GUILD OF FRUGIVORES ON THREE FRUIT-PRODUCING TREE SPECIES (*POLYSCIAS FULVA, SYZYGUIM guineensis SUBSP. BAMENSDAE* AND *POUTERIA ALTISSIMA*) IN NGEL NYAKI FOREST RESERVE, A MONTANE FOREST ECOSYSTEM IN NIGERIA.

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ABSTRACT
This research was conducted in Ngel Nyaki Forest reserve, a montane forest ecosystem located at the western escapement of Mambilla Plateau, Taraba State, Nigeria. The area comprises core montane forest and riparian forest fragments. The aim was to investigate the nature of the guilds of fruit-eating animals (frugivores) found on three montane forest tree species, Polyscias fulva, Syzyguim guineensis subsp. bamendae and Pouteria altissima. Observations were made during the fruiting season to determine frugivore composition on each of the focal tree species. Observations were continued until almost all fruit had been removed prior to selecting another focal tree of the same species. The frugivore guilds were found to overlap in the three focal tree species although there was minimal overlap between Pouteria altissima and the other two species. This may be explained by the fact that P. altissima is present in the main forest, where the majority of the fruit consumers are found, and absent from the fragments. Furthermore the large size of P. altissima fruit limited frugivores to those with wide gapes. Both P. fulva and S. guineensis subsp. bamendae were found in both the main forest and the fragments. In the fragments extraction, deforestation and bush burning have resulted in severe tree species loss resulting in the predominance of pioneering species. One of the means of recovering tree species diversity within these important forest fragments would be to protect the area from grazing and burning, thereby creating refugia for frugivores to inhabit and from there disperse seed.

Key words: *Frugivores, Fruit trees, Montane forest, Seed Dispersal*

INTRODUCTION

Fleshy fruits have most likely evolved to ensure seed dispersal by frugivores away from the parent tree (McKey 1975, Howe and Estabrook 1977). In this mutualism fruit provide frugivores (mainly birds) with energy and nutrients from their fleshy pulp (Howe and Smallwood 1982). However while fruits comprise the major diets of many frugivores, very few birds (Izhaki and Safriel 1988) and no mammals are obligate frugivores. The reason for this is not obvious, but the nutrient value of the fruit pulp of any single fruit species is insufficient for a balanced diet (Izhaki and Safriel 1988). While some specialized frugivores are able to feed on high quality fruits rich in fats and proteins (Snow 1976) more commonly frugivores are facultative (Izhaki and Safriel 1988; Snow 1981). While many birds depend on fruits for food for at least part of the year (Howe, 1984) they have evolved to survive on a mixed diet of less nutritious fruit species supplemented by seeds and/or insects. A similar scenario has evolved in frugivorous animals (Snow 1981). This strategy leads to efficient dispersal, with fruit being moved away from the parent tree (Izhaki and Safriel 1988) at different distances and to different sites (Jordano & Schupp, 2000).

Patterns of seed dispersal and frugivore mediated seed shadows depend on a number of factors including fruit choice by frugivores- a consequence of nutrient value and resource

availability (Gautier-Hion *et al.,* 1985), fruit handling behavior (i.e. swallowing or spitting) (Jordano & Schupp, 2000), gut retention time and fruit size (Herrera 1984; Wheelwright - 1985). In terms of fruit size, a significant positive correlation between fruit size and gape width or body mass of frugivores has been reported (Wheelwright – 1985; Brewer 1997).

In tropical forests with a high proportion of fleshy fruited trees (Howe 1984) , local extinction of frugivores can have negative consequences on seed dispersal, which in turn can have other indirect effects on the forest community (Howe, 1976). The general consequence could be a widening circle of extinctions, preceded by the disappearance of one pivotal species (Howe, 1977; Bond 1994; Stoner *et al*., 2007).

It is within this context that this contribution reports on a study to determine which frugivores feed on fruits of *Polyscias fulva, Syzyguim guineensis* subsp. *bamendae* and *Pouteria altissima.* Description of the study area

Montane forest ecosystems in Nigeria are found on the Jos Plateau and also on the expansive sweeps of Cameroon Mountains between 1400-1830m above sea level (Chapman & Chapman, 2001). The research was conducted in and around the 46 km^2 Ngel Nyaki Forest Reserve (7°30'N, 11°30'E), located on the Mambilla Plateau in Taraba State, Nigeria, at an elevation of approximately 1550 m. This reserve contains 7.5 km^2 of contiguous forest (*from here on in this paper referred to as the main forest*) which is the largest on the Plateau (Chapman and Chapman, 2001). Remnants of riparian forest (*from here on in this paper referred to as fragments*) line the banks of streams which criss-cross the grasslands close to the main forest edge The mean annual rainfall of c. 1800 mm occurs mainly between mid April and mid October (Nigerian Montane Forest Project Rainfall data). Mean monthly maximum and minimum temperature for the wet and dry season are 26°C and 13°C, and 23°C and 16°C respectively (Chapman and Chapman, 2001).

Ngel Nyaki is one of the most floristically diverse montane forest stands in Nigeria) and at least four endangered tree species are common: *Entandrophragma angolense*, *Lovoa trichilioides, Millettia conraui* and *Pouteria altissima.* Resident forest dwelling primates include the Endangered Nigerian Chimpanzee (***Pan troglodytes vellerosus)*** (Beck and Chapman, 2008) the locally uncommon Mona monkey (*Cercopithecus* ***mona)*** and the locally common Putty nose monkey (*C. nictitans*) (Chapman *et al.,* 2004) which is considered to be the genetically distinct, *C. nictitans* subspecies *martini (J. F. Oates pers. com).* Other species (see above) include *Papio anubis* and *C. t tantalus*). This forest is an IUCN Important Bird Area and is likely a centre of diversity for amphibian and reptilian spp. (Blackburn, 2010).

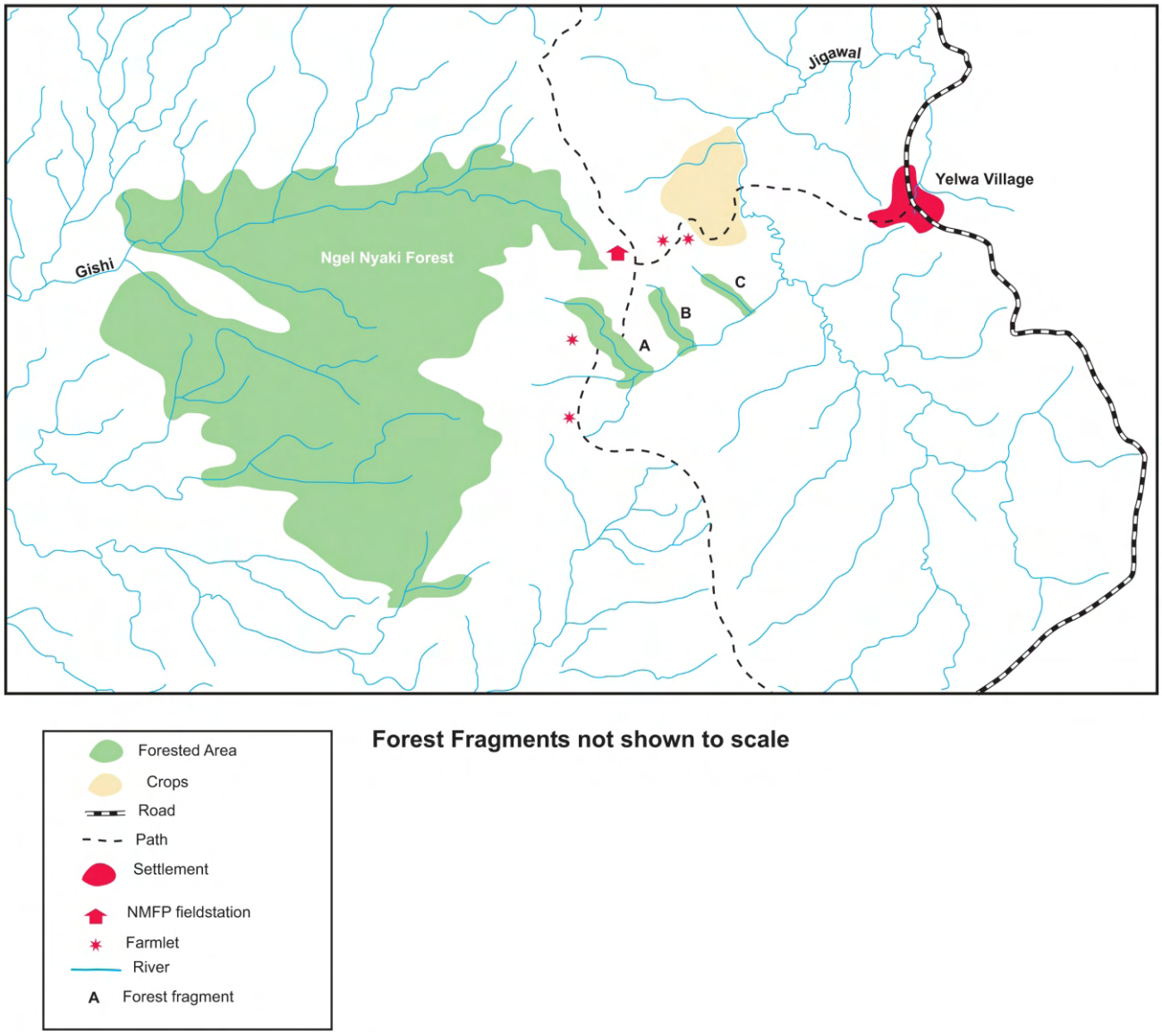

Figure 1: Map showing the study site

MATERIALS AND METHODS

Study specie

The study was conducted in the main forest of Ngel Nyaki Forest Reserve. Three key tree species were selected for this study based on their fruit size (ranging from large to small- see below) and on their being observed to attract frugivores during the fruiting season.

Pouteria altissima (A. Chev.) Baehni (*Sapotaceae*) is a large canopy tree associated with montane to mid altitude forests across Africa (Keay 1964). The ripe fruit is a brown drupe measuring 24mm in diameter and 30mm in length (Fig 2). At the Ngel Nyaki study site it was confined to the interior of the main forest, and was absent from the riparian fragments. *P. altissima* is an IUCN Red Data List species.

Figure 2: Seed of *Pouteria altissima*

Polyscias fulva (Hiern) Harms, (*Araliaceae*) is an evergreen tree species associated with Afromontane forest and forest margins, particularly as a pioneer in clearings. It has a straight trunk and large leaves up to 80cm long. The ripe fruit is a two-seeded drupe, purple/black in colour. It is 4mm in diameter and 5 mm in length (Keay 1964). *P. fulva* occurred in both the main forest of Ngel Nyaki forest reserve and in the riparian fragments.

Syzyguim guineensis (Willd). subsp. *bamendae* F. White (*Myrtaceae*) is a medium-sized evergreen tree 10- 20 m high associated with Nigerian/Cameroon montane and riparian forest above approximately 1500m. The ripe fruit is a purple drupe and measures 20mm in diameter and 30mm in length (Fig 3) (Keay 1964).Within the study area it is found mostly on forest edge and in the fragments.

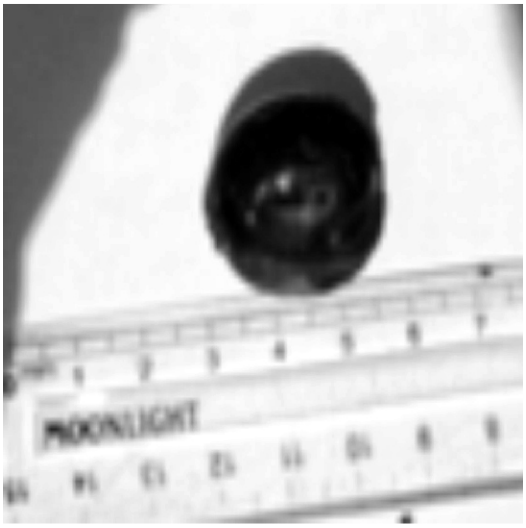

Figure 3: Seed of *Syzyguim guineensis* subsp. *Bamendae*

METHODS

Frugivore and Fruit-tree identification and observation

When each species was fruiting, the observer identified three focal individual trees of each species as they were beginning to fruit, to observe for frugivore behavior. Observations of frugivore visitors were made between the hours of 06.00-10.00 am GMT and 16.00-18.00 pm GMT. The observer watched from a distance of about 20m from the focal tree, under cover in order not to scare the animals. They recorded all visits to the tree by frugivores. This study continued from the time of onset of fruiting until all the fruits had been removed. Multiple visits by frugivores were documented, although for the purpose of this particular contribution only presence/absence data was used in the analysis. Birds were identified using Borrow & Demey (2004).

Characteristics of fruit of *Pouteria altissima, Polyscias fulva and Syzyguim guineensis subsp. bamendae*

At the time the fruits were being fed on by the frugivores, the observer removed from each of the study tree species a total of thirty fruits each from different parts of tree canopy (low, middle, and high). Using calipers, the observer measured the diameter and length of each of the fruit to the nearest millimeter to create average diameter and length values.

RESULTS

Guild of frugivores on *Pouteria altissima, Polyscias fulva and Syzyguim guineensis subsp bamendae*

Table1 lists the frugivores observed to be feeding on the three tree species. A total of 28 different frugivores belonging to 13 families were observed and identified. Fig 4 is a network diagram illustrating the interaction among the three tree species and their frugivores. The network is assymetrical, and many more frugivore species (22) were observed feeding on S. *guineensis* subsp. *bamendae* and *P. fulva* (20) than on than on *P. altissima* (9). Six species of frugivore, including the monkey *Chlorocebus tantalus tantalus,the baboon Papio anubis, the squirrel Funisciurus anerythrus and the birds Ceratogymna fistulator, Zosterops senegalensis and Treron calvus* were observed to feed on all the three tree species. There was also overlap in species feeding on both *P.fulva and S. guineensis* subsp. *bamendae.* Nine bird species (*Columba sjostedti, Pycnonotus barbatus, Streptopelia semitorquata, Streptopelia hypopymha, Lybius bidentatus, Tauraco persa, Tauraco leucolophus, Crinifer piscator and Hypergerus atriceps*), belonging to five families, fed on both tree species. Two primate species (***Pan troglodytes vellerosus*** and *Cercopithecus nicitans*) were observed feeding on both *P. altissima and P. fulva. Only one species of frugivore, Gymnobucco calvus, was observed to feed on both P. altissima and S. guineensis* subsp. *bamendae* (Table 1, Figure 4).

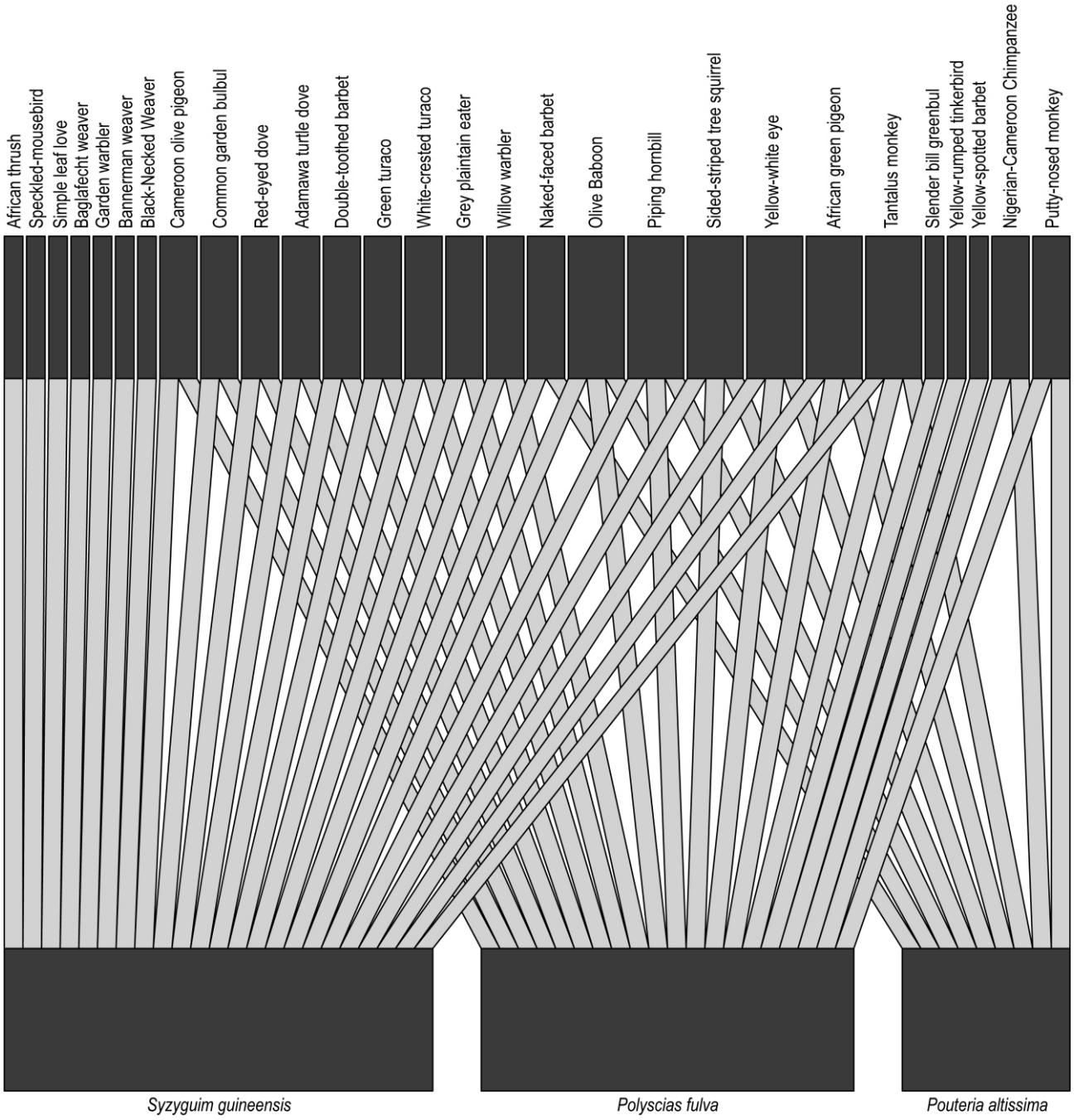

Figure 4: Guild of Frugivores on *Pouteria altissima, Polyscias fulva and Syzyguim guineensis subsp. bamendae showing overlap.*

TABLE 1: Frugivores identified feeding on the fruits of three Afromontane forest species, *Pouteria altissima, Polyscias fulva and Syzyguim guineensis subsp. bamensdae.*

FRUGIVORES			FRUIT-PRODUCING TREE SPECIES		
COMMON NAME	**FAMILY**	**SCIENTIFIC NAME**	***Pouteria altissima***	***Polyscias fulva***	***Syzyguim guineensis* subsp. *bamendae***
Tantalus monkey	CERCOPITHECINAE	*Chlorocebus tantalus tantalus*	+	+	+
Nigerian/Cameroon Chimpanzee	PONGIDAE	*Pan troglodytes*	+	+	-
Olive Baboon	CERCOPITHECINAE	*Papio Anubis*	+	+	+
Putty-nosed monkey	CERCOPITHECINAE	*Cercopithecus nicitans*	+	+	-
Piping hornbill	BUCEROTIDAE	*Ceratogymna fistulator*	+	+	+
Sided-striped tree squirrel	SCIURIDAE	*Funisciurus anerythrus*	+	+	+
Naked-faced barbet	CAPITONIDAE	*Gymnobucco calvus*	+	-	+
Yellow-white eye	ZOSTEROPIDAE	*Zosterops senegalensis*	+	+	+
African green pigeon	COLUMBIDAE	*Treron calvus*	+	+	+
Cameroon olive pigeon	COLUMBIDAE	*Columba sjostedti*	-	+	+
Common garden bulbul	PYCONOTIDAE	*Pycnonotus barbatus*	-	+	+
Red-eyed dove	COLUMBIDAE	*Streptopelia semitorquata*	-	+	+
Adamawa turtle dove	COLUMBIDAE	*Streptopelia hypopymha*	-	+	+
Double-toothed barbet	CAPITONIDAE	*Lybius bidentatus*	-	+	+
Green turaco	MUSOPHAGIDAE	*Tauraco persa*	-	+	+
White-crested turaco	MUSOPHAGIDAE	*Tauraco leucolophus*	-	+	+
Grey plaintain eater	MUSOPHAGIDAE	*Crinifer piscator*	-	+	+
Willow warbler	SYLVIIDAE	*Hypergerus atriceps*	-	+	+
Slender bill greenbul	PYCONOTIDAE	*Andropadus gracilirostris*	-	+	-
Yellow-rumped tinkerbird	CAPITONIDAE	*Pogoniulus bilineatus*	-	+	-
Yellow-spotted barbet	CAPITONIDAE	*Trachylaemus purpuratus*	-	+	-
African thrush	TURDIDAE	*Turdus pelios*	-	-	+
Speckled-mousebird	COLIIDAE	*Colius striatus*	-	-	+
Simple leaf love	PYCONOTIDAE	*Chlorocichla simplex*	-	-	+
Baglafecht weaver	PLOCEIDAE	*Ploceus baglafecht*	-	-	+
Garden warbler	SYLVIIDAE	*Sylvia borin*	-	-	+
Bannerman weaver	PLOCEIDAE	*Ploceus bannermani*	-	-	+
Black-Necked Weaver	PLOCEIDAE	*ploceus nigricollis*	-	-	+

Source: Daily observation of frugivores at Ngel Nyaki Forest Reserve by Ihuma, Jerome

Fruit characteristics of Pouteria altissima, Polyscias fulva and Syzyguim guineensis subsp. bamendae.

The characteristics of the fruits from the three selected tree species are presented in Table 3.

Table 3: Characteristics of tree fruit.

	Fruit characteristics				
Tree species	**Mean Diameter (mm)**	**Mean Length in (mm)**	**Colour**	**Seed No**	**Type**
Polyscias fulva	4	5	Purple/black	2	Drupe
Pouteria altissima	24	30	Brown	1	Drupe
Syzyguim guineinse	20	30	Purple	1	Drupe

Source: Measured fruit data at Ngel Nyaki Forest Reserve by Ihuma, Jerome.

DISCUSSION

In recent decades, studies of the interactions between fruit and their vertebrate consumers have generated a great deal of interest (Dowsett, 1988), although dealing with a whole class of vertebrates, such as birds, has been rare (Frost, 1980). Rather investigation has been carried out into assemblages of vertebrate fruit consumers on fruit-producing plants or there has been investigation into habits of a single bird or mammal species (Philips, 1926, 1927, 1928; Frith, 1957; Snow, 1962; Gautier-Hion, 1971; Alexandre, 1978). In contrast other work has focused on assemblages of birds species, mainly attracted to the fruits of particular trees (Land, 1963; Willis, 1966; Leck, 1969, 1981; Bronstein & Hoffmann, 1987) or the behavour of phylogenetically-related groups of consumers (Snow & Snow 1971; Crome, 1975; Gautier-Hion, 1980; Beehler, 1983).

Co-adapted features of fruits that influence choice by frugivores include colour (e.g. Turcek, 1963; Wheelwright & Janson, 1985), size (limited in birds by gape width: Wheelwright, 1985a), structure (e.g. Gautier-Hion *et al*., 1985; Pratt & Stiles, 1985) and accessibility (Snow, 1971; Moermond & Denslow, 1983). In this study, 28 frugivore species were found to feed on one or two or all the three focal tree species as seed predators or dispersers (Fig. 4).

The majority, although not all) of the frugivores that fed on the fruits of P. altissima were large relative to passerine birds, and had a large gape width. This was predictable as the fruit of P. altissima is generally large (24 mm in diameter and 30 mm in length). Moreover the larger-gaped frugivores, other than C. tantalus tantalus, were never observed in the riverine forest strips/fragments. These observations therefore go a long way in explaining why P. altissima is not found in the riverine forest strips/fragments. The majority of the frugivore guild on P. altissima do not cross over the grassland to the fragments but are permanent residents of the main forest. Dispersal of P. altissima is therefore limited to the bulk of the main forest where the animals capable of dispersing these large seeds are found. This result is consistent with the finding of Ihuma 2007 & Ihuma et al, 2011 who found that the main forest was very diversified in terms tree species compared to the surrounding forest fragments. Frugivores with small gape width which were

observed feeding on P. altissima included the birds G. calvus, Z. senegalensis and T. calvus. However, these relatively small gaped species were only observed to peck chunks of fleshy pulp out of the fruit, and could not swallow fruit whole.

In contrast to P. altissima, large numbers of frugivores from a wide range range of families were found to feed on P. fulva. This was attributed to the fruit's small size (4mm in diameter and 5mm in length), making it available to all groups of frugivores including mammals, passerines and non-passerines birds. It therefore follows that in Ngel Nyaki forest reserve, P. fulva will be found in the main forest and some in the important riverine forest fragments. It is not limited to the main forest but is also present within the fragments.

S. guineensis subsp. bamandae which has relatively large fruit (4mm in diameter and 5mm in length) was never the less widely consumed in both the main forest and the forest fragments. As with P. altissima small passerines such as S. borin ate chunks of the fleshy pulp and didn't swallow the seed whole. In the main forests there were sufficient large gaped frugivores to swallow the fruit whole, and in the fragments C. tantalus tantalus and T. leucolophus were both common. Moreover, secondary dispersal by the sided-striped tree squirrel (F. anerythrus) was observed by the squirrel moving intact seed away from the parent plant.

Seed of S. guineensis subsp. bamendae was also observed in the faecal samples of donkeys, tantalus and putty nosed monkeys and mongoose in open grassland between the fragments and the main forest. This is an indication that S. guineensis subsp. bamendae serves as a major dietary component of a large number of frugivores and its extinction would have a long term negative effects that would probably perturb the ecosystem.

This work is the first contribution of its kind towards understanding seed dispersal in a Nigerian Montane forest. The results indicate that dispersal is asymmetric, and that the interplay between seed and frugivore size are important in determining tree species distributions. In terms of frugivore loss, the fragments in this study may already reflect local tree extinctions as a result of loss of large gaped frugivores. However, future research is required to fully understand such interactions.

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