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Conservation of biodiversity in a relic forest in Benin – an overview

Peter Nagel, Brice Sinsin, and Ralf Peveling

Abstract

Lama forest is one of the last remnants of the West African forest/savannah mosaic known as the Dahomey Gap. It comprises natural forest and forest plantations and has the protection status of a classified forest. In the present article, we give an overview of an ongoing research partnership project focusing on the conservation of biodiversity in Lama forest. The project is based on the assumption that conservation and management strategies must be founded on an understanding of both structural and functional ecological traits. It comprises studies on the biodiversity of arthropods, a group which has received little attention as yet in tropical biodiversity assessments, as well as studies on key ecological processes such as the breakdown of litter. Emphasis is laid on the relationship and interaction between natural forest and plantations. With respect to ecological as well as biogeographical peculiarities, we found evidence of the importance of Lama forest for biodiversity conservation in Benin. Specifically, our study elucidated the role of anthropogenic forests as buffer zones, migration corridors and surrogate habitats for rare forest animals. Important insight has been gained with regard to the management and conservation of isolated biodiversity resources in Benin and other African countries.

Zusammenfassung

Der Lama-Wald ist einer der letzten Reste des westafrikanischen Wald/Savannen-Mosaiks, des 'Dahomey Gap'. Er enthält natürlichen Wald sowie Plantagen und hat den Schutzstatus einer "Forêt classée". Im vorliegenden Artikel geben wir einen Überblick über ein laufendes Gemeinschaftsforschungsprojekt, das sich auf die Erhaltung der Biodiversität im Lama-Wald konzentriert. Das Projekt basiert auf der Annahme, dass Erhaltungs- und Managementstrategien auf der Basis des

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Verständnisses der strukturellen und funktionalen ökologischen Merkmale entwickelt werden müssen. Es umfasst Untersuchungen über die Biodiversität der Arthropoden, einer Tiergruppe, der bis jetzt in tropischen Biodiversitätsuntersuchungen eher weniger Aufmerksamkeit geschenkt wurde, sowie Untersuchungen über ökologische Schlüsselprozesse wie den Streuabbau. Hauptgewicht wird auf die Beziehung und die Interaktion zwischen natürlichem Wald und Plantagen gelegt. In Bezug auf ökologische wie biogeographische Besonderheiten fanden wir Belege für die Bedeutung des Lama-Waldes für die Erhaltung der Biodiversität in Benin. Insbesondere klärte unsere Studie die Rolle der anthropogenen Wälder als Pufferzonen, Migrationskorridore und Ersatzlebensräume für seltene Waldtiere auf. Wichtige Einblicke hinsichtlich des Managements und der Erhaltung isolierter Biodiversitätsressourcen in Benin und in anderen afrikanischen Ländern wurden gewonnen.

1 Introduction

The Dahomey Gap is a zone of low rainfall separating the western and eastern part of the humid Guineo-Congolese evergreen and semi-evergreen forests of West and West-central Africa, extending along the coast from Takoradi in Ghana to Cotonou in Benin (L'Hôte & Mahé 1996). The annual precipitation ranges from 900 to 1,500 mm. With respect to the natural vegetation expected under the prevailing climate, Sayer (1992) postulated a spatial dominance of semi-deciduous forest, interspersed with tracts of denser vegetation such as riverine forest as well as patches of swamp forest and lowland evergreen forest. This implies that the present savannah vegetation is of anthropogenic origin. During the humid phase in the Holocene, the area was presumably covered with evergreen lowland rainforest (cf., Anhuf 1994). There are several examples of disjunction of plants and animals along the Dahomey Gap (Knapp 1973, Kingdon 1990, Schiøtz 1999). For some West and West-central African species, the Dahomey Gap demarcates the eastern and western limit, respectively, of their present range. This suggests that extant patches of natural forest in Southern Benin are remnants of the former semi-evergreen lowland forest that has been largely destroyed by humans. For species distributed in the lowland rainforest during the Holocene, these forest remnants are important refuges. Likewise, it is likely that they serve as stepping stones for species moving between the western and eastern rainforest belts. Of the forest remnants in southern Benin, Lama forest represents one of the largest tracts.

With few exceptions (e.g., Sayer 1992), the possible role of Lama forest for biodiversity conservation has not been acknowledged adequately by the international conservation community (IUCN 1987, 1991). Even though, national institutions (ONAB 1992) and development agencies (German Development Agency and German Development Bank), consider Lama forest a priority conservation area, despite its small size. Preliminary biodiversity inventories were conducted under the auspices and with the financial aid of these organizations (Emrich et al. 1999). However, the studies were confined to natural forest in the centre, the so-called

Noyau central. While the importance of plantation forests for the conservation of wildlife and as nuclei for the regeneration of natural forest has been demonstrated elsewhere in the tropics, confirmation from West Africa is still pending.

The overall goal of the present, ongoing study is the conservation and enhancement of biodiversity through an improved management of natural and plantation forests in Lama forest. A central theme in this research is the ecological and biogeographical role of plantations within an overall conservation strategy for Southern Benin. To this end, our study focuses on the functional importance of biodiversity as well as on key ecological processes. The project is conducted within the scope of a research partnership between the *Faculté des Sciences Agronomiques*, University of Abomey-Calavi, Benin, and the *Institut für Natur-, Landschafts- und Umweltschutz (NLU) / Biogeographie*, University of Basel.

2 Geographical and historical characteristics of the study site

Lama forest is situated at the northern limit of the central part of the *Dépression médiane* (between 6°55.8–58.8'N and 2°4.2–10.8'E). The altitude ranges between 40–80 m above sea level, and the average annual rainfall is about 1,200 mm. A large rainy season from April to July is followed by a short dry season from August to September, followed by a second, shorter rainy season from October to November and the large dry season from December to March. During the rainy season, the soil may become temporarily waterlogged which restricts the agricultural use. The

Tab. 1 Recent history of the development of Lama forest (modified after *Emrich et al.* 1999)

Year	Total forest cover (ha) (except plantations)	Natural forest cover (ha)	Events
1946	16,250	11,000	Gazetted as a <i>forêt classée</i> ; colonization by autochthonous ethnic groups (Fon, Aïzo)
mid 1950s			Immigration of allochthonous ethnic groups (Holli and Aïzo from other parts of Benin)
1960		10,800	Afforestation with exotic timber species, mainly teak
1972		6,700	Increased immigration of Holli population
1984		3,800	
1985		2,500	
1987	4,500	1,900	Full ban on logging of natural forest; reforestation in the <i>Noyau central</i> ; resettlement of Holli people in two agro-forestry centres

prevailing soil type is a black cotton soil (vertisol) rich in humus and young clay deposits. The vernacular name *Kô* is synonymous with *Lama*, a word of Portuguese origin meaning mud.

Of the different ethnic groups living at Lama forest, only the Holli tribe – immigrants from eastern Benin – are specialized in the cultivation of black cotton soil. Until their resettlement in 1988, about 1,200 families practiced small-scale shifting agriculture within the *Noyau central*. During the preceding five years, the mean annual deforestation was 400 ha, compared to an overall annual loss of natural forest of 300 ha between 1946–1988. The former Holli land use system is reflected in the present structure of the *Noyau central* which is composed of a mosaic of fallow land of different age and successional stage, secondary forest and patches of primary forest.

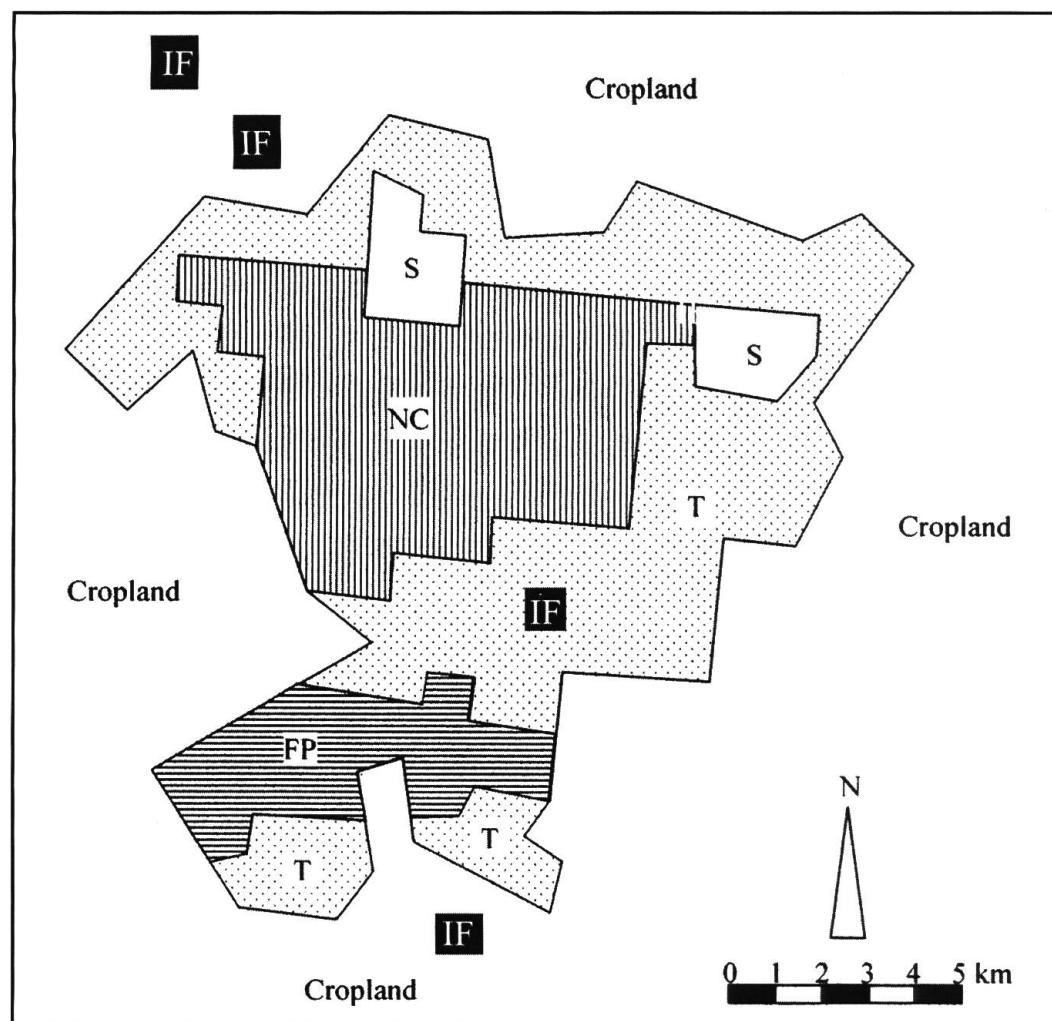


Fig. 1 Outline map of the Lama forest (from Lachat et al. 2004a).

NC = Noyau central
 FP = Fuelwood plantations
 IF = Isolated forest fragments

T = Teak plantations,
 S = Settlements, small-scale agriculture,

Tab. 2 Forest cover in Lama forest in 2000 (modified after *Emrich et al. 1999*)

Area	Total surface (ha)	Composition
<i>Noyau central</i>	4,800	1,900 ha natural forest 1,200 ha degraded forest of different successional stages 1,400 ha fallow land of different successional stages, covered mainly with <i>Chromolaena odorata</i> 300 ha teak (<i>Tectona grandis</i>) and grey teak (<i>Gmelina arborea</i>) plantations
Plantations	9,000	5,600 ha teak plantations 1,400 ha grey teak plantations, partly mixed with teak, <i>Eucalyptus</i> spp., <i>Acacia</i> sp. and other species 2,400 ha firewood plantations (mainly <i>Senna siamea</i>)
Other	2,400	Agriculture, settlements

Except for teak forests planted in the early sixties (1963–1965) in the northern and southern part of the area, teak plantations were established 1985–1996, enclosing the *Noyau central* nearly entirely. In the south-western part, fuelwood forests were planted to satisfy the demand of the local population for firewood, and to reduce the pressure on remnant natural resources. Open canopy forest patches, clearings and former farmland within the *Noyau central* are encroached with thickets of *Chromolaena odorata*, an alien, invasive species of neotropical origin. Enrichment plantings with native forest species were established in these open areas in order to assist and accelerate the regeneration of natural forest.

In view of dramatically diminishing forest coverage and ever increasing deforestation rates, a new forest management and protection project was implemented in 1987/88. All settlers were banned from the *Noyau central* and resettled in neighbouring agro-forestry schemes where they were granted housing and agricultural land. Moreover, education and health services were provided, and new opportunities to work in the forest sector were created. The idea was to convert forest users into forest conservationists. Other measures taken to support local communities were an improvement of the infrastructure (road network), the establishment of tree nurseries, and the construction of a saw-mill for the processing of teak and production of parquet floor tiles for the global market. For educational purposes, an ecological trail was established in the *Noyau central* in 1995.

3 Implementation of research

To evaluate the role of teak and fuelwood plantations for the protection of the natural forest remnants, we focused initially on the following areas of research, (1) the diversity and composition of arthropod assemblages, in particular detritivorous and xylophagous species, (2) the niche differentiation of key ecological groups, and (3) the breakdown of litter and dead wood in relation to forest type.

Access into the forest is possible by a system of parallel trails (*layons*) running from East to West at a distance of one kilometre from each other. We selected four replicate sites in each of nine different forest types. Within the *Noyau central*, these

comprise (1) semi-deciduous forest (primary forest), (2) seasonally flooded *Cynometra megalophylla* lowland forest (primary forest), (3) *Anogeissus leiocarpa* dry forest (secondary forest), (4) abandoned settlements (secondary forest) and (5) perennial *Chromolaena odorata* thickets. Outside of the Noyau central, we studied (6) old teak plantations, (7) young teak plantations, (8) fuelwood plantations and (9) isolated small forest islands.



Fig. 2 Dry season aspect of Lama forest (teak plantations, left, and semi-deciduous forest, right).
Photo: T. Lachat

4 Results

4.1 Geographical Information System

Specht (2002) integrated a geo-ecological catalogue of maps into a Geographical Information System (GIS). Emphasis was put on the classification of the vegetation, using multitemporal Landsat 7 data. The exact delimitation of the main vegetation types is an important basis for both the interpretation of ecological and biodiversity data as well as for the management of Lama forest. Moreover, possible dispersal and migration corridors as well as suitable habitats of animals and plants can be detected.

4.2 Biodiversity studies

4.2.1 Vegetation and flora

The natural vegetation of the Lama depression is classified as a dense semi-deciduous forest. *Azelia africana* and *Ceiba pentandra* are dominant, emergent species of the uppermost stratum of this forest type, while *Diospyros mespiliformis*, *Dialium guineense* and *Mimusops andongensis* represent the lower tree stratum. Disturbed secondary forest is often characterized by *Anogeissus leiocarpa*. The vegetation in seasonally waterlogged areas is dominated by large individuals of *Cynometra megalophylla* (Emrich et al. 1999).

The most abundant trees are *Dialium guineense*, *Diospyros mespiliformis*, *Albizia zygia*, *Azelia africana*, *Khaya senegalensis* and *Anogeissus leiocarpa*. The last three species have their main distribution in the drier Sudan zone further to the North. Two tree species new to Benin were recorded in a recent study. More than 15 species have been listed in the Red List of threatened plants (Emrich et al. 1999).

4.2.2 Arthropod diversity and faunistics

Preliminary evidence was found that the Lama forest and probably other forest remnants of the Dahomey gap are home to endemic Coleoptera and Lepidoptera species (Goergen 2003). Furthermore, about half of the 83 butterfly species recorded so far are new to Benin (Fermon & Schulze 1998).

By using a combination of different types of traps (pitfall, Malaise, window and light traps) we found seven different myrmecophilous ant nest beetles (Carabidae: Paussini), six of which are stenoecious, typical forest species (Nagel 2003). It is remarkable that these are extremely rare species. Even though most specimens were sampled in the *Noyau central*, we also found some specimens in old teak plantations and isolated forest fragments.

Lachat et al. (2004a) demonstrated that arthropod diversity was similar among natural, degraded and secondary forests of the *Noyau central*, whereas isolated forest fragments differed from all other forest types. Species richness was lowest in young teak and fuelwood plantations, highest in old teak plantations and forest islands and intermediate in the different forest types within the *Noyau central*. A rare ground beetle, *Hoplolenus obesus* (Murray) (Carabidae: Oodini), was identified as an indicator species of old teak plantations, suggesting that anthropogenic forest ecosystems may have a role to play in biodiversity conservation.

4.2.3 Mammals

Several mammals are frequently encountered in Lama forest, e.g., the common cusimance (*Crossarchus obscurus*), Maxwell's duiker (*Cephalophus maxwelli*), red river hog (*Potamochoerus porcus*) and bushbuck (*Tragelaphus scriptus*). The most conspicuous monkeys are the three guenons mona, red-bellied monkey and vervet monkey (Kassa & Sinsin 2003). It has been suggested that colobus monkeys, including *Colobus vellerosus*, have disappeared from Lama forest (Matsuda 1995). However, new sightings have been recorded recently by our research team.



Fig. 3 Bush meat (duiker), confiscated by a forestry officer.

Photo: P. Nagel

Rare and threatened forest ungulates include the sitatunga (*Tragelaphus spekei*), the royal antelope (*Neotragus pygmaeus*), the black duiker (*Cephalophus niger*) and the yellow-backed duiker (*C. silvicultor*) (Kassa & Sinsin 2003). It is also possible that the Kintampo rope squirrel (*Funisciurus substriatus*), an endemic of the Dahomey Gap, occurs in Lama forest (Refisch 1998).

The flagship species of the Lama forest is the red-bellied monkey (*Cercopithecus erythrogaster erythrogaster*). This subspecies is endemic to the Dahomey Gap and Benin. Its former range in Southern Benin extended from the valley of the Couffo river to the Nigerian border. Due to hunting and habitat destruction, surviving populations now seem to be restricted to sacred groves, equally small swamp forests (e.g., Lokoli forest) and humid forest relics, of which Lama forest is the largest (Sinsin et al. 2002, Sinsin & Assogbadjo 2002).

There are indications of dispersal movements among these habitat fragments. In most cases, the red-bellied guenon is associated with mona monkeys. This affords mutual benefits in terms of predator avoidance and forage location. During the dry season, the diet of red-bellied guenons consists of immature fruits of the cotton tree, providing not only food but also water which is a scarce resource during this time of the year (Nobime & Sinsin 2003). A pilot study on the feasibility of radio telemetry and habituation techniques for studying the behavioural biology and ecology of red-bellied monkeys showed that both methods are difficult because of the timidity and shyness of this species (Altherr 2003).



Fig. 4 The flagship species of Lama forest: red-bellied monkey (*Cercopithecus e. erythrogaster*).
Photo: G. Altherr

4.2.4 Birds and reptiles

Fifteen forest bird species in Benin have been observed only in the Lama forest thus far, including the white-crested hornbill (*Tockus albocristatus*), the crested Guinea fowl (*Guttera pucherani edouardi*), the western bronze-naped pigeon (*Columba iriditorques*) and the purple-headed glossy starling (*Lamprotornis purpureiceps*). Densities of species such as the bristle-bill (*Bleda syndactyla*) seem to be at their lowest limit to maintain viable populations (Waltert 1998).

Among the reptiles, there are interesting species such as *Python regius* and *Python sebae* (Daouda 1998). A more recent survey found 44 species, including a new chameleon species and probably a new gecko species (Ullenbruch 2003; Ullenbruch et al. submitted).

4.3 Functional ecological studies

The litterbag technique was used to study the breakdown of leaf litter in different forest types (Attignon et al. 2004). Decay rates in semi-deciduous forest were significantly lower than in plantation forests. Moreover, natural leaf litter (afzelia, *Afzelia africana*, and cotton tree, *Ceiba pentandra*) degraded faster than exotic litter (teak, *Tectona grandis*, and cassia, *Senna siamea*). This was related to the activity of litter-dwelling invertebrates, suggesting that their role in litter breakdown and nutrient-cycling must be considered in forest management. Several studies have been initiated to analyse decomposer communities and soil quality in different types of natural and plantation forests. A synthesis of these ongoing studies, however, is still

pending. Thus far, there are indications that earthworm relative abundance is higher in natural than in plantation forests (Weibel 2003), whereas the contrary is true for termites (Attignon et al. submitted a,b).

From 2002–2004, emergence trap studies were conducted to study the association of beetles with dead wood (Cakpo 2003, Lachat et al. 2004b). Again, final results cannot be presented as yet. Preliminary evidence suggests that the saproxylic beetle fauna responds very specifically to the type of dead wood and the degree and state of its decomposition. From these studies we expect to gain general insight into the ecological significance of dead wood in these types of tropical forests.

5 Conclusions

All investigations of the composition and distribution of biodiversity resources in Lama forest conducted so far demonstrated the unique biogeographical and ecological status of the *Noyau central*. Here, rare Dahomey Gap endemics such as the red-bellied guenon found one of their last refuges in Benin. Moreover, numerous rainforest-adapted species occur only in Lama forest, the largest continuous tract of dense natural forest in southern Benin. For West African forest species such as the royal antelope, Lama forest represents the easternmost limit of their current range. These examples underline the importance of this last remnant of dense semi-deciduous forest and its characteristic fauna for biodiversity conservation in Benin.

Due to a lack of surface water during the dry season, species in need of water may have to conduct seasonal movements and migrations into more humid areas such as the Lokoli swamp forest. These movements can be a risk to maintaining viable populations. Moreover, there is a higher poaching risk for animals moving through settled land, even though the overall poaching pressure seems to be relatively low. The plantation forests encircling the *Noyau central* may serve as a *Cordon sanitaire*, i. e., a protection forest reducing the risk of illegal logging of natural forest.

The paucity of litter-dwelling invertebrates in plantation forests and the resultant reduction in litter breakdown clearly suggest that specific forest management programmes should aim to prevent an impoverishment of decomposer communities in order to maintain productivity.

The present study focuses on the role of forest plantations for biodiversity conservation in the Dahomey Gap. All evidence collected so far suggests that old teak plantations in particular (about 40 years old) may provide suitable habitats even for stenoeccious rainforest insects. This seems to be due to the dense and species-rich undergrowth resembling secondary forest undergrowth. It is noteworthy that even extremely rare species were found in these plantations, as well as in isolated forest islands. It follows that conservation programmes should aim to include certain types of forest plantations as habitats for rare and/or threatened species. Nature conservation and forest production – even monocultures – are not necessarily mutually exclusive goals. Rather, both can be combined in an ecologically and economically viable way.

6 Outlook

Few studies have investigated the role of forest plantations as wildlife habitats and migration corridors. This even holds for mammals and birds, the best studied taxa. Future studies should therefore aim to identify dispersal routes between Lama forest and other forest remnants or forest-like habitats. These studies should establish the scientific basis for the development of a protected area system. The degree of isolation of fragmented populations should be investigated using molecular genetic methods, and the analysis be based on metapopulation models. Aspects of the functional importance of biodiversity in natural forests and plantations are as yet grossly understudied and should receive more attention in future research in order to predict possible risks timely.

The Lama forest reserve represents the most important element in the existing network of remnant forest biotopes in southern Benin. It may even serve as a stepping stone across the Dahomey Gap, even though more field evidence has to be collected to support this assumption. However, the existing database clearly exemplifies the potential of Lama forest as a national heritage of regional importance. The data collected so far even suggest the establishment of a *Lama Biosphere Reserve*. Scientifically, this claim is founded on the outstanding importance of the *Noyau central*, old teak plantations and forest remnants for biodiversity conservation. In the past twenty years, the local population has been affected tremendously by conservation as well as forest production activities of governmental authorities and development agencies - sometimes detrimentally, sometimes beneficially. It therefore certainly must be integrated into a community conservation process inherent to the designation of biosphere reserves.

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