolin in Côte d'Ivoire and West Africa(Dupuy, 1968; Doran et al., 1973).

In the Krozialé classified forest, data collection showed that Phataginus tetradactyla and Phataginus tricuspis are found more in the eastern part of the forest. This can be explained by the presence of the Cavally River along the entire easternside of the Krozialé classified forest. This waterwayprovidescharacteristic habitats for the pangolin's survival. Indeed, water is a vital resource for animal species, including the pangolin (Emry, 1970). Within the Goulaleu classified forest, both pangolin species are found more in the western part of the forest. This area of the forest consists of plateaus that are difficult for humans to traverse. The pangolins have therefore retreated to these areas to escape potential hunting. This distribution pattern of pangolins in the Goulaleu classified forest has also been observed in the Daapleu community forest, where pangolins are only found in closedcanopies. Dense Mountain Forests (DMFs) would thus be the ideal habitat for pangolins, allowing them to escape human activities, including hunting (Chao et al., 2020).

Conclusion:-

In the Krozialé classified forest, the species Phataginus tetradactyla is found in the east, south, and west of the forest. Phataginus tricuspis is found in the east, south, central, and western parts of the forest. In the Goulaleu classified forest, Phataginus tetradactyla is found in the north and west of the forest. Phataginus tricuspis is found in the north, west, and south of the forest. In the Daapleu community forest, Phataginus tetradactyla is found in the northeast, east, and southwest of the forest. Phataginus tricuspis is found only in the northern part of the forest.

During our study in the Krozialé and Goulaleu classified forests, and later in the Daapleu community forest, four different habitat types were identified: Dense Humid Forest (DHF), Dense Mountain Forest (DMF), Dense Dry Forest (DDF), and Anthropogenic Forest (AF). The majority of pangolin individuals were identified in the Dense Mountain Forest (DMF) habitat. The threats to the sustainable conservation of pangolins in the Krozialé and Goulaleu classified forests and in the Daapleu community forest, in order of frequency, are agriculture, hunting, logging, and bushfires.

Aknowledgement:-

We would like to thank Commander LOBA Don Alexandre and Captain EBE Yao Bertin for providing us with a map of the classified forests of Krozialé and Goulaleu, which facilitated our fieldwork during village surveys. We also extend our thanks to the youth leaders of Daapleu, Mr. GhislinMemen and Mr. Diaglo Kamin, for their invaluable collaboration at the study sites.

Conflits D'interets:-

The authors declare that there is no conflict of interest for this article.

Contribution Des Auteurs:-

Kramoko BAMBA collected the data, Kramoko BAMBA and Koffi Jules GOSSÉ performed the data processing, statistical analysis, and manuscript writing. The other co-authors contributed to proofreading and improving the article.

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