Aspects of community ecology of amphibians and reptiles at Bonny Island (Nigeria), an area of priority relevance for petrochemical industry

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Abstract

Finima Nature Park, situated in Bonny Island (Niger Delta, Nigeria), is a protected forested area placed within one of the most industrially developed (and environmentally polluted) regions of the whole African continent. Amphibian and reptile community composition in relation to season and microhabitat characteristics was studied, by a combination of field techniques, during the wet and dry seasons of 2007 and 2008. Overall, a total of 21 species of reptiles from nine families (with 668 individuals caught) and eight amphibian species from five families (492 individuals caught) were recorded. Nearly 94% of the amphibian individuals and most of the species were recorded, especially during the wet season, whereas most of the reptiles were found with no inter-seasonal differences. However, *Agama agama* and *Mabuya affinis* were found especially during the dry season. As for microhabitat use, the reptile species showed a clear, aggregated preference for two microhabitat types (dry leaves and under logs), which are probably crucial when these animals need to lose body temperature to avoid overheating. Concerning amphibians, the various species used the available microhabitats in a way expectable from their main ecological traits, with toads differing from aquatic frogs, and these differing from arboreal frogs.

Key words: composition, conservation status, ecology, Finima Nature Park, habitat preference, herpetofauna

Résumé

Le Parc Naturel de Finima, situé sur *Bonny Island*, dans le Delta du Niger, au Nigeria, est une aire forestière protégée incluse dans une des régions développées les plus industrialisées (et dont l'environnement est le plus pollué) de tout le continent africain. On a étudié la composition de la communauté des amphibiens et des reptiles en fonction des saisons et des caractéristiques des micro-habitats, en combinant diverses techniques de terrain, au cours des saisons sèches et des pluies de 2007 et 2008. En tout, on a rapporté un total de 21 espèces de reptiles appartenant à neuf familles (668 individus capturés), et huit espèces d'amphibiens de cinq familles différentes (492 individus). Près de 94% des amphibiens et la plupart des espèces ont été capturés pendant la saison des pluies alors que chez les reptiles, il n'y avait pas de différence marquée entre les saisons. Cependant, on trouvait les *Agama agama* et *Mabuya affinis* plus spécialement en saison sèche. Pour ce qui est de la fréquentation des micro-habitats, les espèces de reptiles montraient une préférence nette et s'aggloméraient dans deux types d'habitats (feuilles sèches et sous les troncs abattus) qui sont probablement cruciaux lorsque ces animaux doivent faire baisser leur température corporelle pour éviter la surchauffe. En ce qui concerne les amphibiens, les différentes espèces fréquentaient les micro-habitats disponibles de façon prévisible en raison de leurs principales caractéristiques écologiques, les crapauds différant des grenouilles aquatiques, et ces dernières différant des grenouilles arboricoles.

Introduction

Ecology and economy are often in strong contrast (e.g. Battisti & Romano, 2007), and petrochemical industry may represent one of the most relevant threats to natural environments in ecologically important regions (e.g. Hudson, 1991). It is therefore crucial to study the ecology of the environments under threats from petrochemical

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industry, especially because of their eventual conservation implications. The Niger Delta region (southern Nigeria) is the main production area for oil and natural gas of the whole African continent (e.g. Moffat & Linden, 1995; Singh, Hewawasam & Moffat, 1995). During the last two decades, this region, despite being a biodiversity hotspot, has also become known for the frequent cases of oil spills, with catastrophic consequences for the natural environment (e.g. Ajao & Anurigwo, 2002; Luiselli, 2006a,b). In this sense, the coastal area of Bonny Island (Rivers State) is particularly vulnerable, following the occupation of a vast area of the island by various oil and gas companies, including Shell Petroleum Development Company (SPDC), Nigeria Liquefied Natural Gas (NLNG), Exxon-Mobil, TSKJ, Daewoo, etc.

The intensive petrochemical industry activity at Bonny Island culminated with the establishment of the oil and gas facilities at the old Finima town. After this, the people inhabiting Finima town were relocated for safety reasons to the southerly forested area. The relocation to a new Finima town culminated in evident, albeit scientifically not documented, loss of biodiversity (FCNL, 2004, 2006). Therefore, as a measure of environmental compensation, the Finima Nature Park was delineated for conservation in 1999, with the primary aim to protect the integrity of the forest and to provide a refuge for wildlife threatened or displaced by oil industry activities and the relocation to New Finima on the island. Sponsored by NLNG, the 10-year-old park is conserved by a nongovernmental organization, the Niger Delta Wetland Centre (NDWC).

In spite of the fact that reptiles and amphibians are a conspicuous component of the wildlife of the Niger Delta (e.g. Akani *et al.*, 1999; Luiselli & Akani, 2002; Luiselli, 2006a,b), there are no ecological data available on the herpetological communities on Bonny Island and, more specifically in Finima N.P., with the only scattered information coming from environmental impact assessment reports (e.g. Politano, 1997, 1998). This study reports on the community composition of reptiles and amphibians in relation to seasonality and habitat characteristics at Finima N.P.

Materials and methods

Study area

Finima Nature Park (Fig. 1) is essentially a seasonally flooded freshwater swamp forest located barely 3 km from the sandy beach of the ocean in the south of Rivers State, Niger Delta, Nigeria. The forest is flanked in the east by SPDC/Exxon-Mobil's right-of-way and on the north and west by New Finima town, and by the headquarters of the aforementioned companies. The New Finima and Bonny town road is the immediate road on the north. To reduce crushing of animals by vehicular traffic, the speed in Finima is limited to maximum 35 km h^{-1}. The study area is characterized by an equatorial climate type, with wet season from May to October (Barbour *et al.*, 1982). An annual average rainfall of 3200 mm is measured. The peak of the rains is in July and September, when depressions in the park are inundated. Dry season stretches between November and April. The annual temperature range is small, often <3°C. Mean monthly maximum temperatures vary between 27°C and 34°C, and mean minima vary between 22°C and 24°C. Relative humidity is high (from 65% in dry season to 98% in wet season).

The Finima Park vegetation has progressively developed into a high forest considering the disturbed form from which it started in 1998. Two distinct storeys are now distinguishable from outside the forest and the emergents include *Symphiona globulifera*, *Cleistopholis patens*, *Uapaca* sp., *Musanga cecropoides*, *Hallea ledermanni*, *Terminalia* sp., *Anthosterma aubreyanum*, *Tectonia grandis* and *Elaeis guineensis.* The understorey is composed mainly of *Calamus deeratus*, *Alchornea cordifolia*, *Monodora tenuifolia*, *Harungana madagascariensis*, *Spondiathus preussi*, *Rauvolfa vomitoria* and *Raphia* sp. The interior of the forest is very shady and as a result, a wide variety of shade-tolerant forbs (e.g. *Nephrolepis biserata*, *Culcasia scandens*, *Laportea* sp., *Chromolaena odoratum*, *Aframomium melegueta* and *Costus afer*) and various sedges form thickets on the forest floor. By dry season, large cushion of litter cover the floor because of increase in abscission rate of some plants such as *Musanga cecropoides*, *Hallea ledermanni*, *Calamus deeratus*, *Gmelina arborea*, *Raphia* sp. and *Elaeis guineensis.*

Protocol

Field studies were carried out during the wet and dry seasons of 2007 and 2008 around two study stations: Agaja and Seibikiri. Agaja trail area of the park is located at 04°24.490′N; 007°11.401′E on the eastern flank, behind LNG Residential Area. It is appoximately 3.3 km away from Seibikiri trail sampling point at 04°24.213′N; 007°08.324′E, on the western flank. Agaja trail traverses the Park from the LNG Residential neighbourhood and

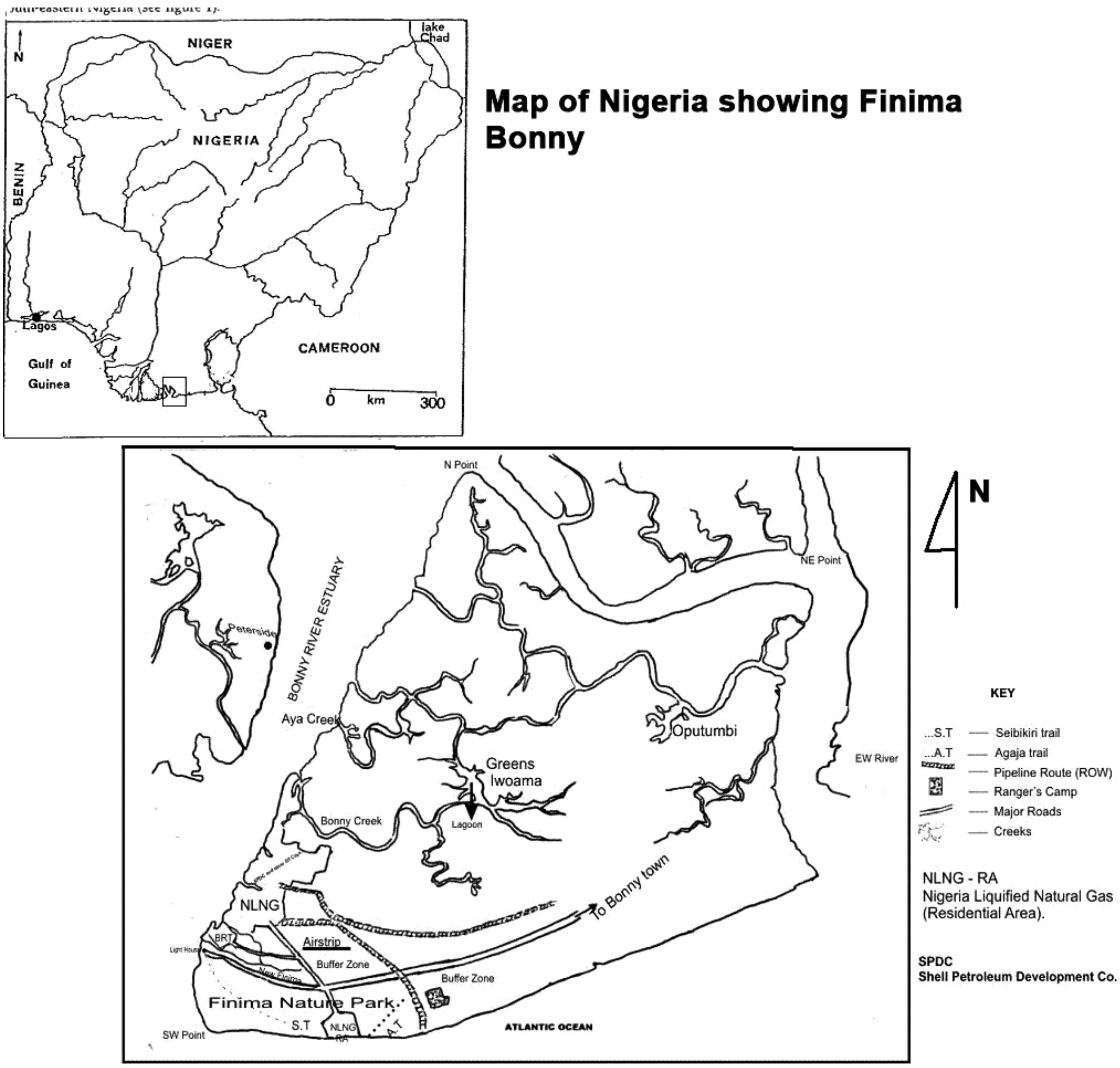

Fig 1 Map of Bonny Island (Rivers State, Nigeria), showing the study sites

ends at commonly shared right-of-way (ROW) by SPDC/Texaco/Exxon-Mobil. Except for this ROW that is often used by people, the forest around this area is relatively pristine compared with that of the Seibikiri section. This latter area is partially degraded because of increased anthropogenic activities of Lighthouse village people, a few kilometres away.

The study consisted of a pilot phase (which was made of interviews to local people) and a successive field research phase. During the pilot phase, the Park Rangers, who are natives of Finima, helped obtain information from the interviewees. The people were asked concerning the amphibians and reptiles of the area, local names and sites of high densities. Colour plates of the various species potentially present at the study area were made available to the rangers to enable local people distinguish and confirm the species discussed. Although these interview data were not used for data analysis in this study, they were instrumental in helping us decide the sites for conducting field surveys.

The proper field investigation consisted of a combination of (i) drift fences with pitfall traps and (ii) Visual Encounter

Surveys (VES). Each sampling point at Agaja and Seibekiri was located midway of the trail, in the interior of the thick forest. The fences consisted of planks nailed together to form barricades approximately 50 m long and 50 cm high. At intervals of 5 m, five pitfall traps were dug and plastic buckets measuring 64 cm deep and with 17 cm radius were lowered into them. Overall, both the Agaja and the Seibikiri trails had 20 pitfall traps. To prevent trap deaths from exposure to predation, desiccation, shock or capture myopathy (Marcus, 1981), the traps were sheltered from direct sunlight, and inspected at short time intervals (once every 6 h) for identification, marking and release of any trapped individuals. The habitat of encounter was recorded on the spot for every captured individual. VES surveys included (i) raking of 2 m × 2 m quadrats for litter amphibians and reptiles (Scott, 1982); (ii) screening of tree branches for arboreal species using high-power binoculars (Akani *et al.*, 2008a); (iii) inspection of broad-leaved hydrophytes, e.g. *Cyrtosperma senegalense*, for tree frogs; (iv) lifting of logs, stones, planks, panels, plastics, etc., for any hiding specimens (Luiselli, Akani & Capizzi, 1998; Akani *et al.*, 2008b) and (v) walking /searching along Agaja and Seibikiri trails as well as forest edges for basking reptiles, tracts, sloughed skin, etc., between 9.00 AM and 12 noon, and 2 PM and 5.00 pm. During these procedures, examination of road-kills and carcasses was also carried out. Substratum/microhabitat use by amphibians and reptiles was studied by capturing animals in six microhabitat types: under logs (UL), under dry leaves (DL), in burrows (BU), on sandy substratum (SS), on arboreal/tree branches (ATB) and at ponds or pond shorelines (PDS). In this regard, animals caught in pitfalls were included in habitat preference analysis, considering the habitat surrounding the location of the pertinent trap.

Overall, a total of 56 days was spent in the field. For dry season, we worked 14 days in January 2008 and another 14 days in March 2008. For wet season, we worked 14 days in July 2008 and 14 days in September 2008. Each time the team consisted of five researchers moving independently of each other throughout all the study areas, and each day we worked 4 h in Agaja trail and 4 h in Seibikiri trail, using Hilux vehicle provided by LNG/NDWC. Thus, the field effort was identical in both seasons.

During line transects, conducted along predefined tracks, all the encountered specimens of amphibians and reptiles were captured by hand. The captured animals were determined at the species level, sexed, individually marked and then released at the capture point. Turtles and tortoises were marked by notching of a dorso-lateral scute, snakes by ventral scale clipping and lizards and frogs by toe clipping. For some genera (*Hyperolius*, *Afrixalus* and *Typhlops*), as identification to species level in the field might have been problematic, we only considered the genus level for our analyses.

To avoid data pseudo-replication in our analyses, we never used recaptures. All tests were two tailed, and alpha was set at 0.05. Inter-seasonal differences in terms of frequencies of individuals sampled were assessed by χ^2 test. Multivariate analyses (Principal Component Analysis with normalized data; and UPGMA dendrogram with Jaccard's similarity measure) were performed to study the microhabitat use similarities among species. Principal component analysis (PCA) was performed using a VARIMAX rotation, and including only those factors whose variance was at least equal to that of the single variables entered in the analysis (i.e. factors with eigenvalues ≥1; Kaiser's theorem).

Results

In the course of the study, a total of 21 species of reptiles from nine families (with 668 individuals caught) and eight amphibian species from five families (492 individuals caught) were recorded (Table 1). Additional species are certainly present at Bonny Island, but were not uncovered during this study. For instance, previous studies reported the presence of the snakes *Rhamnophis aethiopissa* and *Hapsidophrys lineatus* (Luiselli, Angelici & Akani, 2000; Luiselli, Akani & Angelici, 2001) and the chameleons *Chamaeleo gracilis gracilis* and *Rhampholeon* sp. (Akani, Ogbalu & Luiselli, 2001) at the study area. Moreover, one individual of the snake *Thelotornis kirtlandii* was captured in October 2009 by G.C. Akani, after the acceptation of the present article. In addition, hunters reported that *Crocodylus cataphractus* was occasionally found at Finima, but they also indicated that it has not been caught since the last 20 years.

Amphibians were significantly more abundant during the wet season ($\chi^2 = 379.32$, df = 1, $P < 0.0001$) and reptiles during the dry season ($\chi^2 = 26.08$, df = 1, $P < 0.0001$) (Table 1). Closer inspection of the data revealed that this overall pattern was relevant for only on two of 21 species in reptiles (i.e. *Agama agama* – $\chi^2 = 4.55$, df = 1, $P < 0.033$; and *Mabuya affinis* – $\chi^2 = 24.01$, df = 1, $P < 0.0001$) and on five of eight species in amphibians

Table 1 Summary of the number of individuals of the herpetofaunal species captured at each study site, during both the wet and the dry seasons, in Finima Nature Park, Bonny Island, Nigeria

		Agaja trail area		Seibikiri trail area	
Family	Species	DS	WS	DS	WS
Reptilia					
Crocodylidae	*Osteolaemus tetraspis*	5	8	0	2
	Crocodylus niloticus	3	2	0	1
Testudinidae	*Pelusios niger*	0	4	1	1
	Kinixys erosa	3	1	2	0
Varanidae	*Varanus ornatus*	3	7	5	2
Agamidae	*Agama agama*	78	51	43	39
Scincidae	*Mabuya affinis*	92	67	105	44
	Mabuya maculilabris	2	0	0	1
	Lygosoma fernandi	5	1	7	16
Boidae	*Python sebae*	2	0	0	1
	Python regius	0	1	0	0
	Calabaria reinhardti	0	1	0	0
Elapidae	*Naja nigricollis*	3	0	1	0
	Naja melanoleuca	1	0	2	0
	Dendroaspis jamesoni	2	1		1
Viperidae	*Bitis gabonica*	2	0	1	0
	Causus maculatus	6	2	2	1
	Atheris squamiger	1	0	0	0
Colubridae	*Gastropyxis smaragdina*	10	4	4	1
	Grayia smithii	7	2	0	5
	Mehelya poensis	2	0	0	1
Total		227	152	173	116
Amphibia					
Bufonidae	*Bufo maculatus*	4	26	2	17
	Bufo regularis	6	11	5	31
Ranidae	*Ptychadena* sp.	2	30	5	54
	Hoplobatrachus occipitalis	2	9	0	11
Pipidae	*Silurana tropicalis*	4	145	0	108
Hyperolidae	*Hyperolius* sp.	0	7	0	4
	Afrixalus sp.	0	3	0	2
Rhacophoridae	*Chiromantis rufescens*	0	3	0	1
Total		18	234	12	228

DS, Dry Season; WS, Wet Season.

(i.e. *Bufo maculatus*, *B. regularis*, *Ptychadena* sp., *Hoplobatrachus occipitalis* and *Silurana tropicalis*; in all cases at least $P < 0.01$ at χ^2 test with df = 1). Thus, it can be concluded that most of the reptiles did not show any seasonal abundance pattern, whereas most of the amphibians did, being more active in the wet season.

Lizards accounted for the great majority of the reptile individuals encountered and overall, there were no inter-seasonal differences in terms of relative frequency of encounter of the four main reptilian groups (in all cases, at least $P > 0.255$ at χ^2 test, with df = 1; Fig. 2). The commonest lizards in Finima N.P. were *Agama agama* and *Mabuya affinis*. All snakes, chelonians and crocodiles occurred uncommonly during our surveys (Fig. 2). Concerning amphibians, at both stations the dominant species was *Silurana tropicalis*, but *Ptychadena* and *Bufo* spp. were also commonly observed. On the contrary, tree frogs (genera *Hyperolius*, *Afrixalus* and *Chiromantis*) were only recorded during the rainy season, over 90% of them being located clamped under the broad leaves of *Cyrstosperma senegalense*.

The distribution of observations of the various species among microhabitat types is presented in Table 2. Most

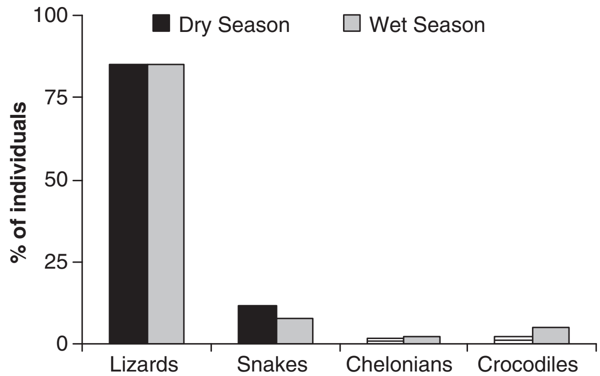

Fig 2 Percent contribution of the various reptilian groups to the total number of encountered individuals (totals: $n = 400$ in dry season, and 268 in wet season). For statistical details, see the text

Table 2 Microhabitat preferences of amphibians and reptiles at Finima Nature Park, Nigeria

Species	UL	DL	BU	SS	ATB	PDS
Reptilia						
Osteolaemus tetraspis				4		11
Crocodylus niloticus				2		4
Varanus ornatus				7		10
Pelusios niger						6
Kinixys erosa	6					
Agama agama	40	107		36	28	
Mabuya affinis	82	189		25	12	
Mabuya maculilabris		4				
Lygosoma fernandi	18	3	8			
Python sebae	2					
Python regius	1					
Calabaria reinhardtii			1			
Naja nigricollis		4				
Naja melanoleuca		3				
Dendroaspis jamesoni				4		
Bitis gabonica	1	2				
Causus maculatus	6	5				
Atheris squamiger					1	
Gastropyxis smaragdina						19
Grayia smithii						14
Mehelya poensis		3				
Amphibia						
Bufo maculatus	19	15				15
Bufo regularis	25	17				11
Ptychadena sp.						91
Hoplobatrachus occipitalis						22
Silurana tropicalis		21				236
Hyperolius sp.					11	
Afrixalus sp.					5	
Chiromantis sp.					4	
Total number of species	10	12	2	6	6	11

UL, Under logs; DL, Under dry leaves; BU, Burrow; SS, Sandy substrate; ATB, Arboreal/Tree branches; PDS, Ponds.

species in the park appeared to prefer DL and UL to other habitats. For reptile species, a PCA, with the first three factors explaining 99.4% of the total variance, indeed showed a strong correlation of most reptiles towards negative values of factor 1, which corresponds exactly to the microhabitat combination UL–DL (Table 3). Indeed, the eigenvalue relative to Factor 1 ($E_{\text{fact.1}} = 2573.31$) was much higher than those of the other factors ($E_{\text{fact.2}} = 41.29$; $E_{\text{fact.3}} = 0.41$), thus reinforcing the evidence of the very strong influence of UL and DL as good microhabitats for reptiles. An UPGMA dendrogram (Fig. 3a) showed that four main clusters of species are formed in terms of microhabitat type similarity: (i) *Osteolaemus tetraspis*, *Crocodylus niloticus*, *Varanus ornatus*, *Pelusios niger*, *Gastropyxis smaragdina* and *Grayia smithii*; (ii) *Lygosoma fernandi*, *Bitis gabonica* and *Causus maculatus*; (iii) *Kinixys erosa*, *Python sebae* and *Python regius* and (iv) *Mabuya maculilabris*, *Naja melanoleuca*, *Naja nigricollis* and *Mehelya poensis*. Concerning amphibians, a same set of PCA with first three factors explaining 99.2% of the total variance (Table 3) and an UPGMA dendrogram (Fig. 3b) showed that three clear clusters were formed: (i) the two *Bufo* species; (ii) *Hyperolius*, *Afrixalus* and *Chiromanthis* species and (iii) *Hoplobatrachus occipitalis* and *Silurana tropicalis*.

Discussion

Species richness

Overall, our study revealed that the herpetofaunal community of Finima N.P. is composed of a relatively low number of species, i.e. only 29 including both reptiles and amphibians, or not more than 32–33 if we include other species that are known from Bonny island but escaped our sampling. These numbers are low when compared with the species richness observed in other areas of the Niger Delta, despite the relative surfaces of the investigated sites being similar: for instance, 47 amphibians and 18–24 snakes were recorded in forests and forest-derived habitats of the Port Harcourt and Eket territories (Akani *et al.*, 1999; Akani, Politano & Luiselli, 2004). However, the species richness observed in this study was similar to that (31 species including both reptiles and amphibians) observed in the coastal barrier island of Brass, approximately

Table 3 Scores of the various species among factors in a Principal Component Analysis performed on the basis of the normalized frequency of sighting of each species across the six microhabitat types recorded at the study area (for more details, see the text)

Species	Symbol	Factor 1	Factor 2	Factor 3
Reptilia				
Osteolaemus tetraspis	1	−16.936	4.3676	−6.7619
Crocodylus niloticus	2	−17.104	1.1327	−0.4884
Varanus ornatus	3	−16.438	6.0932	−5.3065
Pelusios niger	4	−17.465	0.34475	−2.7185
Kinixys erosa	5	−15.079	−3.6863	2.9597
Agama agama	6	103.29	21.685	7.7508
Mabuya affinis	7	190.12	−11.946	−4.9947
Mabuya maculilabris	8	−13.708	−1.3128	2.6228
Lygosoma fernandi	9	−7.856	−9.2343	3.0975
Python sebae	10	−16.584	−2.0865	2.9536
Python regius	11	−16.96	−1.6866	2.9521
Calabaria reinhardtii	12	−17.337	−1.3777	2.9963
Naja nigricollis	13	−13.708	−1.3128	2.6228
Naja melanoleuca	14	−14.615	−1.3062	2.7048
Dendroaspis jamesoni	15	−16.7	1.3768	3.6314
Bitis gabonica	16	−15.146	−1.6997	2.7882
Causus maculatus	17	−10.544	−3.7191	2.55
Atheris squamiger	18	−17.236	−0.72587	3.2142
Gastropyxis smaragdina	19	−17.745	3.8794	−15.002
Grayia smithii	20	−17.637	2.5199	−10.277
Mehelya poensis	21	−14.615	−1.3062	2.7048
Amphibia				
Bufo maculatus	25	−6.0834	17.215	0.18743
Bufo regularis	26	−10.504	22.919	−0.46087
Ptychadena sp.	27	71.325	−1.9026	−1.6262
Hoplobatrachus occipitalis	28	2.6384	−6.1869	3.3551
Silurana tropicalis	29	1.6429	−6.249	3.4273
Hyperolius sp.	30	−19.94	−9.2782	−5.8988
Afrixalus sp.	31	−19.57	−8.3371	0.01513
Chiromantis sp.	32	−19.508	−8.1803	1.0008

The symbols that are used to define species in Fig 3 are also shown.

82 km west of Bonny (Akani *et al.*, submitted). Thus, it is likely that the species richness is lower in the small islands of the Delta than that in the inner mainland, although this pattern should be confirmed by further studies. We suppose that the reduced number of species is because of the presence of a wide mangrove zone in between Bonny island and the inland swamp forest zone. The mangrove zone, with wide brackish water marshes and strong tidal oscillations in the water level, may have been an obstacle to the dispersal and colonization of several typical forest-dwelling species (especially amphibians) towards the coastal islands such as Bonny, given that these species are typically very sedentary and habitat specialists (e.g., Luiselli, 2006a, 2007). In case of amphibians, the low number of species could not be attributed to human demands, as the people of Finima are essentially fishers and do not have the culture of hunting amphibians for food or for bait (Akani & Luiselli, interview data). It seems possible that the low number of amphibian species may be as a result of the intrusion of saltwater and brackish water into the ponds of several sites at the study area (given their close proximity to the ocean), thus disturbing the amphibian fauna. However, one should be careful before stressing firm conclusions concerning the reduced number of species found in Bonny Island. Indeed, there are some possible shortcomings associated with our sampling that may have affected the results. For instance, the fact that we captured only 8 anuran species may be attributed to our sampling by VES only during the day (whereas tropical frogs tend to be active particularly at night), although our pitfall traps

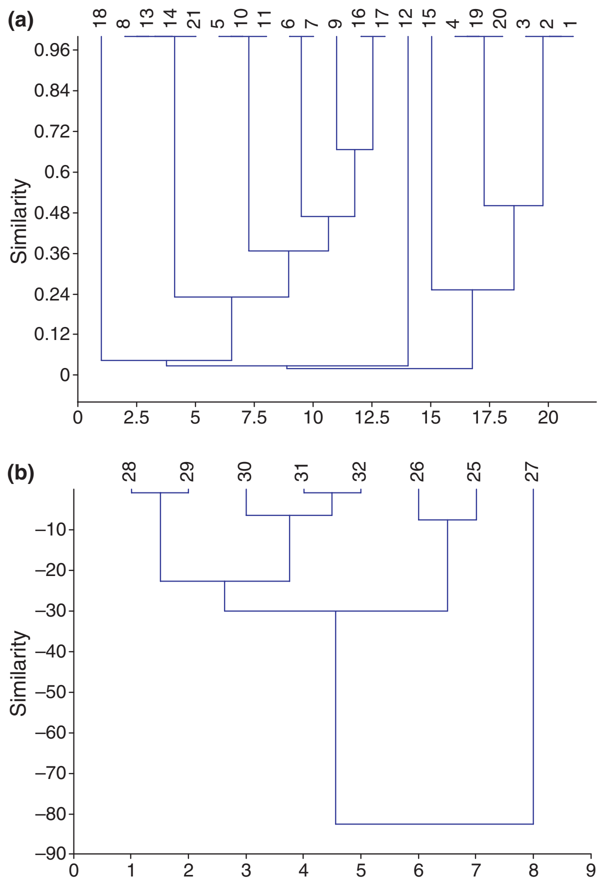

Fig 3 UPGMA dendrogram, with Jaccard's similarity measure, showing dissimilarities among reptiles (graphic a) and amphibians (graphic b) in terms of microhabitat preferences. For symbols, see Table 3

would have captured animals also at night, thus lowering the eventual biases depending on our diurnal transect sampling. Therefore, we have probably underestimated the local species richness, particularly concerning arboreal anurans (families Hyperoliidae and Rhacophoridae) and lizards (Gekkonidae), and possibly also some nocturnal snakes (e.g. *Lamprophis* species). Although bucket traps may provide data on nocturnal species also, yet they are highly selective, usually selecting only for ground-dwelling or burrowing species (e.g. Arthroleptidae and Bufonidae) and migrating pipids (e.g. *Silurana tropicalis*). In addition, they are not very efficient in capturing smaller and/or very mobile taxa (cf. e.g. Rödel & Ernst, 2004). In general, all the species found in Bonny are typical of altered biotopes (Schiotz, 1999; Akani, Politano & Luiselli, 2004). Thus, it is likely that environmental pollution caused by petrochemical substances from the companies – gasoline, diesel, engine oil, etc – which are accidentally introduced into freshwater bodies during routine works, may contribute to the low diversity of amphibian species at the study area.

Seasonality

Concerning the amphibians, we found a higher diversity of species and a higher number of individuals during the wet season. This pattern is in agreement with previous studies carried out in tropical Africa (e.g. Barbault, 1976, 1977, 1987, 1991; Luiselli, 2006b; Gardner *et al.*, 2007; Behangana, Kasoma & Luiselli, 2008; Behangana & Luiselli, 2008) and is certainly linked to the reproductive seasonality of these animals in equatorial Africa. On the contrary, as for the reptiles, there was no clear seasonal pattern, apart from the two commonest lizard species that were more active by dry season. The pattern exhibited by reptiles is a little bit surprising, as in general also the reptiles follow the same pattern of higher activity intensity by wet season (e.g. Akani *et al.*, 1999; Luiselli & Akani, 2002). Our data are still insufficient to explain this unusual phenology pattern in reptiles.

Microhabitat use

In terms of microhabitat use, reptiles and amphibians exhibited some noteworthy differences in overall pattern. Reptiles showed a clear, aggregated preference for DL and UL, which are the favoured substratum types where these animals hide when needing to lose body temperature to avoid overheating (Luiselli, 2007). Hence, given the aggregated use of the same resources by most species, it is evident that the reptile community at Bonny does not show the potential for a nonrandom microhabitat niche partitioning as observed in other African reptile communities (e.g. Luiselli, 2008). Anyway, looking at the clusters formed through our multivariate analyses, it can be concluded that group (i) include mainly semi-aquatic species (e.g. crocodiles and monitor lizards), group (ii) ground-dwelling species from the forest-plantation ecotonal mosaics, group (iii) species of rather altered habitat types, whereas group (iv), inclusive of two python species and one tortoise, is heterogeneous and of difficult interpretation. Concerning the amphibians, the clusters formed by our multivariate analyses are congruent with expectations from general ecology traits of the various species, with toads (genus *Bufo*) separated from arboreal frogs (*Hyperolius*, *Afrixalus* and

Chiromantis), and these two groups from the aquatic frogs (*S. tropicalis* and *H. occipitalis*).

Conservation implications

Following the ranking of Federal endangered species list of Nigeria (Act 11 of 1985 Schedules 1 and 2), Finima N.P. is inhabited by six species falling into the Schedule 1 category, including critically endangered species that should not be removed by anybody (namely *C. niloticus, O. tetraspis, Varanus ornatus, Python sebae, P. regius* and *Calabaria reinhardtii*). On the contrary, none of the species recorded in Finima N.P. falls into schedule 2, which includes species that could be taken with permit from appropriate wildlife authorities after signing by the head of State. Thus, the presence of some species of conservation concern and the strong environmental pressure caused by oil companies do make Finima N.P. an important and potentially threatened forest habitat in southern Nigeria. It is therefore required in this work that the oil companies should not impact again on the remnant natural habitats found in Bonny island, and that possibly they may mitigate the impacts they are already causing to the environment by economically sustaining ecological projects aimed at improving the network of corridors among forest remnants, especially for species having large home ranges and a clear tendency for dispersal (e.g. *Python sebae*; see Luiselli & Akani, 2002).

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