Land use and ecosystem services: a case study of seed dispersal in Benin, West Africa

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Abstract
The majority of tropical plants rely mainly on seed dispersal to guaranty natural regeneration and for their maintenance in natural habitats. We assessed how far land use in the traditional agroforestry system affects food resources availability and the abundance of animals that act as seed dispersers like fruit bats. In farmed lands of the north-western Benin the shea butter tree, an important agroforestry plant, is not cultivated but only preserved. We reported higher fruit production of shea trees in farmed lands compared with the protected areas. Its fruit were eaten by bats that in turn dispersed seeds contributing thereby to the natural regeneration of the plant. Shea fruits were the most consumed among the 7 different fruit species identified from faecal samples and from ejecta pellets but also from seeds dropped under feeding roosts. The three common fruit bats species of the region showed different relative abundance patterns between farmed lands and protected areas. Furthermore, the three bats species displayed different diet behaviour on shea fruits. Due to the quasi systematic collection of fruits and seeds of shea tree by local people for shea butter making, we recognized the seed dispersal as a crucial ecosystem service on which the conservation of this tree species depends.

Key words: Agroforestry system, fruit bats, land use, seed dispersal, tree conservation.

Introduction

Traditional agriculture is the dominate activity of the rural populations in Sub-Saharan Africa (Tiffen 2003, Beintema & Stads 2004). This farming system induces a rapid reduction in natural vegetation coverage because people believe that natural ecosystems have rich soils suitable for cropping. Population growth in rural areas goes with fallows periods becoming more and more shortened (Boffa 1999, Lovett & Haq 2000, Djossa et al. 2008a). Cash flow culture like cotton promotion complicates the situation and lead to land conversion. Therefore, natural vegetation is quasi completely cleaned and only selected utilized native plants are preserved (Agbahungba & Depommier 1989, Maranz & Wiesma 2003). Indigenous woody plants of savanna parklands, with edible fruits, are important for household in terms of consumption for rural people (Okullo et al. 2004). To fulfil these needs, local rural communities select desired tree species and individuals (Maranz & Wiesma 2003). Thus, each landscape type reflects the local population's activities (Neumann et al. 1998, Boffa in Maranz & Wiesman 2003). Parklands in savanna region in Western Africa are therefore dominated by fruit producing woody plants like *Vitellaria paradoxa*, *Tamarindus indica* and *Diospyros mespiliformis* which fruits are eaten and marketed providing substantial support for households (Oliver 1999, Ayuk et al. 1999). Thereby, plants composition and structure are affected (Djossa et al. 2008a). These changes in natural ecosystems due to human's intervention are likely to affect food resources availability for fruit eating animals such as bats (Djossa et al. 2008b).

Food resources availability is a major condition to attract and maintain animal populations (Yamagiwa et al. 2008). Fruit bats like many other animals migrate in food penury condition (Hodgkison et al. 2004, Richter & Cumming 2006, Djossa et al. 2008b). A large number of plant species depend on fruit bats for either pollination and/or seed dispersal (Fujita & Tuttle 1991). In the savanna Sudanian region the shea butter tree is a socio-economically important plant but not yet cultivated so it relies on seed dispersal by fruit bats to guaranty its natural regeneration (Djossa et al. 2008b). The presence of these fruit bats is crucial since many other seed dispersers are actually lacking in this region as reported in many parts of Africa, where changes in land use and hunting for bushmeat (Fa et al. 2005, Thibault & Blaney 2003) are leading to a serious decline in large to medium-sized seed dispersers, including elephants, antelopes, and primates. In the study area, the aid of fruit bats was crucial because due to the multiple use of the shea butter trees' products fruits and seeds were quasi completely collected underneath fruiting trees so that the transportation of some seeds relatively far from the fruiting tree is an important service for the natural regeneration of this plant species. Fortunately, the shea fruits constitute a key food source for fruit bats during its fruiting period (Djossa et al. 2008b).

The aim of this study was first to assess how far land use influence food resources availability for fruit bats. We then surveyed simultaneously in protected areas (Biosphere Reserve of Pendjari) and in farmed lands the fruit production of 5 selected woody plants that are utilized by fruit bats. Three of these plants are also used by local rural communities (*Vitellaria paradoxa*, *Tamarindus indica* and *Diospyros mespiliformis*) and two not directly utilized by them (*Detarium microcarpum* and *Sarcocephalus latifolius*). Second, we evaluated the fluctuation of the abundance of the three common fruit bats with regard to food resources but also the importance of the shea fruits in their diets as this socio-economically important plant species still need seed dispersal for its natural regeneration. We therefore sampled bats and faecal samples to recognize fruit eaten by fruit bats. The results of the present study are essential to assess the ecological service provided by the fruit bats through out the dispersal of shea butter seeds with regard to tree recruitment in a context of human pressure due to land use. Results also pointed out the necessity of taking into account fruit bats for the development of meaningful conservation and management plans in such areas.

Materials and Methods

Study environment

This study was conducted in Pendjari region in farmed lands surrounding the Biosphere Reserve of Pendjari (BRP) and inside the BRP. The region is geographically situated in the sudanian zone of Benin (10°40'-11°28'N and 0°57'- 2°10'E). The BRP covers an area of 4,661.4 km² and is constituted of the Pendjari National Park (2,660.4 km²), the hunting zone of Pendjari (1,750 km²) and the hunting zone of Konkombri (251 km²). The Pendjari River is the only permanent watercourse. The BRP is located in the Sudanian Zone with a single wet season from April-May to October and one dry season from November to April. Average annual rainfall is 1000 mm, with 60% falling between July and September (Sinsin et al. 2002). During the wet season large parts of the National Park of Pendjari are flooded. The dominant vegetation type is savanna interspersed by some patches of dry forests with deciduous trees (Bousquet 1992).

Temperature varies from around 21°C during the night up to around 40°C during the day. The annual mean temperature varies from 25° to 28°C during the cooler period of the dry season, 30° to 33°C during the hot period of the dry season. Relative humidity varies between 17 and 99%.

The border of BRP is lined with many small villages (figure 1). The total human population in this area comprises about 213,000 people, and a population density of 13 persons/km² (INSAE / MPPD 2002). Agriculture is the main economic activity of the local population in addition to herding where the Fulani keep the largest herds of livestock, i.e. cattle. Women mainly exploit and process non-timber forest products.

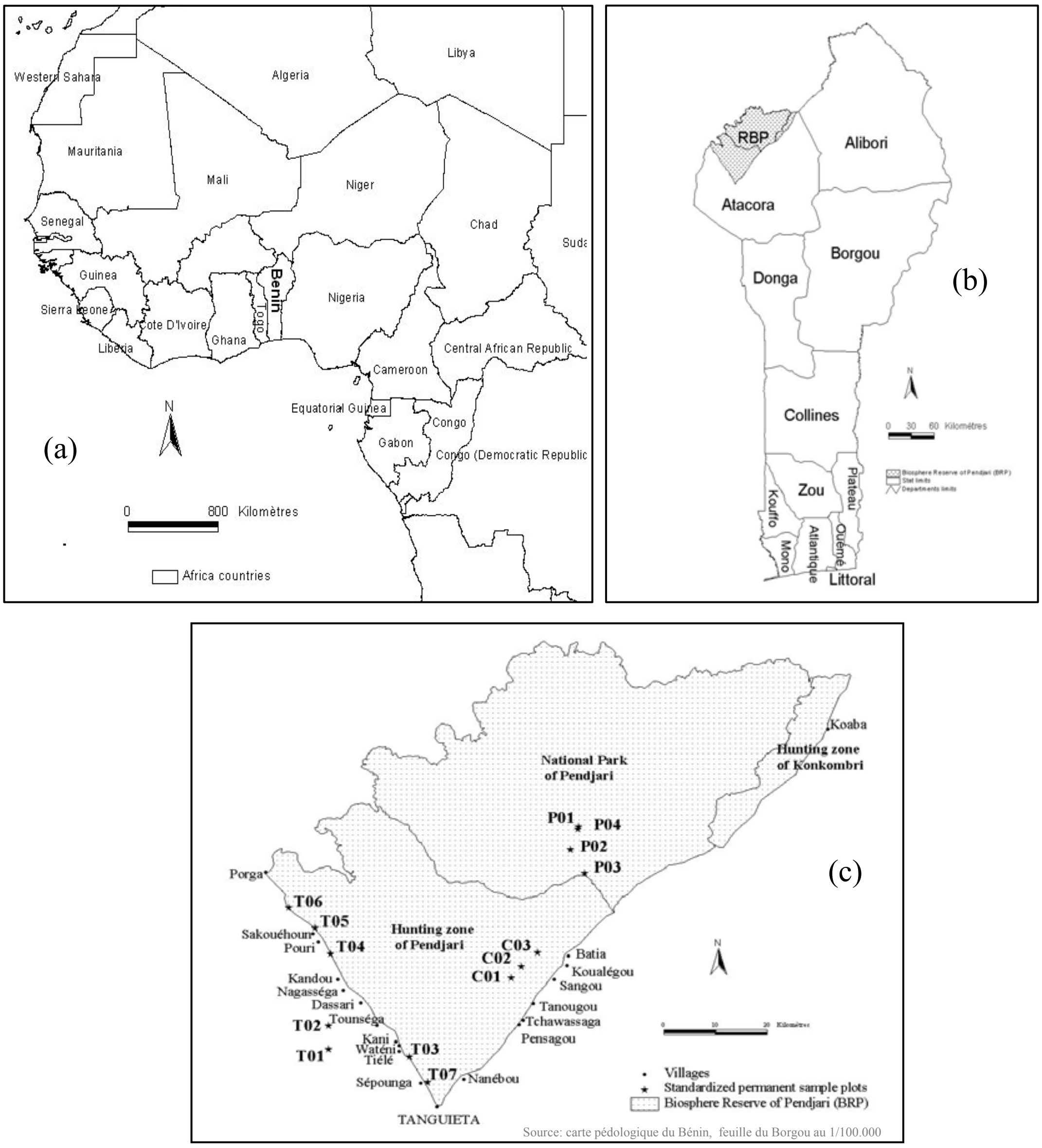

Figure 1: Study area. *a*) Benin in West Africa, *b*) map of Benin with position of BRP and *c*) position of the plots within the BRP. T01 to T07 stands for plots in the village land use areas, C01 to C03 for plots in the hunting zone and P for plots in the Pendjari National Park.

Inventory approach and data collection

Fourteen 2 ha-plots of approximately 100 m x 200 m were installed in homogeneous and comparable habitat types, comprising seven plots in farmed lands, i.e. fallows (1-3 years old) in village territories where farming activities had been previously conducted for a number of years and seven plots in protected area inside the BRP (Figure 1 c). Plots were established randomly. In protected area they were located in the National Park of Pendjari and in the hunting zone of Pendjari.

Food resources assessment

Five native woody plants foraged by fruit bats were selected within and /or in the vicinity of permanent plots and monitored twice per month to record fruit production. At each visit, fruit

production was estimated or counted (when possible). A total of 397 trees selected were distributed like followed: *Vitellaria paradoxa* (140), *Detarium microcarpum* (62), *Sarcocephalus latifolius* (50), *Tamarindus indica* (78) and *Diospyros mespiliformis* (67). The monitoring covered 12 months (September, 2005–August, 2006).
To use collected data to make statistical analysis for comparison, we followed Korine et al. (2000) method to quote counted or estimated numbers of fruits in order to calculate phenology scores. For that we defined estimation ranges: fruit production with 1, 2 and 3, respectively for < 100, 100-1000 and > 1000 fruits. Thus, we were able to calculate phenology scores per month and between zones (farmed lands vs. BRP) that were used to draw curves and to make statistical analysis.

Shea fruit production
As shea tree (*V. paradoxa*) which is the dominant woody plants of parklands, was reported like a key food resource in this region for fruit bats (Djossa et al. 2008b) we measured structure variables of shea trees (dbh, height and crown radius) and estimated its fruit production in farmed lands and within the BRP. We followed the method Korine et al. (2000) used to quantify fruits production in 12 species of strangled *Ficus* in Panama. This method consists in categorizing fruiting trees branches in main branches, secondary branches and small branches. Per fruiting tree all main branches are counted among which a minimum of 6 were randomly selected. On these 6 main branches, all secondary branches were counted and on one secondary branch, all small branches were counted. On 30 small branches randomly selected from one secondary branch all fruits were counted. Average fruit produced was calculated per small branch multiplied by the number of small branches, multiplied by the number of secondary branches, multiplied by the number of main branches. The result represented the estimated fruit production.
If we consider **nmb** for the number of main branches, **nsb** for the number of secondary branches, $\mathbf{ns_mb}$ for the number of small branches, $\mathbf{n_af}$ for average number of fruit on the 30 selected small branches and **Nf** for the number of estimated fruit produced, we have the following formula:

$$\mathbf{Nf = n_af * ns_mb * nsb * nmb}$$

This method was modified to adapt to the branch system of the target tree species. First because shea tree has generally less than 6 main branches but has two categories of secondary branches so that we changed the formula with the integration of $\mathbf{nsb_1}$ and $\mathbf{nsb_2}$**.** Thus, we can have:

$$\mathbf{Nf = n_af * ns_mb * nsb_1 * nsb_2 * nmb.}$$

Bats sampling
Fruit bats were mist netted on the permanent plots from September 2004 to September 2009. Mist nets (Reinhard Vohwinkel, Velbert, Germany) measured 12 m x 2.8 m and had 5 shelves (16 mm mesh; 70 denier / 2-ply netting). Bat sampling was conducted each trimester during a 5 or 6 week periods in a standardized configuration where 12 mist nets were set in a rectangle on a 2 ha plot with nets spaced about 50 m apart (Figure 2). Netting took place from 19:00-19:30 pm until 00:00 for the first part of the night; nets were closed and re-opened in the early morning from 4:00 to 6:00 am. Nets were also closed during heavy rain. Bat species were identified based on the key of Hayman & Hill (1971) as well as the compilation of Bergmans (2002) on bat species for Benin. The animals were weighed with balance (precision 1 g) and their forearm length was measured with metallic caliper (precision 1 mm). We subsequently recorded sex, age and reproductive status through well-developed testicles in scrotum for reproductive males and with the observation of lactation, presence of well-developed nipples at rest and presence of fetus in the belly for reproductive females.

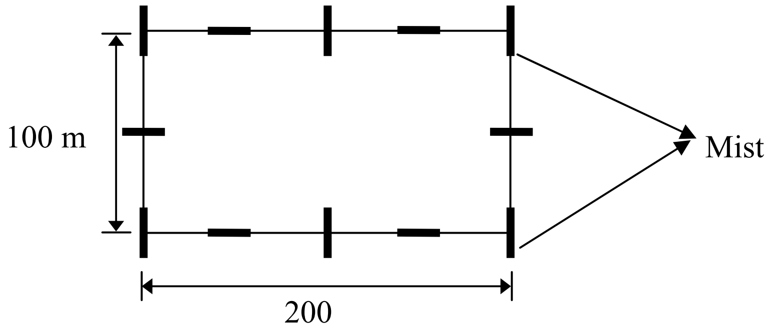

Figure 2: Pattern of mist netting with 12 nets around 2 ha plot.

Resources use assessment

Parallel to mist-netting, we searched for feeding roosts and collected ejecta pellets and fresh seeds dropped by bats underneath these roosts. We also reported fruit eaten by bats through faeces emitted by captured bats. To identify fruit pulp in the faeces of fruit bats, we established a reference collection where we fed identified fruits ad libitum to 3-4 individuals of *Epomophorus gambianus* and *Micropteropus pusillus*, which were the most abundant fruit bats at our study site. They were individually and temporarily kept for 24 hours in a flight cage (1.2 m x 1 m x 0.7 m). After we had fed a number of identified fruits to the bats, we collected the faecal material, noted its characteristics including colour, texture, smell, and consistency, thereby creating our reference collection. Only a few faecal samples (5 %) could not be identified according to these characters. To obtain faecal material from wild-caught bats we usually kept them for 20–30 min in a clean cloth bag.

Data analysis

We performed a one way ANOVA statistic (in SigmaStat 3.1) to compare phenology scores of the five targeted woody plants between farmed lands and the BRP. A T-test (with normal distribution data) or Mann Whitney Rank Sum Test (with non normal distribution data) (in SigmaStat 3.1) was performed to compare shea fruit production and distribution of production in tree age classes between farmed lands and the BRP. A multiple regression (Foreword Stepwise regression) (SigmaStat.3.1) permitted to identify the crown radius like the parameter that influence most the fruit production.

Results

Food resources availability

Fruit production recorded through the one year monitoring of the five targeted woody plants (figure 3).

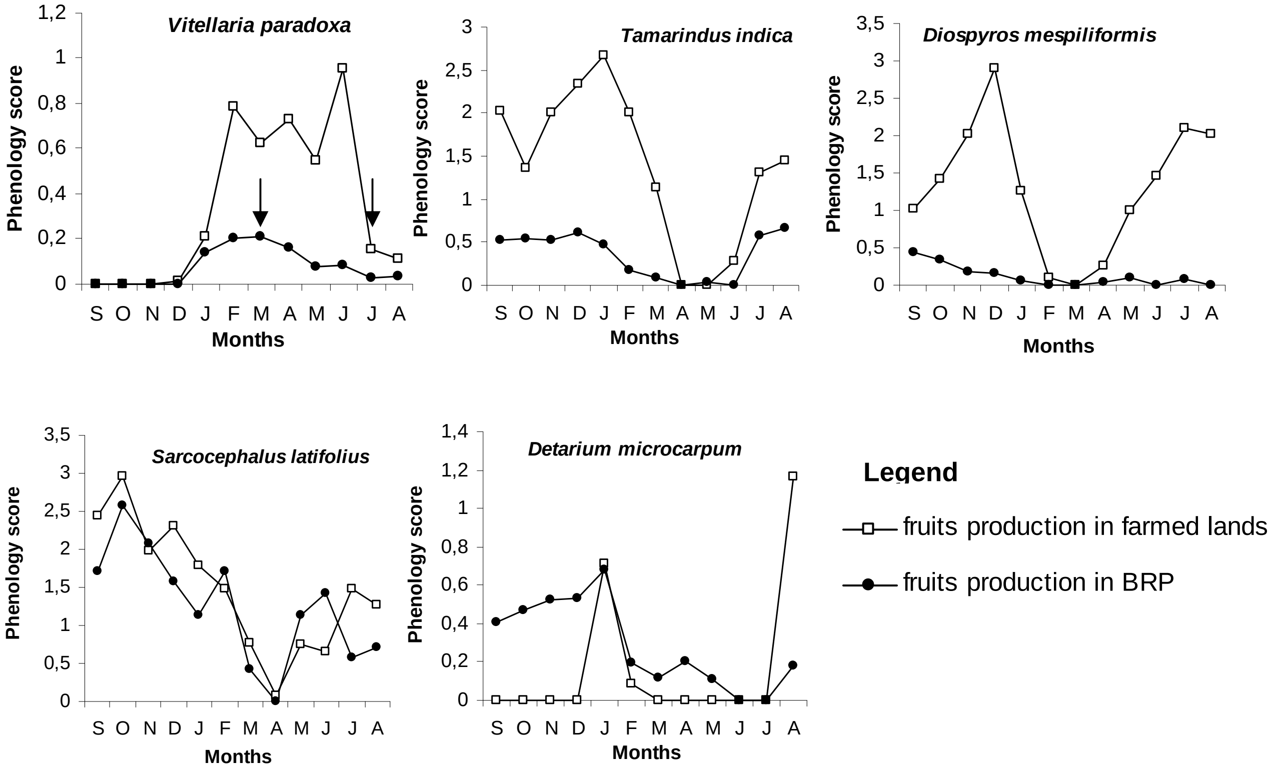

Figure 3: Phenology scores of selected woody plant species in farmed lands vs. BRP.
Fruit scores shown here cover fruit bearing complete period and ripen fruits period is shorter like indicated for shea tree with two arrows.

Selected plants species showed phenological events year round. *D. mespiliformis*, *T. indica* and *D. microcarpum* produced fruits from September to April and restarted around July-August; *V. paradoxa* produced fruits from April to August whereas *S. latifolius* produced fruits continuously except around April. All these plants had synchronized phenological events but showed some differences in fruits production between farmed lands and BRP (Tab. 1).

Table 1: Results of One way Analysis of Variance to compare phenology scores taking into account only fruits production on selected native woody plants between farmed lands and BRP. Significant differences (at 95 %) are marked with bold.

		Effect			Error			
Selected species	SC	df	MC	SC	df	MC	F	p
V. paradoxa	0.422693	1	0.422693	1.485581	22	0.067526	6.259662	**0.020281**
T. indica	6.37149	1	6.37149	9.650361	22	0.438653	14.52513	**0.000955**
D. mespiliformis	8.338432	1	8.338432	8.894123	22	0.404278	20.62547	**0.000161**
S. latifolius	0.349579	1	0.349579	13.86342	22	0.630155	0.55475	0.464266
D. microcarpum	0.088688	1	0.088688	2.122693	22	0.096486	0.919176	0.34811

SC : Sum of squares ; df : degree of freedom ; MC : Mean squares ; F : F Statistic ; P : probability.

V. paradoxa, *D. mespiliformis* and *T. indica* produced much more fruits in farmed lands compared to BRP (Tab. 2) whereas the *S. latifolius* and *D. microcarpum* showed similar fruits production in the two different zones.

Shea fruit production

An assessment of fruits production in shea trees revealed an average 1,391 fruits per tree in farmed lands whereas only 344 fruits were produced per tree in BRP. The distribution of this fruit production in diameter classes is showed in Table 2.

Tableau 2: Shea fruits production distributed in size classes as represented by dbh classes

Size classes (cm)	Farmed lands (X ± σ)	BRP (X ± σ)
dbh 10-20	714 ± 495 (1974 - 174, n = 19)	324 ± 458 (1726 - 6, n = 13)
dbh 20-30	1415 ± 1211 (5013 - 168, n= 18)	342 ± 324 (947- 30, n= 8)
dbh 30-40	3009 ± 1532 (4750 - 409, n = 6)	840 (n = 1)
dbh 40-50+	2069 ± 922 (3357 - 1272, n= 4)	116 (n = 1)

dbh: diameter at breast height

Fruit bats are interested in fruit pulp and we measured 243 fruits to report the average weight (19.7± 3.3 g) and the mean production of pulp (65.1 ± 12.7%) in shea fruits. Basing on that pulp production between zones and related to diameter classes are showed on Figure 4.

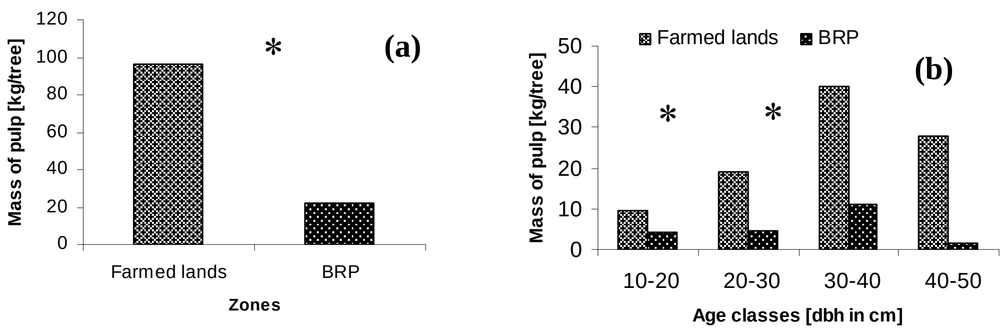

Figure 4: Average production of fruit/pulp per shea tree between farmed lands and the BRP (n=70) (a) and the distribution of this production in age classes (b). Significance at 95 % precision level is marked with an asterisk (**a**: Mann-Whitney Rank Sum Test [n (small) = 23, n (big) = 43, t = 424, p<0.001], **b**: dbh 10-20, t-test [n = 31, t = 2.130, df = 29, p = 0.042; dbh 20-30, Mann-Whitney Rank Sum Test [T = 54.000, n (small) = 8, n (big) = 18, p = 0.003]).

The two last classes (dbh 30-40 cm and 40-50 cm) counted few individuals so that analysis was not possible.
Fruit/pulp production in the shea tree was higher in farmed lands than in the BRP and aged trees (dbh>30 cm) contributed more to this production.

Fruit bats population fluctuation

A total of 1644 fruit bats captured comprised 8 species (*Epomophorus gambianus*, *Micropteropus pusillus*, *Nanonycteris veldkampii*, *Eidolon helvum*, *Myonycteris torquata*, *Lissonycteris angolensis*, *Rousettus aegyptiacus* and *Hypsignathus monstrosus*) all belonging to Pteropodidae family. Figure 5 presents fruit bats relative abundance in farmed land and the BRP.

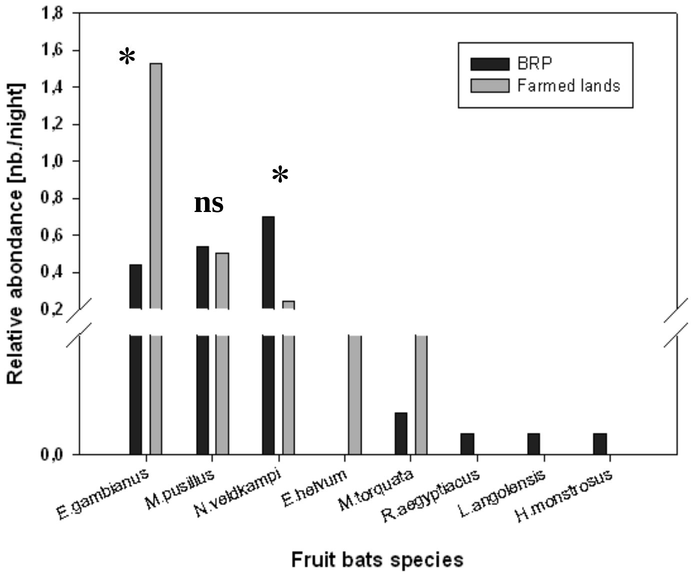

Figure 5: Relative abundance of fruit bats between farmed lands and the BRB. Significance at 95 % precision level is marked with an asterisk [*E. gambianus*, Mann-Withney Rank Sum Test (n (small) = 7, n (big) = 7, T = 71.000, p = 0.016); *M. pusillus*, t-test (n = 14; t = 0.400; df = 12; p = 0.696), *N. veldkampii*, t-test (n = 14, t = -2.182; df = 12; p = 0.050)].

E. gambianus are abundant in farmed lands while *N. veldkampii* score much more in BRP. *M. pusillus* didn't show clear preferences. Higher abundances where recorded during wet seasons and less common and/or migrating species like *E. helvum*, *M. torquata* and *N. veldkampii* were captured during the same season. Les common bats species such as *H. monstrosus*, *L. angolensis* and *R. aegyptiacus* were reported during the wet season and only from the BRP.

Shea fruits use by fruit bats and implication for seed dispersal

A total of 337 fecal samples were collected during netting sessions, and fruit remains and seeds dropped were collected from 124 feeding roosts. The results showed that the bats fed on nine different fruits species (Fig. 6). Fruits species composition was almost similar both for fecal and feeding roost samples, with a clear dominance of *Vitellaria paradoxa*. In addition to the letter fruit species, the following fruits species were reported: *Sarcocephalus latifolius* (Rubiaceae), *Lannea microcarpa* (Anacardiaceae), *Ficus* spp. and *Ficus glumosa* var. *glaberrima* (Moraceae), *Annona senegalensis* (Annonaceae), *Balanites aegyptiaca* (Zygophyllaceae), *Diospyros mespiliformis* (Ebenaceae), and *Vitex doniana* (Verbenaceae).

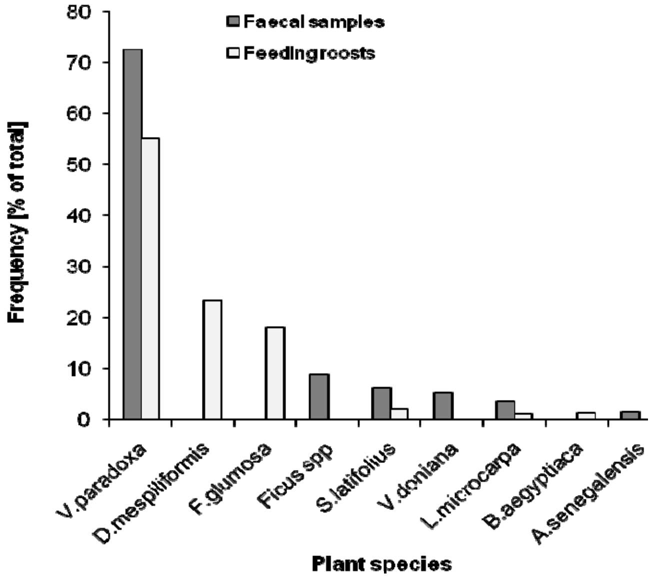

Figure 6: Resource use by fruit bats based on fruit species identified from fecal samples (n = 337), and fruit species identified from fruits pulps and seeds dropped under feeding roosts (n = 124).

Based on fecal samples, shea fruits were used by five out of eight fruit bats species (Fig. 7), which were *E. helvum* (n = 5), *E. gambianus* (n = 172), *M. pusillus* (n = 30), *M. torquata* (n = 1), and *N. veldkampii* (n = 40).

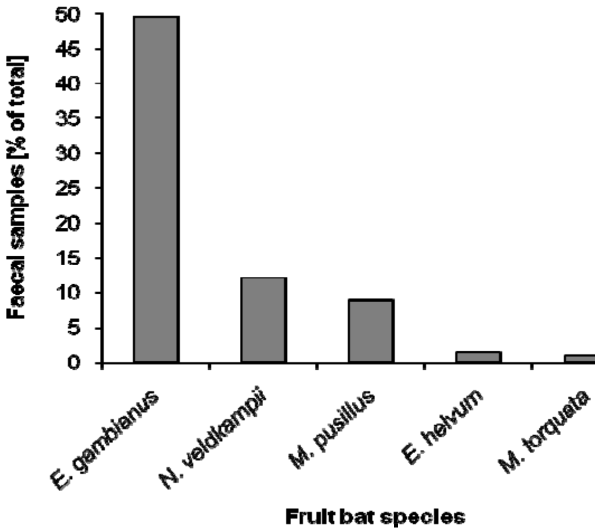

Figure 7: Proportion of fecal samples containing pulp from shea fruit for the different species of fruit bats in the RBP (n = 248).

Discussion

In the Pendjari region the socioeconomic valued fruit trees like *V. paradoxa*, *T. indica*, *D. mespiliformis* were preserved so that they dominate parklands (Agbahungba & Depommier 1989, Djossa et al. 2008a) because their fruits were used directly by local communities for food mainly during period between two cropping seasons but were also marketed to sustain households. Plants without such economic values very often occur quasi exclusively in difficult access areas (Oumorou 2003), in non-cultivated areas or in protected zones (Aubreville 1939). Such situation is obviously causing phytodiversity reduction and thereby the decline of food production potential for plant dependant animals. Changes in ecosystem due to deforestation are likely to affect the animals in this ecosystem like bats as reported by Brosset et al. (1996).

Numerous studies were conducted worldwide on plant-animal interactions with particular focus on foods resources availability and use (Corlett 1996, Kitamura et al. 2002) because this is a key factor to maintain animals in general and fruit bats in particular (Thomas 1984, Delorme & Thomas 1999) in a given habitat. Our study assessed food production potential through the monitoring of the phenology of selected native woody plants, and the results showed that woody plants preserved and selected by local people (Maranz & Wiesman 2003) produced more food resources than their homologues existing in the BRP. These plants certainly benefit from cropping activities in term of soil fertilization but also in diminishing of competition with other plants. However, they were overall less abundant in farmed lands than in the BRP even if these few isolated individuals (Teklehaimanot 2003) counted dominantly larger individuals that produced more fruits (Lamien et al. 2004). The BRP host a high phytodiversity compared with farmed lands. Competition between and within plant species is known (Ritchie & Olff, 1999) and this can influence fruits production. In another hand, in the BRP, the fire that is annually set in management purpose to renew grasses for ruminants also can influence plant (Hjerpe et al. 2001) and thereby the fruit production as it stress trees when all leaves and barks (partially) are burnt because they need energy and resources to renew all that even though Hall et al. (1996) reported positive effect of fire on the phenology of shea tree. When crown size played important role in fruits production, intense fire due to accumulation of grass biomass easily reached in undisturbed areas (BRP) has negative impact on tree branches. Then, our findings on fruits production of shea butter tree in farmed lands compared with the BRP could be explained accordingly.

Shea fruits constituted a key food resource for fruit bats in this region (Djossa et al. 2008b) and the high production of fruit/pulp in farmed lands attracted a large group of fruit bats and this is conform to Richter & Cumming (2006) finding that reported from Kasanka National Park (Zambia) a rise in abundance of *E. helvum*, a migrating fruit bats during the peak fruiting period of key resources. Hodgkison et al. (2004) found comparable increase in relative abundance of fruit bats in Malaysia.

Fruit bats captured during this study showed more diverse fruit bats communities in BRP compared with farmed lands (7 species vs. 5) and less common fruit bats species were exclusively (*Rousettus aegyptiacus* and *Hypsignathus monstrosus*) or mainly (*Myonycteris torquata* and *Lissonycteris angolensis*) recorded from the protected area. This showed the importance of protected area in biodiversity conservation (Bruner et al. 2001). Indeed, the BRP is characterized by different habitat types (Sokpon et al. 2001) certainly due to current conservation efforts. Fahr et al. (2006) reported from Guinea (Conakry) that bats species richness increase with conservation status and habitat complexity in a given protected area.

Our findings showed the necessity to reconsider the agroforestry system in this region in order to maintain at least actual woody plants density and to enlarge the diversity of woody plants preserved by farmers to guaranty feeding resources availability and habitat for bats in order to benefit from their ecological services like flowers pollination and seed dispersal on which depend many tropical plant species like shea tree (*V. paradoxa*), a socioeconomic important plant that is not yet cultivated by local people at large scale in the whole Sudanian region where it is endemic of.

Differences in relative abundance showed by *E. gambianus* and *N. veldkampii* in this study is probably dictated by food preference and availability. *E. gambianus* prefers fleshy and large fruits (Mickleburgh et al. 1992) to satisfy its needs. Shea fruit fitting these characteristics is well consumed by this bat species (Djossa et al. 2008b) and one can consider the high production of shea tree to explain the preference of *E. gambianus* for farmed lands. In contrary *N. veldkampii* that prefers small and soft fruits and nectar (Mickleburgh et al. 1992) could satisfy its needs in the BRP which houses more conserved habitats with high phytodiversity that is likely to provide more diverse food sources. On the other hand *M. pusillus* that showed comparable abundance in the two zones is probably less selective in food resource use but can also eat more or less large fruits due to its medium size. It is also easy to notice that *E. gambianus* is abundant over the wet season that stands mainly from May to end October while shea trees produce fruits from May to late July. This fruit bat population abundance fluctuation is therefore supported by a combination of different food resources like showed in the phenology events of selected woody plants.

The preference of shea fruits may in turn help in dispersing its large-seeds as reported by Ebigbo (2004) in Ivory Coast on *Cola cordifolia* (Sterculiaceae), an important Guinea savanna tree. With a high visitation rate by highly mobile dispersers like fruit bats, shea trees are likely to benefit for several reasons, thus achieving a higher success rate in the recruitment of seedlings (Tellería *et al*. 2005). Firstly, if the majority of seeds are dropped beneath the parent tree, they might be exposed to a high number of seed predators. Furthermore, seedlings are often out-shaded and particularly prone to pathogens. According to the escape hypothesis of Janzen (1970) and Connell (1971), transportation of seeds away from parent trees can substantially increase survival chances. Secondly, removal of seeds by fruit bats away from parent trees is of particular importance in the Pendjari Region and other areas used by humans where the plant’s natural seed bank, i.e., ripe fruits fallen to the ground, is almost completely removed, here mainly by women who collect most of the fruits for multiple purposes. In village areas near the Pendjari Biosphere Reserve, where only a few scattered woody plants in fallows and farmed lands remain, feeding roosts of flying foxes are likely to be widely scattered. Potentially, because of their high mobility, fruit bats could transport seeds to places that are not regularly visited by collectors. There, those seeds may have a better chance of survival when they are deposited at sites with suitable light and water conditions for germination, especially in rather open areas of lower land-use intensity such as fallows. In addition, the mechanical removal of pulp is known to speed up the germination of shea seeds (Hall *et al*. 1996). Since shea seeds are recalcitrant, they have to germinate quickly in order not to lose viability.

Conclusion

With this study we reported from the Pendjari region that traditional agriculture practices preserve mainly native plants utilized by local people. These woody plants in the agroforestry systems still producing food resources to support fruit bats communities that in turn contribute to the natural regeneration of the shea tree, a socioeconomically important tplant species that is not yet cultivated by local people. Protective effort need to be maintained and strengthened to conserve plant mutualists like bats and others to increase chances for conserving biodiversity for the present and future generations.

Acknowledgments

We are grateful to BIOTA (Biodiversity Monitoring Transect Analysis) project for financial support, the Biosphere Reserve of Pendjari managers for granting research permit, for Mathurin Guèdègbé, my field assistant and for local communities for collaborating and accepting that we set data collecting permanent plots in fallows of their village territories.

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