academicJournals

Vol. 8(9), pp. 142-154, September 2016
DOI: 10.5897/JENE2016.0601
Article Number: 58526D460222
ISSN 2006-9847

http://www.academicjournals.org/JENE

Journal of Ecology and The Natural Environment

Full Length Research Paper

Nest Characteristics for the Conservation of the Grey Parrot in Cameroon

Simon A. Tamungang[1]*, Ghislain P. N. Kougoum[2] and Alexis Teguia[3]

[1]Department of Basic Sciences, College of Technology, University of Bamenda, PO Box 2164, Bamenda, Cameroon.
[2]Department Biological Sciences, Faculty of Science, University of Maroua, PO Box 814, Maroua, Cameroon.
[3]Department of Physiology and Animal Production, Faculty of Agronomy and Agricultural Sciences, University of Dschang, PO Box 222, Dschang, Cameroon.

Received 17 July, 2016; Accepted 10 August, 2016

The study was initiated to gather data on nest preferences of the Grey Parrot in Cameroon. Knowledge on nesting preferences of the parrot can be implemented in the field and captivity to improve on the breeding of Grey Parrots. The Kom National Park-Mengame Gorilla Sanctuary complex was chosen as a representative site in the country. A total of 40 sample plots of size 200 m x 200 m were randomly established and distributed to represent major vegetation types in the area. Line transects were established in each sample plot and data on nest characteristics were collected along them. Results revealed that nests were found in 14 tree species belonging to 12 families with high preferences for *Terminalia superba* (84%). Nest density varied between 0.23 to 0.45 nests/ha in various vegetation types and the highest density was recorded in the secondary forest. Nests entrance varied with a mean length of 13.2 ± 6.0 cm and a majority of them were rounded (85.42%) in shape. Nest concealment varied with tree height, 35.4 ± 6.1 m); trunk diameter, 90.8 ± 23,6 cm; height of nest from the ground 22.1 ± 6.4 m and canopy diameter,18.0 ± 6.1 m. Most nests of Grey Parrots were found in secondary forest (32.72%). The Grey Parrots tolerated degraded vegetation with suitable nests in nearby villages and were not, threatened through hunting and poaching activities from villagers. It strongly recommended that, villagers should learn to co-habitat with the Grey Parrot in their villages to enhance long-term survival of the bird species in the wild.

Key words: Grey Parrot, *Psittacus erithacus*, grey parrot nest, nest site, nest characteristics, parrot conservation.

INTRODUCTION

The endemic range of the Grey Parrot (*Psittacus erithacus*) covers a surface area of about 3 000 000 km^2 corresponding to approximately the area of the African rainforest and the surrounding woody savannah (Clavaud-Besson,1996).The species generally are found within the rainforest ecosystem in Central and West Africa and

*Corresponding author. E-mail: atamungang@yahoo.com.

marginally in East Africa (Fry et al., 1988). The parrot has a particular affinity for the tropical rainforest with low altitude, the edge of forests and clearings. The bird is a frequent visitor to gallery forest of the grassland, mangrove forest along Riverbanks, swamp forest, guinea savannah, cultivated farm, plantations and tall trees in parks. The bird can be observed sometimes in human gardens (Clavaud-Besson, 1996; Del Hoyo et al., 1997; Juniper and Parr, 1998; Hunt et al., 2002).

The Grey Parrot is a secondary cavity nester since it cannot excavate its own nest. On the contrary, a primary cavity nester like the woodpecker excavates a cavity and uses it for a nest (Fry et al., 1988). Therefore, the Grey Parrot relies on natural cavities formed in trunks of big trees up to many meters above ground (Tamungang and Cheke, 2012). The first step in nesting is the search for a nest site, which may be at the beginning of a breeding season and vary from species to species as well as from habitat to habitat (Pain et al., 2006). In most bird species, both sexes cooperate in looking for a nest, but the female determines the appropriate one (Brawn and Balda, 1988; Ramos et al., 1997). Sustainable population growth of the Grey Parrot its endemic range therefore depends on the availability of suitable nest cavities for active population recruitment (Martin, 1993).

Nevertheless, the destruction of habitats of the Grey Parrot is today the greatest threat to the survival of the species in the range states (Martin et al., 2014; Olah et al., 2016). Habitat encroachment and fragmentation by humans often has subtle and far-reaching effects that are not readily apparent at the beginning. As patches of habitats become smaller and more isolated from each other, the Grey Parrot which is known to require a large home range (Tamungang et al., 2001) finds itself restricted to areas that are too small for its food, shelter and reproductive requirements. Such a parrot in the isolated habitat with reduced size is much more vulnerable to nearby human activities such as poaching, pesticide use, air pollution and noise. Consequences of these activities are population depletion that could lead to local extinction if the pressure continues on the birds for a long time. The rapid destruction of the rainforests therefore has an alarming implication for both humans and the animals. It is estimated that 1.10 x 103 km^2 of rainforest were destroyed in Cameroon between 1981 to 1985 (Food and Agricultural Organization (FAO), 2000). Myers (1989) made a combined estimate of deforestation of rainforests in Cameroon, Congo, Gabon and Zaire at 4, 200 km^2 in 1980 and 7,300 km^2 in 1989. About 70% of rainforests in Cameroon have already been destroyed (GFW, 2000). In another study Tamungang et al. (2013) noted that no primary forest is left in Cameroon outside the remaining National Parks and Reserves. With improving road networks, rising prices of timber and increasing number of rainforest species being used, many forests are being repeatedly exploited unsustainably (FAO, 2000). This situation has been worsened by the current economic crisis and a big slash in salaries of civil servants and in the face of inadequate environmental education and weak wildlife law enforcement. Extensive poaching and illegal parrot trade are some of the major challenges facing sustainable Grey Parrot conservation proponents in Cameroon (Tamungang et al., 2016b).

Thus, high socioeconomic exploitation pressure of the parrot habitats leads to the destruction of nests and nest sites, which in turn reduces breeding pair potentials (Amuno et al., 2010; Tamungang and Cheke, 2012). The paucity of studies on nesting, site characteristics of the Grey Parrot and the urgent need for such information for informed conservation management and policy decisions which was the driving force behind the initiation of the study. Hence, results of the research will be used to ameliorate habitat conditions for improved breeding activities of parrots in the wild by reducing human impact on critical nesting sites and also to improve the design of captive breeding facilities of the parrot around the world.

Concisely, identifying critical nest characteristics and conserving a majority of the nesting sites of the Grey Parrot and the values associated with them is a contribution in consonance with the current global efforts in the conservation of biological diversity and in fulfilment of a unique role of African rainforests as a repository of genetic resources. Thus, the need for effective conservation and management of parrot resources as an integral part of our biological diversity may not be over emphasised.

MATERIALS AND METHODS

Study area design

The first phase of data collection was a broad base survey of nest sites of the Grey Parrot in the entire South Region of Cameroon. However, to reduce the surface area of the study a more detailed study was carried out in the proposed Kom National Park (KNP) and the adjacent Mengame Gorilla Sanctuary (MGS) Complex which has more varied vegetation representing major vegetation types that can be found in the Grey Parrot range in the South Region of Cameroon. The general survey was carried out from 2008 to 2010 and the detailed study in the KNP-MGS Complex was conducted from November 2010 to December 2014 (Figure 1).

The KNP-MGS complex is located between latitudes 2°15'and 2°25' N; and longitudes 11°40' and 12°42'E. It covers an area of about 958 km^2 found in the lowland rainforest of the Congo Basin. The complex is rich in species diversity, composed of many types of sub-ecosystems (evergreen rainforest, swamp forests, raffia palm forests, and secondary forests). The Complex is bordered to the South by Kom River which is the natural border between Cameroon and Gabon to the North by Mvangane and Oveng Sub-Divisions to the West by Lobo River and to East by Djoum Sub-division Figure 1.

The study area had an average annual temperature of about 24°C and the rainfall from 1500 to 2000 mm. It usually rains throughout the year with two maxima: in September to October (long rainy season) and March to April (short rainy season). The minima occur in December to January (long dry season) and July to August (short dry season) (Laclaviere, 1980).

Identification and distribution of nests

Sample plots of 200 m x 200 m each were selected and considered to be random representative of the vegetation types with a spacing distance of at least 200 m apart (Scherrer, 1984). Thus a total of 40 sample plots were obtained for the study area and distributed as follows: 10 in primary forests, 10 in secondary forest, 10 in cocoa plantations and 10 in annual crop plantations(Figure 1). Four lines transect each with a length of 200 m and a width of 50m were established in each sample plot for data collection. An observer walked along the middle of each line transects and observed at a distance range of 0 to 25m on each side to identify and count cavities. The initial nest inventory were carried out during non-breeding months of the Grey Parrot to avoid disturbing of any breeding pair. When a cavity was detected a pair of binoculars was used to observe details of its size and suitability for a parrot nest.If it was suspected to be suitable for nesting; an observer climbed the tree and made detailed observations. Robes made with tough nylon materials were, used as tree climbing gears. Two robes of about 50 m but of different weights were frequently used. A very light robe was tied on carved stone and thrown over a tree branch to roll over it and fell back to the ground. A big robe was then tied to the light one and pulled to roll over the same tree branch. The climber then gripped the big robe on the tree branch and used it to climb the tree to the position of the nest. When the climber reached the nest he pointed the torch-light beam into it. Clues of the bird activity (such as loose feathers and eggshells or even abandoned eggs) were, looked for in the cavity. When any of such clues were found, it could be concluded that the nest was that of a Grey Parrot.

In the whole study area 362 trees were identified as potential nesting hollows for Grey Parrots. Difficulties were encountered in accessing many of these nesting trees, as some of them were found in flooded or marshy areas. Finally 120 nests were maintained carefully, examined for active occupancy and monitored for nesting activities. Since most of the nests were not concealed the investigators could easily monitor their entrances from a few meters away while hiding below the nest-bearing tree on a line transect. The 120 nests were located in plantations (18 nests) primary forest (25 nests) and secondary forest (77) in the study area. An identification number was assigned to each nest and the coordinates were recorded by GPS.

Dimensions of nests and nest sites

Further close examination of each nest was carried out exclusively outside reproduction period of the parrots (November to February) to avoid disturbing a breeding pair. For close examination and measuring nest dimensions a trained tree climber used the robe climbing gears to climb each tree to the level of the nest. For nest dimensions information was collected on the diameter of the entrance depth and internal diameter. For more accurate measurements of the depth of nest, a long flexible ribbon tape of about 150 cm was introduced into the nest until it touched the bottom. The tape was then marked at the entrance of the nest and the readings recorded in centimetres.

For measurements of the internal width of the nest the tape was introduced horizontally into the nest until it touched the opposite side. The corresponding point at the entrance was then marked and read in centimetres. Each tree climber had a “parrot nest mirror” (a periscope with a mirror and a torch) that was locally made and used for observations and descriptions of the contents of the nest. The instrument was pointed at a reasonable height at the entrance of a nest and a torch light pointed into the nest. The light from the bottom of the next reflected on the mirror and the nest contents was observed.

The height of each nest from the ground was measured using a 50 m tape when the climber was at the level of the nest. Canopy diameter of each nest-bearing tree was measured by the vertical projection of the canopy edges at ground level. Two perpendicular diameters of each canopy were taken and the average recorded. The total height of tree bearing the nest was measured by triangulation method with the aid of a laser meter. The circumference of each tree trunk was measured at breast height using a ribbon tape graduated in meters. When the buttress of the tree was more than 2 m above the ground a scaffolder was built to allow measurement of the circumference of the tree trunk; this technique enabled us to calculate the diameter of the nest-bearing tree from the following formula:

$$D = C / \pi$$

Where C = circumference (cm)

D = diameter (cm)

π = 3,14

Characteristics of nest sites and especially the vegetation cover were described. These parameters were measured to determine the impact of neighbouring trees on nest site selection criteria. All the trees found within a circle with 25 m radius whose centre was the tree bearing the nest were measured.

Tree species with nest cavities were identified by botanists from the National Herbarium in Yaoundé, Cameroon. For this purpose the fresh leaves were harvested and preserved using paper and cardboard presses. For trees that seemed difficult to be identified their roots bark and fruits of the tree were also collected and stored in sealed plastic bags and labelled. Likewise the local names, collection sites, the season and other characteristics of tree species were noted. The type of vegetation around the nest-bearing tree was recorded and classified into three categories: primary forest (dense evergreen rainforest) secondary forest, cocoa plantation and annual crop plantation (corn field, cassava field, fallow farms, etc.).

Determination of nests occupancy rate.

Active nests were, identified and monitored during breeding seasons to determine the nests occupancy rates**.** A major indicator of valid occupancy was the active and frequent presence of a breeding pair around the nest site. Key observed activities of a breeding pair included going in and out of a nest, guiding of the nest from predators and feeding of nestlings (Amuno et al., 2010). The best time to observe active nest occupancy was during the breeding season for example from May to October. During this period a breeding couple was regularly seen near their nest. When a parrot was not found around a suspected nest a machete was used to hit the trunk of the tree and resulting noise draw the attention of the bird and it sent out its head to see where the noise was coming from or flee away. If there was no reaction from the nest, it was assumed that there was no bird in there. This method allowed us to distinguish between active nests and those not active following two to four consultative visits per month.

Statistical analyses

The density of nests in each vegetation type was calculated by dividing the number of nests encountered by the total area of the plot. The entire area of each tree canopy was calculated and then divided by the area of the circle ($\pi r^2 = 3.14 \times 25^2$). This method enabled us to, obtain the vegetation cover and was, expressed in percentage. ANOVA test was used for the comparison of mean nest measurements between active and inactive nests at the

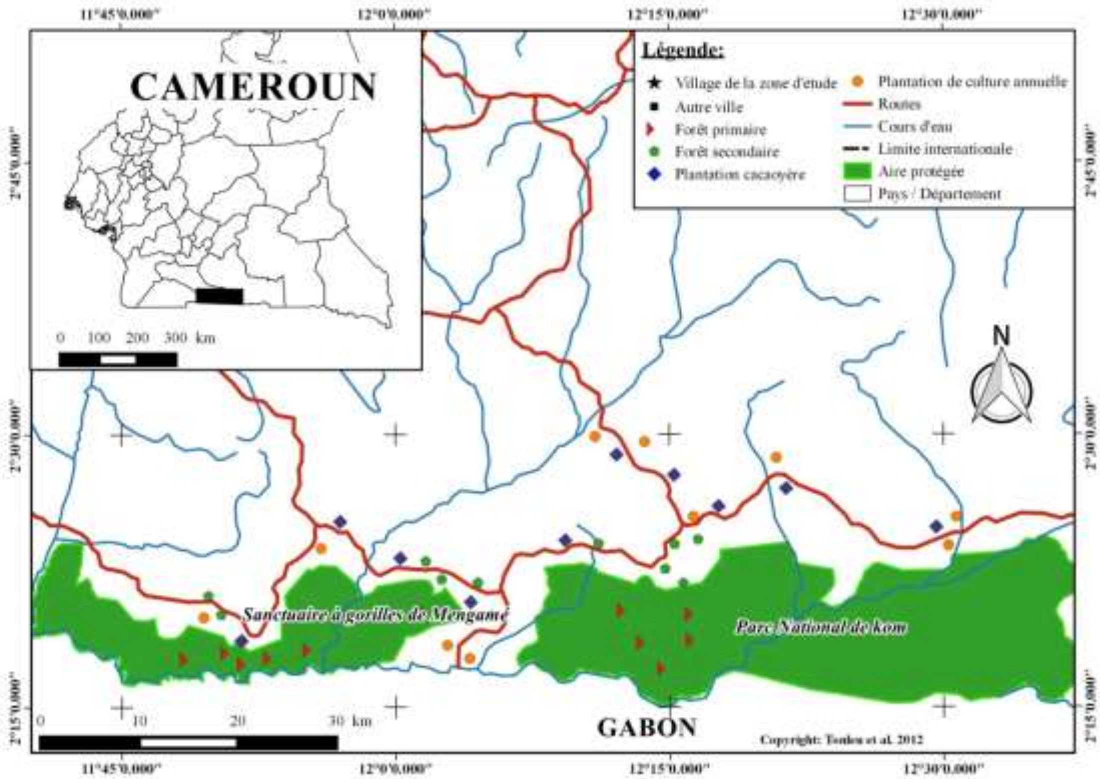

Figure 1. General presentation of the proposed Kom National Park - Mengame Gorilla Sanctuary Complex (green) in the South Region of Cameroon showing sample plots layout and physical features. Copyright: Tonleu et al. 2012.

probability level, α = 0.05. Chi-squared test was used for the comparison of nests occupancy rates over years in the different localities and the nests repartition on the type of vegetation (α = 0.05). The normality of nest characteristics was tested using the Kolmogorov and Smirnov method. When the samples did not show normal distribution, a non-parametric test of Kruskal-Wallis was, used. The equality between variances was, tested using the Barlett test. The regression and correlation methods were carried out using the GraphPad InStat 3.0 software for various variables (nest height, trunk diameter, canopy diameter, nest entrance length, the internal diameter of the nest and nest depth).

RESULTS

Distribution of nest density

Cavities were observed on many tree species in the study area and those associated with the Grey Parrot identified and carefully monitored for confirmation. Nests of Grey Parrots were found in many sites in the field and were identified for both in primary and secondary forests and both active and fallowed farms. The forest tree species were more diverse than those found in the farmland. Table 1 presents the distribution of nests densities in major vegetation types in the study area. The total density of nests of the Grey Parrot in the sampled area of 160 hectares was 0.43 nest/ha, corresponding to 69 nests identified. The density of occupied nests (54) in the study area was slightly lower than the total number of identified nests and corresponded to 0.34 nests/ha. When major vegetation types in the study area were considered the highest occupied nest density was observed in secondary forest (0.45 nests/ha) and lowest in seasonal crop plantations (0.23 nests/ha). These were farms used to grow seasonal crops like maize and beans which were harvested within a season (rainy or dry seasons).

Height of tree with nest

Nests were found on very tall trees of 25 to 45 m in the forest. A majority of tree species identified with parrot nests were usually found in secondary vegetation. The lowest nest cavity was at 9 m (two nests had this measurement) and the highest was at 37 m. The smallest circumference of these nesting trees was 180 cm. A majority of them had circumferences ranging from 184 to 231 cm. The largest circumference value was 244 cm and the record was obtained only on one tree. It should be noted that trees such as *Terminalia* spp. Had most of their buttresses at breast height and their

Table 1. Density of nests in major vegetation types on the KNP-MGS Complex.

Vegetation	NTN	NO	SE	Density (number of nest/ha)	
				Total density	DNO
Primary forest	23	16	40 ha	0.58	0.40
Secondary forest	20	18	40 ha	0.50	0.45
Cocoa plantation	14	11	40 ha	0.35	0.28
SC plantation	12	9	40 ha	0.30	0.23
Total	69	54	160 ha	0.43	0.34

NTN: total number of nest; NO: number of occupied nest; SE: surface area sampled; DNO: density of occupied nests; SC: seasonal crop .

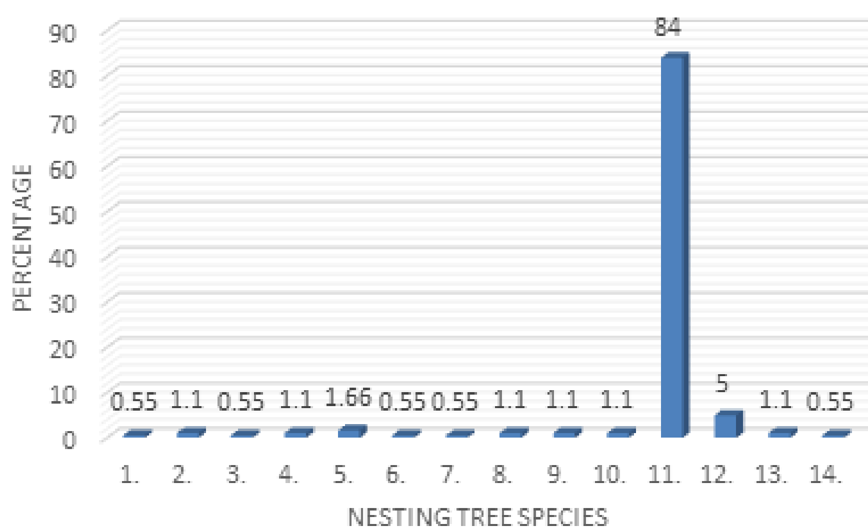

Figure 2. Proportions of tree species used by Grey Parrot for nesting.

circumferences were, measure above the buttresses using a scaffolder. All identified nests were found on the main stem or bole of the tree (Figure 6). A majority of them were found between 1 to 5 m below the crown of each tree (Figure 6H).

Nest tree species used by the Grey Parrot

As a secondary nester the Grev Parrot relies on natural agents to create suitable nests and uses them as an opportunist for breeding. Naturally many tree species form cavities but not all the cavities can be used for breeding by the parrot depending on the suitability of each of them. Figure 2 represents the percentage of nest tree species which were identified and used by Grey Parrot for breeding activities. It was observed that 14 nesting tree species belonging to 12 distinct families *(Combretaceae, Euphorbiaceae, Sterculiaceae, Bombacaceae, Apocynaceae, Caesalpiniaceae, Irvingiaceae, Myristicaceae, Rutaceae, Lecythidaceae, Mimosaceae* and *Fabaceae*) were used by the Grey Parrot for the nests. The trees were use in varying percentages and *Terminalia superba* was the most frequently used tree with a relative proportion of 84%. The frequency of *Terminalia superba* was therefore significantly different (P<0.05) from the other tree species sampled Figure 2.

1. *Ceiba pentandra*
2. *Alstonia boonei*
3. *Crotono ligandrum*
4. *Cylicodiscus gabunensis*
5. *Distemonanthus benthamianus*
6. *Irvingia gabonensis*
7. *Klainodosa gabonensis*
8. *Petersianthus macrocarpus*
9. *Pterocarpus soyauxii*
10. *Pycnanthus angolensis*
11. *Terminalias superba*
12. *Triplochiton scleroxylon*
13. *Uapaca guineensis*
14. *Zenthoxylum heitzii*

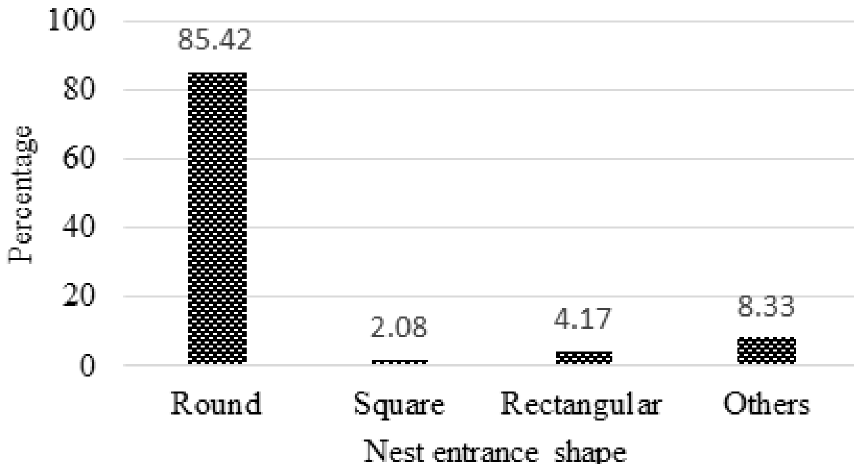

Figure 3. Shapes of entrance of nests used by the Grey Parrot.

Table 2. Measurements (mean ± SD) of nesting trees and nest cavities of Grey Parrots in three sample sites of the South Region in Cameroon.

Parameter	Oveng	Kom NP	Mengame	Total
Trees height (m)	35.7 ± 6.3	37.2 ± 5.2	33.3 ± 6.2 *	35.4 ± 6,1
Trunk diameter (cm)	91.4 ± 24.6	94.0 ± 22.6	87.0 ± 23.7	90.8 ± 23.6
Diameter of canopy(m)	18.4 ± 6.0	19.3 ± 5.8	16.2 ± 6.1 *	18.0 ± 6.1
Nest height from the ground (m)	22.6 ± 6.2	23.5 ± 6.4*	20.1 ± 6.4	22.1 ± 6.4
Nest entrance width (cm)	12.4 ± 2.6	12.4 ± 2.8	11.5 ± 1.8	12.1 ± 2.4
Internal diameter of nest (cm)	33.1 ± 7.1	34.1 ± 6.7	33.2 ± 8.0	33.5 ± 7.3
Depth of nest (cm)	74.3 ± 14.0	79.1 ± 15.7	76.4 ± 15.2	76.7 ± 15.04

SD = Standard Deviation, * = Significant difference from other localities.

Triplochiton scleroxylon was the second most used tree species with a frequency of 5% (Figure 2). The two most used trees are secondary vegetation species. Nesting trees were usually dominant in height surrounding trees and especially tree canopy in the site where they were found. Although climbers such as vines were usually found at the site they were in most cases absent on crowns and stems bearing useful nests to the parrots.

Shape of nest entrance

Natural tree cavities have various forms or shapes and the entrance into each nest can be used as a criterion for occupancy. Results on the shape of each nest used by the Grey Parrot is presented in Figure 3. Shapes of entrance identified were round, square, rectangular and the rest were an intermediary between these forms (classified as 'others'). It is clear from Figure 3 that the forms of nest entrance used by the parrot were diversified. However, nests with rounded entrance were the most common (85.42%), followed by those with a mixture of all forms designated as 'others' (8.33%), then by rectangular nests entrance (4.17%), and lastly by nests with squared entrance (2.08%). A significant difference ($P<0.05$) was observed between the proportions of round nest entrance compare to 'other' forms of nests.

Dimensions of trees and nests used by the Grey Parrot

Natural forces create cavities in various forms depending on many factors including the species and age of tree and the environmental conditions. From the preceding results we have observed that some tree species such as *T. superba* frequently provide such suitable nests. However, the unanswered question is, 'What makes an appropriate nest of a Grey Parrot'? We took dimensions of active Grey Parrot nests in this study as an attempt to know the important criteria for a suitable nest. Table 2 shows average nest measurements and those of trees containing the nests in the three localities of the study

Table 3. Matrix of correlation between nests characteristics of the Grey Parrot.

	Tree H	Trunk D	C D	Nest H	Nest L	I D	Nest Dp
Tree H	1	0.4388 (0.0000)	0.3822 (0.0000)	0.1100	0.3044 (0.0009)	0.0655	0.1590
Trunk D	0.4388	1	0.6200 (0.0000)	-0.0160	0.0785	0.1405	0.0649
C D	0.3822	0.6200	1	0.0739	0.0199	0.1094	-0.0538
Nest H	0.1100	-0.0160	0.0739	1	0.1309	0.3736 (0.0003)	0.0046
Nest L	0.3044	0.0785	0.0199	0.1309	1	0.0439	0.3033 (0.0001)
I D	0.0655	0.1405	0.1094	0.3736	0.0439	1	0.1590
Nest Dp	0.1590	0.0649	-0.0538	0.0046	0.3033	0.1590	1

Bold print = *significant values, at level α = 0.05 (bilateral test); (…) = probability values*

H = height, D =diameter, CD= tree canopy diameter, L = length, ID= Internal Nest Diameter, Dp = depth.

area.

The results presented in Table 2 shows that no significant difference was observed in nest depth internal diameter, width of the entrance, length of the entrance and the diameter of the trunks among the different localities. The mean height of nests in KNP were significantly higher ($P < 0.05$) compared to that of Oveng and Mengame area. The average height of trees in Mengame was significantly lower ($P < 0.05$) when compared to Oveng and Kom National Park localities.

The correlation between nests characteristics and tree dimensions were very variable (Table 3). Only one nest was, observed at a height less than 10 m. Very few nests had depths greater than 100 cm, 5 of the 120 nests (0.04%). On one hand, the Grey Parrot prefers nests that are not too deep or too shallow (with a range of 40 to 70 cm). It was noted that nests which had depth less than 30 cm, had an upward cavity extension that increased the volume of the internal cavity. On the other hand, a majority of nests used by the Grey Parrot were located on the upper three-quarter region of the tree trunk or on the stem of a broken branch firmly attached on the trunk.

From the matrix of correlation presented in Table 3, it was evident that the height of trees was significantly correlated with the diameter of the trunks, diameter of the canopy and the length entrance of the nest. The diameter of the trunks was significantly correlated with the diameter of the tree canopy. Nest height was, not significantly correlated with the internal diameter of the nest. A significant correlation was also observed between nests entrance length and the nests depth.

The position of a nest on a tree is important for many reasons, including the security of the animal that can live in it. Data from this study show that the ratio of the heights of nest cavities to the height of trees was equal to 65.02% (n = 144). This result means that the cavity is placed in the upper part of the tree, usually on the trunk (70.14%, (101 of 144 nests) or at the end of a broken branch more or less adhered to the trunk (29.86%, 43 of 144). Preferred nests by the parrot were located on tall trees up to 40 m rather than on low ones. Suitable nests were rarely found on secondary tree branches.

Nest materials

Attempts were made to identify various types of substrates used in nests by the Grey Parrot. Active nests could not be visited for this exercise because human presence could disturb nesting activities. Active nests were visited during non-nesting seasons. The bottom of each nest was inspected using a beam of light from a torch pointed to the bottom of the nest and the bottom viewed through a hand held reflecting mirror. Major substrates identified in the nests were dust from rotten wood, leaves, faeces and feathers. Figure 4 shows the various materials used as substrates at the bottom of the nests. It was evident from the result that at least one type of material was found in the nest of the Grey Parrot. In some cases, a combination of the materials was found in a nest such as wood dust and feathers or wood dust, feathers and faeces or feathers.

The dead wood dust was derived from the walls of the nest as these materials were observed to have the same texture. When preparing the nest at the onset of the nesting season the parrot pecks the walls with its beak and deposit the chips and dust at the bottom of the nest. This behaviour continues during incubation of the eggs as it has the habit of peaking on objects around its vicinity. Wood dust and chips serve as cushion and warmth insulators for the eggs and chicks. They are supplemented with down feathers during egg incubation.

The parrot prefers dry wood dust to the wet one. It was suggested that the wet wood dust found in the nests were as a result of rain splash or leakage of the nests. Least materials found in nests were eggshells derived from either hatched eggs or predated ones. Only 4.86% of the nests contained debris of eggshells. Faeces were found in all the used nests and were assumed to be left by the chicks after fledging. It is not known that the Grey Parrot brings in materials into the nest. The presence of leaf debris in the nest might have been dropped by the wind

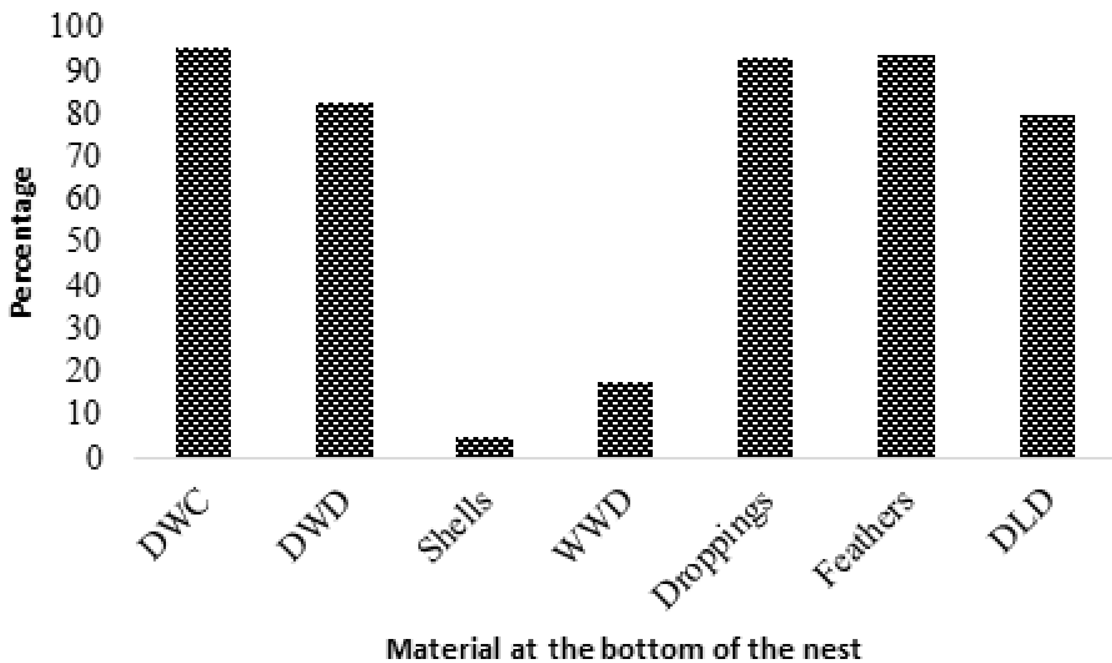

Figure 4. Various materials used as substrates at the bottom of the nests.
DWC = Dead Wood Chips; DWD = Dry Wood Dust; WWD = Wet Wood Dust; DLD = Dead Leaves Debris.

parrot themselves or other animals such as squirrels or birds that can also use the nest especially during non-nesting seasons of the parrots.

Distribution of nests

The vegetation cover of most nest sites, were greater than 30% Figure 5. Few nests were found with vegetation cover of less than 10 %. The nests with vegetation cover less than 30% were found in plantations with annual crops where some trees were left to provide shed to crops. Above 70% of the vegetation cover 24 nests were found and this was in mixed secondary and primary vegetation Figure 5. A majority of parrot nests were present in secondary forest with a proportion of 32.72 % (16 nests over 54). This value was followed by primary forest (30.25%, 16 nests), cocoa plantations (19.75%, 11 nests) and finally by annual crop plantation with the lowest proportion of nests (17.28 %, nine nests). However, no significant difference *(X^2 = 4.730; dl = 3; p = 0.1926)* was observed in the distribution of nests in relation to vegetation type in the study area. The Grey Parrot nests were found close to human habitats such as villages, compounds and road sites. A few nests were found within 100 m from the nearest houses in villages. Between 100 m and 500 m, 23 out of a total of 120 identified nests were found representing 19.16% of the nests. A majority of the nests were found further than 2 km and beyond from nearest houses in villages.

DISCUSSION

Nests density and tree species used by the grey parrot

The highest density (0.45 nest/ha) of active nests were found in secondary forest. This density is slightly greater than that obtained (0.373 nests/ha) by Tamungang and Cheke (2012) in some localities of the South and East Regions of Cameroon. A secondary forest is a logged primary forest or degraded agricultural land which has been abandoned to regenerate for many years. Such a forest is good at producing trees with suitable nest cavities for the Grey Parrot. This vegetation type also attracts many other birds and especially understory species (Bobo and Waltert, 2011), since they are rich in food diversity (Tamungang and Ajayi, 2003) and other habitat resources. Other importance of a secondary forest to a primary forest for the Grey Parrot are that trees may be less congested and therefore provide good visibility for security thereby reducing predator access to nest contents. In a similar study carried out by Tamungang et al. (2016a) in the South West Region of Cameroon, it was observed that the population of the Grey Parrot was higher in mixed secondary and farmland outside the Korup National Park than inside the park area (which was mainly primary forest).

In several sampled localities (Oveng, Akom I Mebassa, Endone, Bitche, Mengame I) nests were found within a distance of 50 meters from the village squares where the

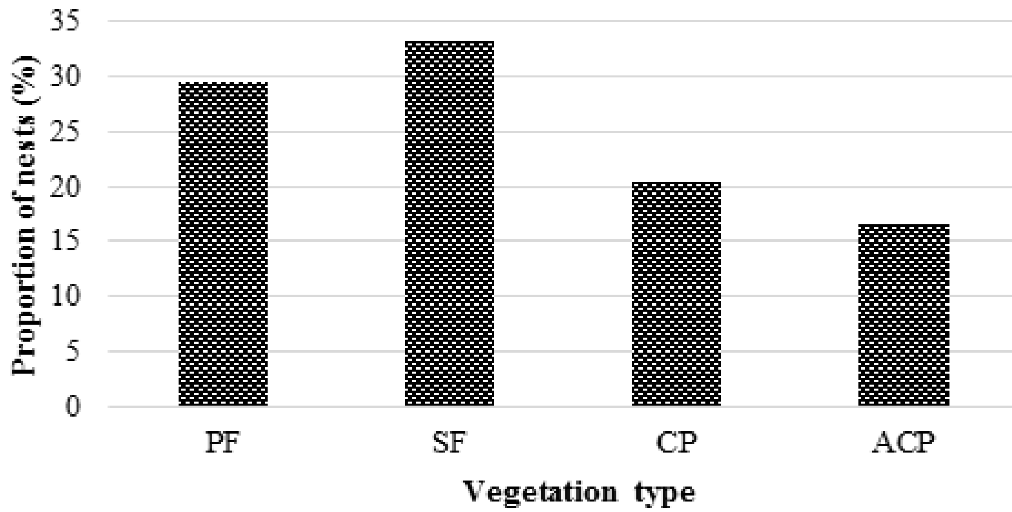

Figure 5. The distribution of nests according to landuse patterns indicated by vegetation types. PF = Primary Forest, SF = Secondary Forest,CP = Cocao Plantation, ACP = Annual Crop Plantation

breeding parrot became habituated to human presence. The birds can only be habituated to the human presence if humans have not threatened them in the recent past. The low nest density observed in annual crop plantations (0.23 nests / ha) could be explained by the fact that selective clearing of tree vegetation to enable crops to have access to sunlight and limits the availability of suitable nesting trees. The density of natural cavity breeding birds such as the Grey Parrot can be negatively influenced by the scarcity of suitable nests. Since natural forces provide such nests in a random manner the Grey Parrot searches for a nest that meets its desired characteristics. Finding a nest that meets such requirements is not an easy task for the bird since there can be in intra-specific and inter-specific competitions for such a nest. Similar observations were made by Brightsmith (2005) and Heinsohn and Legge (2003). This difficulty can push a ready to breed pair of parrots to take up unsuitable nests or postponing nesting activities until when a suitable nest is found. A breeding parrot pair may take up an inadequate nest that meets some minimum nesting conditions as shown in Figure 6I. The work of Newton (2007) revealed that the scarcity of nests can influence the densities of breeding pairs of birds in natural cavities. This shortage of nest can limit the physical size of the breeding population of birds as described by Beissinger and Bucher, (1992); Martin et al., (2014).

The Grey Parrot used fourteen tree species for nesting. Most of the nests were found in the trunks of *Terminalia superba* (family, Combretaceae), a tree species highly preferred by the parrot for nesting activities (Figure 6H). The use of similar tree species has been documented in other bird species like the Electus Parrot (*Electus roratus*) (Heinsohn and Legge, 2003). In Sumba Island, 83% of nests of the Electus Parrot were found in two tree species (*Tremameles*), (Marsden and Jones, 1997). This frequency of use of woody species is closer to the one obtained (84 %) by this study for *T. superba*. There is a huge destruction of secondary forest trees for plantation farming in the endemic habitats of the Grey Parrot. The consequence of deforestation can be a direct reduction of the number of nesting sites which leads to the reduction of the population size of the Grey Parrot and similar breeding bird species (Bessinger and Bucher, 1992; Tamungang et al., 2013; Olah et al., 2016).

Conservation implication of various nest characteristics

The first step of bird nesting is to search for a suitable nest site. The need for an appropriate support and concealment as well as the need for protection against opposing forces of the environment governs the selection of the site (Figure 6). In general birds that nest in natural cavities (like the Grey Parrot) are more restricted in their choice of suitable nests than those that create nest cavities (like woodpeckers) and those that build nests using twigs on a tree (like warblers) (Brawn et al., 1988; Kerpez and Smith, 1989; Blem and Blem, 1994). Moreover, a bird that builds its nest is more flexible in searching for a more suitable site and use better materials for its construction. An ideal nest becomes difficult for a Grey Parrot to find since, it relies on natural agents to create a suitable nest cavity. The first restriction is that cavities are not readily available since any tree species cannot produce one. The second restriction is that even if a cavity is found it may not meet the desired conditions of the bird (Figure 6). A suitable nest may therefore lack one or two desired characteristics since the bird could not modify its nest to a certain extent (Figure 6 I). If the bird cannot cope with the existing conditions of the nest and it cannot change the structure of the nest to a certain extent to suit its preferred condition it abandons it and looks for a more suitable one. A closer look at nest features can reveal some of the challenges faced by the parrot in search for a suitable nest.

Nest entrance

Natural cavities are formed with various entrances depending on the forces that led to the formation of the cavity and its position on the tree the size and species of the tree. As a secondary nester the Grey parrot selects without modification an entrance to a nest that suits its desired characteristics. Most of the desired characteristics are to ensure the security of the parent birds and the juveniles.

The Grey Parrot prefers nests with rounded entrance (Figure 6E). The formation of cavities with a circular entrance in the trunks or branches of *Terminalia superba* is higher than in other species of trees and the Grey.

Parrot takes full advantage of it for a nest cavity. Nest entrance dimensions vary and may not be suitable depending on how the nest was formed. An extra big entrance makes the nest contents vulnerable to predation while and an extra small entrance makes movement in and out of nest by parent birds difficult.

The depth of nest and internal diameter

Most African parrots select their nests in the holes found in the tree trunks and some have specific requirements that make them suitable for breeding (Mawson and Long, 1994; Nelson and Morris, 1994). However, little information exists on nests characteristics of the Grey Parrot in tropical rainforests (Marsden and Jones, 1997). The Grey Parrot selects its nest generally in deep holes in the trunks of big trees formed on the tree trunk or the stem of a branch with a large diameter. If the depth is too shallow the bird has a risk of being, exposed to predation. If the nest is too deep movement in and out of the nest may be challenging to the parent birds especially when taking care of the broods. Furthermore, a nest that is too deep exposes the bird to a high risk of predation since it may not readily escape from imminent danger. It was observed that while sitting in the nest a parent Grey Parrot frequently sticks out its head outside the nest to monitor any disturbance or imminent danger outside the nest. The bird can fly out of the nest depending on the nature of the threat. The bird would have difficulties in monitoring such danger and escaping if the nest is very deep. An optimum depth value is often chosen to maximise optimum breeding conditions by the parrot. The internal diameter of the potential nest may be too short to accommodate the parent bird(s) and the future nestlings (Figure 6F). The nest may be too deep to permit easy accessibility (movement in and out) and to provide good security (Figure 6C).

Tree height and height of nest

The height of a nest is shorter than tree height since the nest is located below the tree canopy (Figure 6H). The height of a nest is crucial for a successful breeding season and this is even more important in the rainforest with frequent rainfall and floods. Very tall trees provide higher nests which are above the canopy of emergent surrounding vegetation and hence free from too much humidity and lianas (Figure 6H). Larger mammalian predators may also reach such heights to eat the contents of active nests. The commanding height of nest also offers an excellent visibility for monitoring of nest against predators. However, the mean height of the trees was significantly lower in Mengame compared to that of another area. This can be explained by the fact that outside the protected area in Mengame big trees were exploited by villagers for the creation of plantations artisanal work and by logging companies. Even inside MGS big cocoa and banana plantations are found. The height of nest from the ground may not be safe from predation. Snakes, squirrels and Falcons can prey on the eggs and nestlings of the parrot.

Nest orientation and concealment

The majority of nests entrance occupied by, the Grey Parrot were situated against rain splash and the surrounding vegetation. This disposition limits the entry of rainwater into the nests also enhances security from a predator that can use the surrounding vegetation to enter the nest (Figure 6C, D, I). Wind and rain directions about nest entrance are dangerous as they may cause nest drainage problems. This observation is the main reason why some nests had dry wood dust while others had wet wood dust. Dry wood dust makes a better nest since it is void of rain infiltration.

Conclusion

The Grey Parrot does not choose a nest for breeding randomly; certain minimum criteria are met in selecting a suitable nest. A suitable nest is a natural cavity on a truck or a branch of a tree sufficiently high from the forest floor, with a round entrance that is not too small or big, limit rain infiltration, must, not be concealed by surrounding vegetation and must not be too deep or too shallow. In the wild it is difficult for the parrot to meet the ideal nest

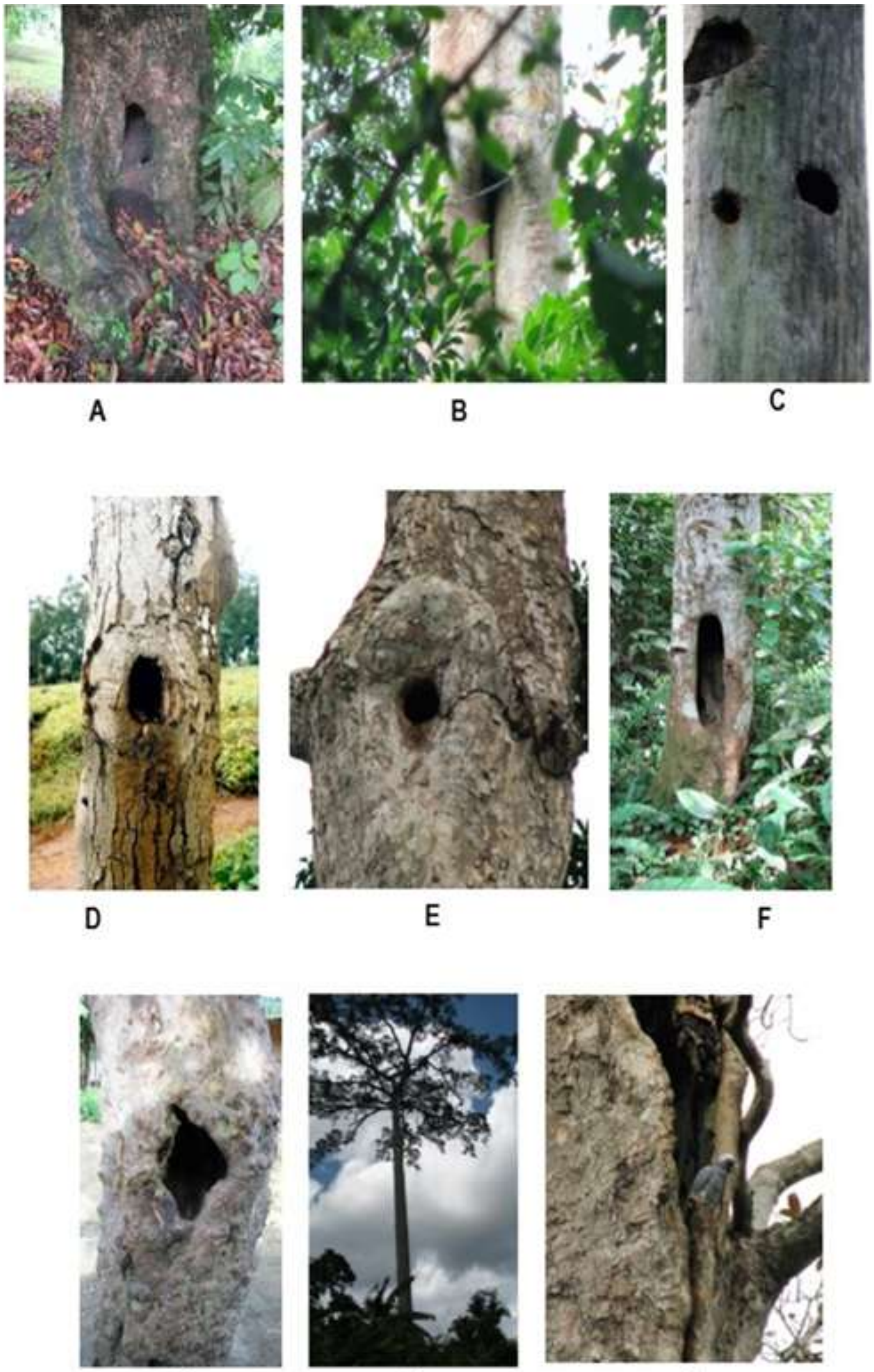

Figure 6. Types of natural tree cavities in the range of the Grey Parrot in Cameroon,depicting the difficulties encountered in selecting a suitable nest for breeding.Source : Fieldwork 2008-2012.

characteristics and so the bird tends to optimise its choices for a suitable nest and time for guarding its juveniles against predators. Optimisation enables the bird to compromise some unfavourable features that can eliminate some competing ecological pressures. Favourable nest characteristics enable the Grey Parrot to have a successful breeding season by raising the highest possible number of fledging chicks. Environmental constraints include intra- and inter-specific competition from other cavity nesting birds and small mammals such as squirrels.

Nest shortages are caused by many factors, which may be natural or anthropogenic events. The biggest anthropogenic problem is that of deforestation, which drastically reduces the natural number of nest cavities that can be used by the parrot for breeding. Physical factors include the inability of many tree species to produce suitable nest cavities that meet the desired characteristics of the Grey Parrot. Knowledge on nesting preferences of the parrot can be, implemented in the field and captivity to improve on the breeding of Grey Parrots. Specifically, results of this study can be used to design artificial nests to improve the number of natural cavities in the wild.

RECOMMENDATIONS

(i) Lack of suitable nest sites can be a major limiting factor to the population growth of Grey Parrots in Cameroon. This problem statement can be tested by carrying out a study on nest density and occupancy in relation to Grey Parrot population growth over time.
(ii) Due to nest scarcity, Grey Parrots can re-use the same nests for many breeding seasons. Similarly, lack of suitable nests can cause some parrots to occupy unsuitable nests as shown in Figure 6 I. More information is needed through radio tracking of parent birds to ascertain re-use of nests and types of competition nesting exhibited.
(iii) The indiscriminate felling of nest trees for socio-economic goals lead to nest scarcity for parrots. It is recommended that:

An enrichment planting of nesting tree species should be carried out in protected areas and in their support zones to increase nest availability to the parrots.

Artificial nest cavities should be made with the characteristics presented by this study and tested for breeding of Grey Parrots.

Results of this study and similar ones have shown that Grey Parrots prefer to use secondary forest nesting trees and roosts around human settlements than primary forests. It is strongly recommended that villagers should learn through conservation education programmes to co-habitat with the Grey Parrot in their villages to enhance long-term survival of the bird species in the wild.

Conflict of interest

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

This study was, supported with the financial assistance from PARROTPRO and with the support of Cameroonian Government through the Ministry of Forestry and Wildlife. Thanks to the authorities of Oveng Sub-Division, the Conservator of Kom National Park-Mengame Gorilla Sanctuary Complex (Mr Zang Mbarga), Eco-guards, Rural Communities, tree climbers, porters, and Forest guides for their services and hospitality. Immense thanks for the logistic support from the staff of the Laboratory of Biology and Applied Ecology (LABEA), Department of Animal biology of the University, Cameroon.

REFERENCES

Amuno JB, Massa R, Okethowengo G (2010). Some observations on nesting African Grey Parrots, *Psittacus erithacus*, in Uganda. Riv. Ital. Orn. 80(1):57-59, 31-XII.

Beissinger SR, Bucher EH (1992). Sustainable harvesting of parrots for conservation. In. New World Parrots in crisis. Beissinger, S. R. & Snyder, N. F. R. (Eds). Washington, DC: Smithsonian Institution Press. pp. 73-115.

Blem CR, Blem LB (1994). Composition and Microclimate of Prothonotary Warbler Nests. Auk 111(1):197-200.

Bobo KS, Waltert M (2011). The importance of agricultural areas for bird conservation in the Korup region, South-western Cameroon. Int. J. Biol. Chem. Sci. 5(2):419-432.

Brawn JD, Balda RP (1988). Population biology of cavity nesters in Northern Arizona: do nest sites limit breeding densities? Condor 90:61-7I.

Brightsmith DJ (2005). Competition, predation and nest niche shifts among tropical cavity nesters: ecological evidence. J. Avian Biol. 36:74-83.

Clavaud-Besson HJ (1996). Contribution à la connaissance du Perroquet Gris d'Afrique (*Psittacus erithacus*). Thesis: Méd. Vét. Toulouse. 329 p.

Del Hoyo J, Elliott A, Sargatal J (1997). Handbook of the Birds of the World, Volume 4, BirdLife International, Lynx Edicions. 679 p.

FAO - Food and Agricultural Organisation of the United Nations (2000). Global Forest Resource Assessment, Main Report.

Fry CH, Keith S, Urban EK (1988). The Birds of Africa, Vol.3, Academic Press, London, UK.

GFW- Global Forest Watch, Cameroon (2000). An overview of logging in Cameroon. A Global Forest Watch Cameroon Report, World Resources Institute, Washington, DC, USA.

Heinsohn R, Legge S (2003). Breeding biology of the reverse-dichromatic, co-operative parrot *Eclectus roratus*. J. Zool. 259:197-208.

Hunt GR, Corballis MC, Gray RD (2002). Animal behaviour: Laterality in tool use manufacture by crows. Nature 415(6872):602.

Juniper T, Parr M (1998). Parrots. A Guide to the Parrots of the World. Sussex: Pica Press. 584 p.

Kerpez TA, Smith NS (1989). Nest-site selection and nest-cavity characteristics of Gila Woodpeckers and northern flickers. Condor 92:193-198

Laclaviere G (1980). Atlas de la République unie du Cameroun. Edition Jeune Afrique. Paris. 72p.

Marsden SJ, Jones MJ (1997). The nesting requirements of the parrots and hornbill of Sumba, Indonesia. Biol. Conserv. 82:279-287.

Martin RO, Perrin MR, Boyes RS, Abebe YD, Annorbah ND, Asamoah A, Bizimana D, Bobo KS, Bunbury N, Brouwer J, Diop MS (2014).

Research and conservation of the larger parrots of Africa and Madagascar: a review of knowledge gaps and opportunities. Ostrich 85(3):205-233.

Martin TE (1993). Nest Predation and Nest Sites. BioScience 43(8):523-532.

Mawson PR, Long JL (1994). Size and age parameters of nest trees used by four species of parrot and one species of cockatoo in south-west Australia. Emu 94:149-155.

Myers N (1989). Deforestation Rates in Tropical Countries and Their Climatic Implications. Friends of the Earth, London, UK.

Nelson JL, Morris BJ (1994). Nesting requirements of the yellow-tailed black-cockatoo, *Calyptorhynchus funereus*, in *Eucalyptus regnans* forest, and implications for forest management. Wildl. Res. 21(3):267-278.

Newton CA (2007). Forest Ecology and Conservation. Series editor: William J. Sutherland. Oxford University Press, 471p.

Olah G, Butchart SHM, Symes A, Guzmán IM, Cunningham R, Brightsmith DJ, Heinsohn R (2016) Ecological and socio-economic factors affecting extinction risk in parrots. Biodivers. Conserv. 25:205-223.

Pain DJ, Martins TL, Boussekey M, Diaz SH, Downs CT, Ekstrom JM, Garnett S, Gilardi JD, McNiven D, Primot P, Rouys S et al.,(2006). Impact of protection on nest take and nesting success of parrots in Africa, Asia and Australasia. Anim. Conserv. 9(3):322-330.

Ramos JA, Monteiro LR, Sola E, Moniz Z (1997). Characteristics and competition for nest cavities in burrowing Procellariiformes. Condor 99:634-641.

Scherrer B (1984). Biostatistique. Edition: Gaëtan Morin. 850 p.

Tamungang SA, Cheke RA (2012). Population Status and Management Plan of the African Grey Parrot (*Psittacus erithacus*) in Cameroon. Full report prepared by MINFOF for CITES Secretariat, Geneva, Switzerland. 158 p.

Tamungang SA, Ajayi SS (2003). Diversity of food of the Grey Parrot in Korup National Park, Cameroon. Bull. Afr. Bird Club 10(1):33-36.

Tamungang SA, Ayodele IA, Akum ZE (2001). Basic Home Range for the Conservation of the African Grey parrot in Korup National Park, Cameroon. J. Cameroon Acad. Sci. 2(3):155-160.

Tamungang SA, Cheke RA, Kougoum GP, Ntiri ES (2013). Linking population size to conservation needs of the Grey Parrot in Cameroon. Int. J. Biodivers. Conserv. 5(8):478-485.

Tamungang SA, Ofeh MA, Tchamba MN, Cheke RA, Kougoum GP (2016b). Challenges and conservation implications of the parrot trade in Cameroon. Int. J. Biol. Chem. Sci. 10(3):1210-1234.

Tamungang SA, Onabid MA, Taku A II, Balinga VS (2016a). Habitat preferences of the Grey Parrot in heterogeneous vegetation landscapes and their conservation implications. Int. J. Biodivers. Volume 2016 (2016), Article ID 7287563, 10 pages.