Full Length Research Paper

Assessing the impact of seasonality on Cross River Gorilla Nest Construction at Kagwene Gorilla Sanctuary, North-West Cameroon

Nkwatoh Athanasius Fuashi[1]*, Akenji Lesly Nji[2], Melle Maurice Ekane[1], Andrew Fowler[2] and Romanus Ikfuingei[3]

[1]Department of Environmental Science, University of Buea, Cameroon.
[2]Wildlife Conservation Society, Takamanda-Mone Landscape Project, Cameroon.
[3]World Wide Fund for Nature, Mount Cameroon National Park, Cameroon.

The Cross River gorilla, one of the most endangered subspecies of western gorilla (*Gorilla gorilla*) is endemic to 12 to 14 sites at the Cameroon-Nigeria border, where it is facing enormous threats from habitat loss, bush meat trade and minor climate changes (seasonal changes). In a strive to reduce the enormous stressors on this subspecies, this study assesses the impact of seasonality on nest construction by Cross River gorillas in the Kagwene Gorilla Sanctuary with the objective of evaluating the impact of seasonal changes on the nest construction. To achieve this goal, the study employed a hunter guided survey team, as well as guides/trackers of the Wildlife Conservation Society. This team regularly tracks and searches the forest for gorilla signs using vegetation trails, food prints, dung, and feeding signs which are subsequently followed onwards to the nesting site. Data were collected from January to December 2014. A total of 268 fresh gorilla nest sites were observed containing 1813 individual nests. Out of the 1813 nests recorded, 39.6% (N=718) of the nests were on the ground and 60.4% (N=1095) on trees. The frequency of each nest type varied significantly among months (P =0.4433). There was a significant effect of season on nest category. Ground categories (bare earth, herbaceous, woody and mixed) were more common in the dry season (74.9%) than in the wet season (25.1%). On the other hand, tree nests were more common in the wet season (77.4%) than in the dry season (22.6%). Mean nest diameter for the two seasons (dry and wet) was 1.1 and 1.3 m, respectively. The mean nest height was 12.5 m for both seasons. Cross River gorillas showed higher preferences for tree nests within the height class interval of 11 to 15 m (49.6%). The distribution of nests across gradient of altitudes did not vary significantly between seasons (P>0.05), and nests were most common on steep slopes (n=810). Seasonality did not significantly affect the choice of slope (P>0.05). There was a significant difference in the habitat types (primary forest, light gap, secondary forest and rock) used for nesting, with primary forest being most preferred. Nest site distribution was predominant in the northern section of the sanctuary. This study reveals that, both temperature and rainfall play an important role in nest construction by Cross River gorilla at Kagwene.

Key words: Cross River gorilla, nest, seasonality, Kagwene Gorilla Sanctuary.

INTRODUCTION

Primate populations, like those of other organisms, face the challenge of coping with the dynamics of their changing in order to survive. If they fail to adapt they are bound to extinct (Isabirye-Basuta and Lwanga, 2008). Cross River gorillas (*Gorilla gorilla diehli*) are the most threatened African ape (De Vere et al., 2010; Nkemnyi et al., 2011). They occupy roughly 14 apparently geographically separated areas in a landscape of approximately 12,000 km^2 of rugged terrain spanning the Nigeria-Cameroon border region. The species is under stress from habitat loss and fragmentation due to pressure from natural and human stressors. This has further contributed to the decline of their population over the last century. The population stands at an estimated number of <300 individuals (Oates et al., 2007; Sunderland-Groves et al., 2009; Nicholas et al., 2010; Etiendem, 2013). Nest construction is an important behavioral feature that all species of great apes share and it is considered to be an adaptation underlying the aptitude of great apes for manipulating objects in their environment (Morgan et al., 2004; Neba, 2011). Gorillas, like all great apes, select a fresh site and build a new nest each night after a day's foraging within a large home range (Remis, 1993). After choosing an appropriate nest location, nests are built from the available vegetation by bending, breaking and interweaving branches and twigs/herbs into a solid platform (Brownlow et al., 2001; Etiendem, 2013). Knowledge of nest-building behavior by Cross River gorilla is limited to five studies conducted at more peripheral and high attitude sites (McFarland, 2007; Sunderland-Groves et al., 2009; De Vere et al., 2010; Neba, 2011; Etiendem, 2013). Previous research has suggested that great apes adjust their nest building efforts in response to seasonal changes and climatic conditions in their environment to their favour. Fruth and Hohmann (1996) further explained that great apes during the dry seasons make very little efforts in nest construction while in the wet season the location of a nest is carefully selected to avoid mid night run offs from heavy rains. The Cross River gorilla one of the most endangered subspecies of western gorillas (*G. gorilla*), is endemic to 14 sites at the Nigerian-Cameroon border where it is facing enormous threats from habitat loss, bush meat trade, and minor climate changes (seasonal changes). In an attempt to reduce the enormous stressors on the subspecies, this study on assessing the impact of seasonality on nest construction by Cross River gorilla in the Kagwene Gorilla Sanctuary had the objective of evaluating the impact of seasonal changes on the subspecies nest construction ability.

METHODOLOGY

Location of study area

Kagwene Gorilla Sanctuary (Cameroon) covers an area of 19.44 km^2, and reaches altitudes of roughly 2,000 m, lying between 06°05'55" and 06°08'25" North and between 09°43'35" and 09°46'35" East (Wiseman et al., 2008). The vegetation is a sub-mountain forest-grassland mosaic and the terrain is characterized by rocky outcrops, with the highest peak reaching 2037 m a.s.l (Sunderland-Groves et al., 2009). It is dominated by a humid tropical climate, characterized by two seasons (dry and wet). The dry season is shorter and lasts from November to April with a corresponding long wet season from May to October. The mean daily temperature in the dry months (November-April) is 20.9°C and total rainfall is 1230 mm. In the wet months, mean daily temperature is 18.7°C and total rainfall is 5015.6 mm (WCS-TMLP long-term records, 2013). The sanctuary is surrounded by eight farming communities and about 2600 people live around its base (Sunderland-Groves et al., 2009). The main economic activity in this area is farming. In accordance with Figure 1 the main vegetation of the area is forest interspersed with grassland.

Field methods

Tracking and selection of nest sites

Data were collected from January to December, 2014. A hunter guided survey team regularly tracks the gorillas, systematically searching the forest for gorilla signs using vegetation trails, food prints, dung, or feeding remains. Upon detection, these signs were subsequently followed onwards to the nest site with the assistance of the Wildlife Conservation Society field trackers. Gorilla nest sites were defined as an assemblage of freshly constructed nests at one site and can be clearly recognized as a sleeping site due to the presence of fresh dung. These sites were located using a cyber-tracker and their positions taken with a GPS. Both day and night nest constructed by gorillas were recorded. As outlined by Lukas et al. (2003), although day and night nests may be composed of similar materials, night nests may be more elaborately constructed than day nests as gorillas sleep on it for a longer time period. Day nest, in turn in most cases constructed to rest and are usually not used for more than 2 h (Brownlow et al., 2001). Thus, only night nests were considered. At the location of each nest site, nest sites were defined as all nest constructed by the same ape species and of the same age class located less than ≤ 50 m from each other (Morgan et al., 2004). To see the nest construction variability within the month, only 1 to 2 days old night nest were examined so as to compare with the present climatic parameters. At every nest site (location), the geographic location was recorded via a Global Positioning Systems (GPS, Garmin GPS 62s). The nest construction categories which described the materials used to construct the nests as Rothman et al. (2006), Sunderland-Groves et al. (2009), and Tutin et al. (1995) puts it, were divided as follows:

(1) Zero: Fattened patch and gorilla smell and dung indicating that the gorilla had slept on the ground.
(2) Minimal: Nest made from a few herbaceous stems.
(3) Herbaceous: More complex structure made exclusively from
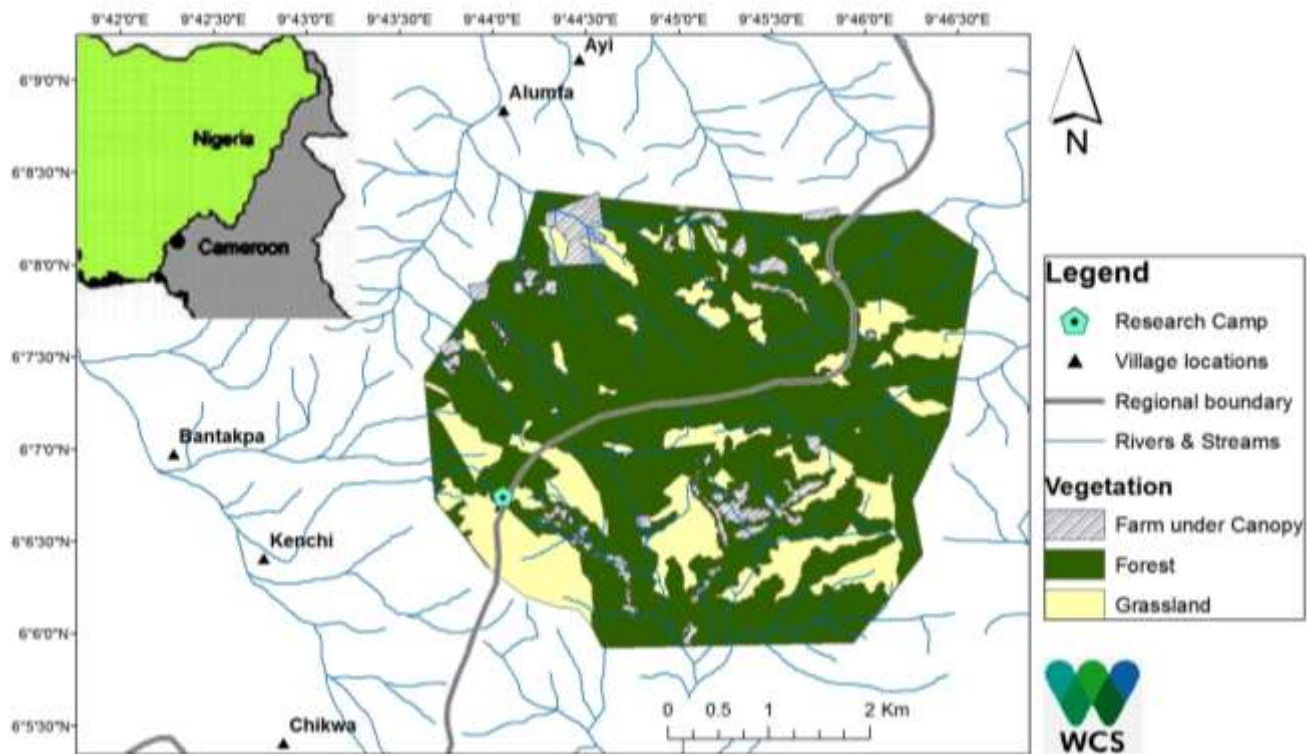
Figure 1. Vegetation map of the study area: Kagwene Gorilla Sanctuary.

herbaceous material.
(4) Mixed: Nest constructed from mixture of woody and herbaceous material.
(5) Woody: Nest constructed exclusively of woody material.
(6) Tree: Nest constructed in tree, mostly constructed exclusively of woody material.

The estimated tree nest height (that is, distance from the base of the tree to the base of the nest) was estimated using a measuring tape. If the nests were constructed on the ground, diameter of the tree was measured (Bergl et al., 2009).

Habitat attributes

An elevation map was derived from a 30-m ASTER digital elevation model (DEM). The extract values from point's tool were used in ArcGIS to get elevation values of each nest site location. The slope map was computed from the DEM using the surface analysis slope function in ArcGIS Spatial Analyst version 10.1. Slope at nest site was described as: flat, 0% = 0; gentle, 1-10% = 1; steep, 11-50% = 2; very steep, 50% + = 3.
   Habitat type at the nest site was described as:

(1) Primary forest: Mature, tall trees; uniform undergrowth indicative of a climax community.
(2) Secondary forest: Recovering from disturbance by humans; younger, smaller trees, herbaceous undergrowth. Canopy cover is discontinuous and herbaceous plants like Aframomum are common.

(3) Disturbed forest: Evidence of recent or current disturbance by cattle or fire.
(4) Colonizing forest: Successional stage, occurring after natural disturbance.
(5) Light gap: Small patch within a forested area, where one or two trees have fallen, allowing light into the understory. Understory vegetation is dense and dominated by Zingiberaceae and Marantaceae.
(6) Grassland: Open patches consisting of grasses only.
(7) Transition zone: Specific vegetation found bordering two vegetation zones consisting of bracken and Zingerberaceae.
(8) Rock: Areas where no vegetation is present due to rocky terrain.

Data analysis

Field data was downloaded from the cyber tracker handle device into the computer software and export into excel format. In R package version 14, field data was subjected to descriptive statistics where measures of central tendency were determined. For purposes of statistical testing, nest heights were grouped in 5-m intervals. Mann-Witney U-test test was used for the equality of means between nest location and size between the wet and dry seasons. Kruskal-wallis test was used to test for nest (construction categories) and habitat types between seasons. ArcGIS version 10.1 was used to produce maps for nest site distribution patterns. The extract values from points tool were used in ArcGIS version 10.1 to get elevation values of each nest site location from 30-m ASTER digital elevation model (DEM) image.
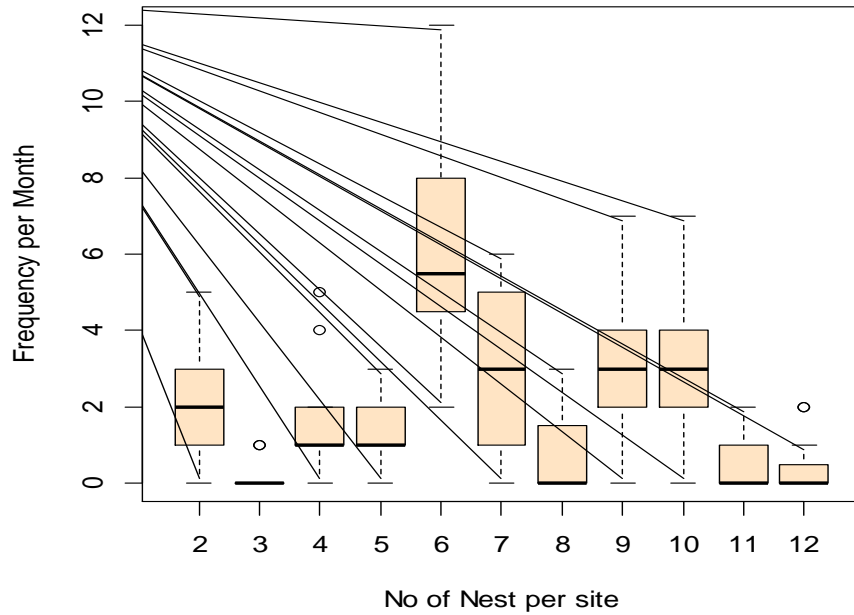
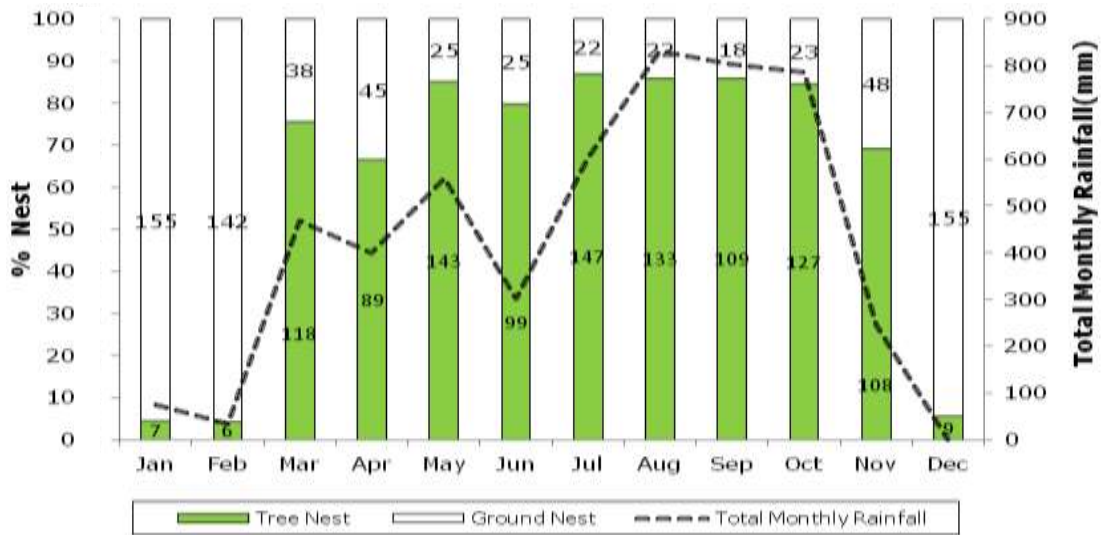**Figure 2.** Distribution of nests per nest site in the study area.

**Figure 3.** Seasonal variation in nest distribution on trees and on the ground.

RESULTS

Nest site dynamics

As shown in Figure 2, a total of 268 nest sites (locations) were identified in the study area. From these, a total of 1813 nests were recorded with and estimated range of 2 to 12 nests per site.

Of the 1813 nest recorded, 39.6% (N=718) were on the ground and 60.4% (N=1095) in trees (Figure 3). Ground nests were found to be constructed mostly in the dry season (December, January, March) while tree nest were more frequent in the wet season (April-November). The frequency of each nest type varied significantly among months at p=0.4433.

The material of constructed ground nests ranged from
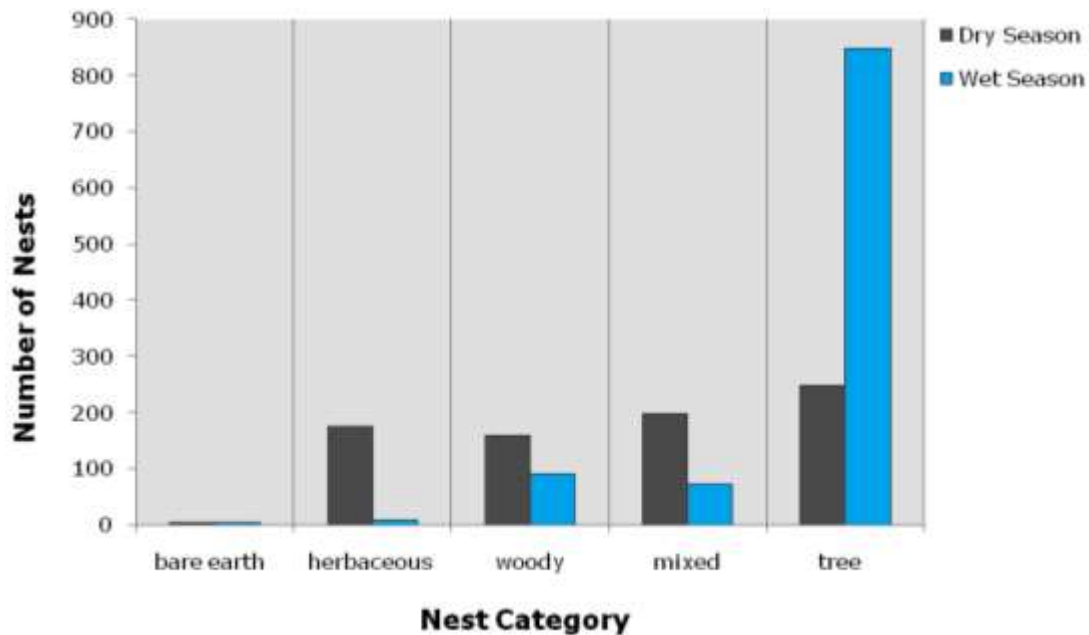
Figure 4. Categories of nest construction by Cross River gorilla across seasons.

bare earth platforms, herbaceous platforms, and woody platforms to a mixture of herbaceous and woody platform (Figure 4). Amongst these ground categories, mixed nests were the most observed (N=272) and bare earth the least observed (N=9). On the other hand, only one tree nest category was found. This was a mixture of leaves and woody platforms on trees. The Kruskal-Wallis chi-squared analysis showed that the proportion of nest at each site varied significantly between the dry and wet season at p=0.434l. On the contrary, bare earth nests showed no significant variation with season at p=0.752.

Nest size and height

The mean nest diameter for the dry and wet season was 1.1 and 1.3 m, respectively with a mean nest diameter for the entire study period of 1.2 m for dry and wet seasons. Nest size showed no significant difference between seasons at p=2.216.
Cross River gorillas showed higher preference for nesting in the height class interval of 11 to 15 m in the dry and wet seasons (Figure 5).

Nesting elevation

The distribution of nests across the elevational gradient did not differ between season at p= 0.1561 level of significance. However, Cross River gorillas had higher nest numbers at steep slopes (n=810) (Figure 6).

Nesting habitat

Habitat types identified in the study area used for nesting ranged from primary forest, secondary forest, light gaps and rocky areas. Habitat selection showed a significant difference with respect to seasons at p=0.5531level of significance. Nests were not distributed equally among the identified nesting habitat types within seasons. The primary forest habitat type was most preferred across seasons (Table 1).

DISCUSSION

Remis (1993), Tutin et al. (1995), and Mehlman and Doran (2002), in their individual and collective studies observed that gorilla nesting habits within their range state are characterized by a series of variations. Although they found a multiplicity of factors responsible for these variations, our studies at the Kagwene Gorilla Sanctuary revealed that the Cross River gorillas nesting habits are strongly influenced by the two seasons (dry and wet) that prevails in the area. This agrees very vividly with the works of the aforementioned authors who in their collective observation recognized seasonality as a prominent factor of variation for gorillas nest construction. At the Kagwene Gorilla Sanctuary, Cross River gorillas were observed to construct more tree nests in the wet season (March-October) with the greatest number of tree nests recorded in the months of June to September. On the other hand ground nest were predominantly
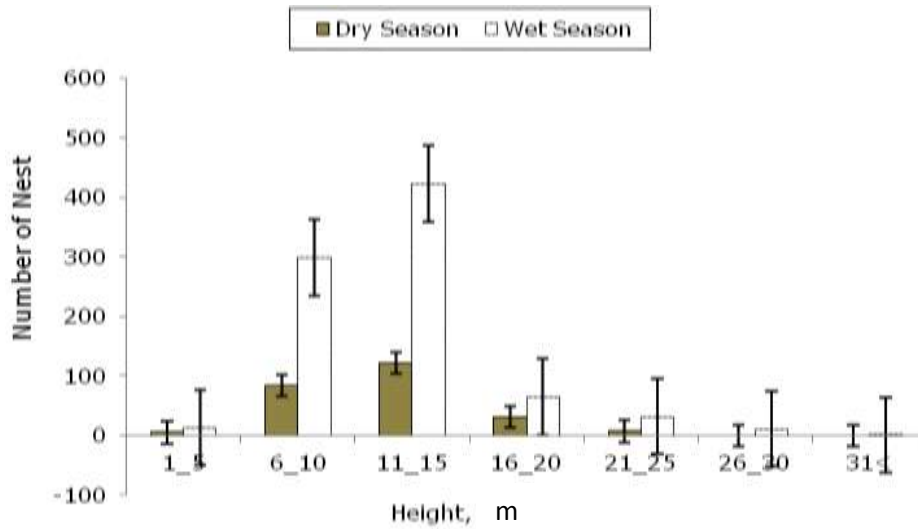
Figure 5. Number of nests per height class for each season (dry and wet).
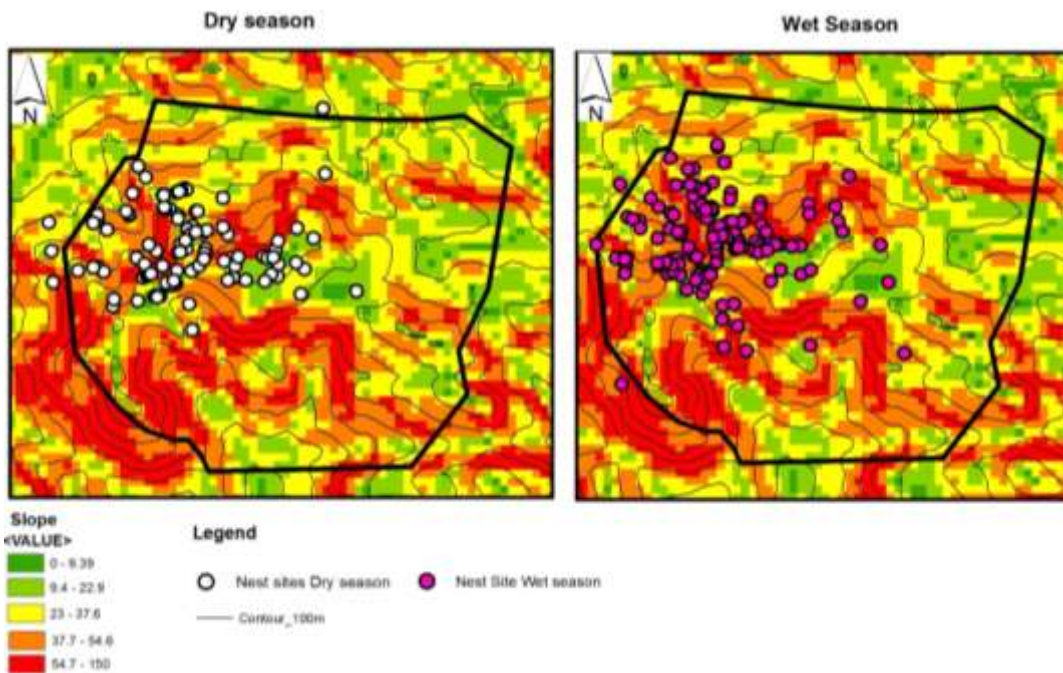

Figure 6. Distribution of Cross River gorilla nest sites across slopes in the dry and wet seasons.

constructed in the dry season (November-February) with December-February recording the highest number of ground nests. This is in line with the findings of Sunderland-Groves et al. (2009) and De Vere et al. (2010), who in their separate studies concluded that in Kagwene, Cross River gorillas ground nest are overwhelmingly found during the dry season. Our findings

also tie with the works of Remis (1993), Tutin et al. (1995) and Mehlman and Doran (2002) who revealed that nest construction by Western Lowland gorillas were associated with seasonal changes. The significant increase in tree nesting during the wet season in the study area is not unconnected to the ability of these animals to secure a safe location void of harassments

Table 1. Seasonal use of habitat type.

Habitat type	Nest sites dry season	No. of nests dry season	Nests (%)	Nest sites wet season	No. of nests wet season	Nests (%)
Primary forest	42	275	38.6	123	830	80.9
Secondary forest	5	28	3.9	10	72	7
Light gap	54	366	51.4	16	113	11
Rock	4	43	6.1	1	11	1.1

from seasonal mid-night runoffs after heavy down pours on hill tops in July, August, and September. Beside run offs the preference of trees for nesting in the wet season may prevent invasion by wild ants and predators. In the Central African Republic (CAR) and in Gabon, tree nesting is known to increase during the wet months and drops steadily with the coming of the dry months (Remis, 1993; Tutin et al., 1995; Mehlman and Doran, 2002). At Kagwene, herbaceous vegetation was observed to be a favored material for ground nest construction as this provided a soft comfortable platform for the heavy body animals. Researchers at Mondika (CAR) and Dzanga-Sangha Reserve (Congo) found out that zero nests (bare earth) is a common phenomenon in the dry and wet seasons. However, at Kagwene within the two seasons of the year this phenomenon was rare. To the best of our evaluation, this disparity can be attributed to the fact that temperatures are cooler at Kagwene (12.9 to 24.2°C), than at Mondika and Dzanga-Sangha Reserves (21.1 to 28.4°C) (Rothman et al., 2006; Etiendem, 2013). This could explain why bare earth nests are in common occurrence (Tutin et al., 1995; Mehlman and Doran, 2002; Rothman et al., 2006).

According to Baldwin et al. (1981) and Koops et al. (2011), chimpanzees (*Pan troglodytes*) which are close relatives to gorillas are known to increase nesting height in the wet season within a class interval of 21 to 25 m. Gorillas in Kagwene showed a similar behavior but differed in their class interval preference of 11 to 15 m. Ukpong et al. (2011), attribute this disparity in class intervals between gorillas and chimpanzees to the large body size and weight of gorillas which prevents them from moving up in the trees in search of appropriate positions for nesting without any fear of accidents from broken tree branches.

Elevation is one of the factors that influence the location at which gorillas nest. The variation in elevation will depend on the area, as well as the environmental and anthropogenic factors affecting the environment in which the species is situated. Etiendem (2013), in his study at Mawambi Hill observed that Cross River gorillas were concentrated along elevations 401 to 550 m above sea level. In the Kagwene, the Cross River gorilla population was observed to be concentrated at elevation 1000 m and above. This situation is connected to habitat

fragmentation and high human presences at lower elevations (401 to 550 m) in the area which has forced the animals to move upwards into regions of lower habitat fragmentation and human presence. As a result, it seems that Cross River gorillas in the study area prefer high-altitude habitats that are difficult for humans to access, and therefore least disturbed by farming, hunting, grazing and other anthropogenic activities, than low-altitude areas with less complex topography. This is in line with Koops et al. (2011), who observes that chimpanzees of the Nimba Mountains occupy high elevations of 1000 m and above.

Primary forests were observed to be pre-dominantly used in the wet season for the construction of tree nests, while light gaps were commonly used in the dry season for the construction of ground nest. Nest site distribution in the study area was predominantly located in a particular area of the sanctuary (northern section of the study area). Our findings revealed that this area is the safest in the vicinity, due to its highly steep topography that has rendered access difficult to human activities. This falls in line with De Vere et al. (2010) and Remis (1993) who affirms that rough and steep hill sides are usually safe habitats for lowland gorillas due to the limited access of such habitats to the surrounding population.

Conclusion

This study reveals that, nest building by Cross River gorilla in Kagwene is strongly in response to seasonal changes (temperature and rainfall). An increase in rainfall and decrease in temperature influence more tree nesting, while decrease in rainfall with increase in temperature result to more ground nesting. The understanding of how nest construction is influenced by seasonal changes can certainly help to predict potential effects of longer term and large scale floristic changes due to climate change. The understanding of this phenomenon could help landscape managers of the area in the planning of activities for a better conservation of the species and its habitat. Our result has provided key information that can be used for the reorientation of tourist schedules in accordance with seasonality and availability of gorilla nests for tourist appreciation.

RECOMMENDATION

It was recommended that this study be extended to include parts of this landscape which is located across the border in Nigeria, where these species are known to migrate to and from in responses to seasonality and other ecological factors. Secondly, the migratory patterns of these species with respect to seasonal changes could also be investigated. Thirdly, the migratory corridors of these animals could also be investigated as this will provide key knowledge that can be used for the protection of these corridors if they are found out of the protected area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

REFERENCES

Baldwin PJ, Sabater PJ, Mcgrew WC, Tutin EG (1981). Comparisons of Nests Made by Different Populations of Chimpanzees (*Pan troglodytes*). Primates 22(4):474-486.

Bergl RA, Warren Y, Rawson M (2009). Kagwene Gorilla Sanctuary CyberTracker Manual.Wildlife Conservation Society (WCS) – Takamanda-Mone Landscape Project Annual Report.

Brownlow AR, Plumptre JA, Reynolds V, Ward R (2001). Sources of Variation in the Nesting Behavior of Chimpanzees (Pan troglodytesschweinfurthii) in the Budongo Forest, Uganda. Am. J. Primatol. 55:49-55.

De Vere RA, Warren Y, Nicholas A, Mackenzie ME, Higham J (2010). Nesting ecology of the Cross River Gorilla at the Kagwene Gorilla Sanctuary Cameroon, with special reference to anthropogenic influence. Am. J. Primatol. 71:1-9.

Etiendem ND (2013). Ecological and anthropogenic factors of Cross River gorilla (*gorilla gorilladiehli*) survival at Mawambi Hills, Southwest Cameroon: PhD thesis. VrijeUniversiteit Brussel, Belgium, unpublished.

Fruth B, Hohmann G (1996).Nest building behavior in the great apes: the great leap forward? Great ape societies Report, 11, 22-25.

Isabirye-Basuta G M, Lwanga JS (2008). Primate Populations and Their Interactions with Changing Habitats. Int. J. Primatol. 29:35-48.

Koops K, William C, McGrew, Han de Vries, Matsuzaw T (2011). Nest-Building by Chimpanzees (Pan troglodytesverus) at Seringbara Nimba Mountains: Antipredation, Thermoregulation, and Antivector Hypotheses. Int. J. Primatol. 29:64-73.

Lukas KE, Stoinski TS, Burks K, Snyder R, Bexell S, Maple TL (2003). Nest building in captive Gorilla gorilla gorilla. Int. J. Primatol. 24(1):103-124.

McFarland KL (2007). Ecology of Cross River gorillas (Gorilla gorilla diehli) on Afi Mountain, Cross River State, Nigeria. PhD thesis, City University of New York, USA.

Mehlman PT, Doran DM (2002). .Influencing western gorilla nest construction at Mondika Research Center. Int. J .Primatol. 23:6.

Morgan D, Sanz C, Robert JO, Strindberg S (2004). Ape Abundance and Habitat Use in the Goualougo Triangle, Republic of Congo. Int. J. Primatol. 26:61-81.

Neba F (2011). Spatial Point Pattern Analysis of Gorilla nest sites in the Kagwene Sanctuary, Cameroon (Master's thesis, Universitat Jaume I (UJI) Castellon, Spain.

Nicholas A, Warren Y, Bila S, Ekinde A, Ikfuingei R ,Tampie R (2010).Successes in Community-Based Monitoring of Cross River Gorillas (Gorilla gorilla diehli) in Cameroon.Takamanda-Mone Landscape Project. Afr. Primates 7(1):55-60.

Nkemnyi MF, Nkembi L, Nkemanteh AE, Nku EM (2011).The Cross River gorilla and large mammals species diversity in the in the Lebialem-Mone Forest Landscape, Cameroon. J. Biodivers. Ecol. Sci. 2(1):73-79.

Oates J, Sunderland-Groves J, Bergl R, Dunn A , Nicholas A ,Takang E, Omeni F, Imong I , Fotso R , Nkembi L , Williamson L (2007). Regional Action Plan for the Conservation of the Cross River Gorilla (Gorilla gorilla diehli). IUCN/SSC Primate Specialist Group and Conser vation International, Arlington, VA, USA.

Remis MJ (1993). Nesting behaviour of lowland gorillas in the Dzanga-Sangha Reserve, Central African Republic, Implications for population estimates and understandings of group dynamics. Yale University, Department of Anthropology, New Heaven U.S.A.

Rothman JM, Pell AN, Dierenfeld ES, Mccann CM (2006). Plant Choice in the Construction of Night Nests by Gorillas in the Bwindi Impenetrable National Park, Uganda. Am. J. Primatol. 68:361-368.

Sunderland-Groves J, Ekinde A, Mboh H (2009). Cross River gorilla (Gorilla gorilla diehli) nesting behaviour at Kagwene Mountain, Cameroon: implications for assessing group size and density. Int. J. Primatol. 30:253-266.

Tutin EG, Parnell RJ, White LJT, Fernandez M (1995). Nest building by lowland gorillas in the Lop´ e Reserve, Gabon: Environmental influences and implications for censusing. Int. J. Primatol. 16(1):53-76.

Ukpong EE, Jacob DE, Ibok PB, Nelson IU (2011). Nest Building Behaviour of Chimpanzee (*Pan Troglodytes blumenbach*) At Filinga Range of GashakaGumti National Park, Nigeria. J. Sci. Technol. 3:7.

Wiseman R, Warren Y, Nicholas A , Mackenzie M, Higham PJ (2008). A GIS Habitat Map for the Kagwene Gorilla Sanctuary, Cameroon.