ASPECTS OF SPECIES RICHNESS AND SEASONALITY OF AMPHIBIANS AND REPTILES IN THE COASTAL BARRIER ISLAND OF BRASS (NIGERIA)

Godfrey C. Akani[1], Luca Luiselli[2], Anthony E. Ogbeibu[3], John N. Onwuteaka[1], Edith Chuku[1], J.A Osakwe[4], Pierluigi Bombi[2], Charity C. Amuzie[1], Michael Uwagbae[5] & Harry A. Gijo[6]

Résumé. — *Aspects de la richesse spécifique et de la saisonnalité des amphibiens et reptiles de l'île-barrière côtière de Brass (Nigéria).* — L'écologie des communautés d'amphibiens et de reptiles des forêts des îles-barrières côtières du delta du Niger, sud du Nigéria, est pratiquement inconnue. Dans cet article nous examinons la richesse spécifique et la saisonnalité des amphibiens et reptiles en divers sites de l'île de Brass, l'une des principales îles-barrières du Nigéria. Nous avons utilisé une série de méthodes pour capturer des spécimens et conduire un effort de terrain équilibré durant les saisons sèche et humide. En tout, 31 espèces appartenant à 17 familles ont été capturées. En ce qui concerne les amphibiens, nous avons collecté une espèce pour les Pipidés et les Ranidés, deux pour les Ptychadénidés, Bufonidés et Hyperoliidés. En reptiles, nous avons capturé une espèce pour les Agamidés, Varanidés, Chamaeléonidés, Typhlopidés, Vipéridés et Pélomédusidés, deux pour les Boïdés, Testudinidés et Crocodylidés, trois pour les Scincidés et Elapidés, cinq pour les Colubridés *sensu lato*. Moins d'espèces ont été trouvées dans les forêts d'île-barrière côtière que dans les forêts marécageuses, mangroves ou savanes dérivées du delta du Niger. Il n'est pas apparu d'effet saison clair sur l'abondance et la diversité des reptiles (mais la plupart des espèces ont essentiellement été trouvées en saison sèche) alors que, pour les amphibiens, un tel effet s'est avéré fort, avec de plus fortes abondances et diversités spécifiques en saison des pluies.

Summary. — The ecology of the communities of amphibians and reptiles are nearly unknown in the coastal barrier island forests of the Niger Delta, southern Nigeria. In this paper, we examine aspects of species richness and phenology of amphibians and reptiles at several sites of Brass Island, one of the main coastal barrier islands of Nigeria. We employed a suite of field methods to capture specimens, and performed an equal field effort during both dry and wet seasons. Overall, we captured 31 species belonging to 17 families. For amphibians, we collected one species of Pipidae and Ranidae, and two of Ptychadenidae, Bufonidae, and Hyperoliidae. For reptiles, we captured one species of Agamidae, Varanidae, Chamaeleonidae, Typhlopidae, Viperidae, and Pelomedusidae, two of Boidae, Testudinidae and Crocodylidae, three of Scincidae and Elapidae, and five of Colubridae *sensu lato*. Fewer species were found in coastal barrier island forests than in swamp forests, mangroves or derived savannas of the Niger Delta. There was no clear seasonal effect on reptile abundance and diversity (but most species were found essentially by dry season), whereas for amphibians there was a strong seasonal effect, with higher abundances and species diversity found in wet season.

---

[1] Department of Applied and Environmental Biology, Rivers State University of Science & Technology, P.M.B. 5080, Port Harcourt, Rivers State, Nigeria.

[2] Author for correspondence. Centre for Environmental Studies, DEMETRA, s.r.l. and F.I.Z.V. (Ecology), via Olona 7, I-00198, Rome, Italy. E-mail : lucamlu@tin.it

[3] Department of Animal and Environmental Biology, University of Benin, Benin city, Edo State. Nigeria

[4] Department of Crop Science / Soil Science, Rivers State University of Science & Technology, P.M.B. 5080, Port Harcourt, Rivers State, Nigeria.

[5] Department of Zoology, Ambrose Alli University, P.M.B 14,Ekpoma,Edo State, Nigeria.

[6] Department of Biological Sciences, Niger Delta University, Amassoma, Yenagoa, Bayelsa State, Nigeria.

Rev. Écol. (Terre Vie), vol. 65, 2010.

The Niger Delta ecoregion (total area of approximately 15,000 km^2), contained within three states, Rivers, Bayelsa, and Delta, in southern Nigeria, is currently an important area in tropical Africa not only because it hosts a high richness and diversity of species, including several endemic taxa (e.g., the monkeys *Cercopithecus sclateri* and *Procolobus badius epieni*; e.g. Baker & Tooze, 2003; Baker & Olubode, 2007), but also because of its crucial relevance for the continental economy, given that this is the main oil-producing area of the whole Africa (e.g., Moffat & Linden, 1995; Singh *et al*., 1995; FCNL, 2004, 2006). This region has also become known for the frequent cases of oil spills, with catastrophic consequences for the natural environment (e.g., Ajao & Anurigwo, 2002; Luiselli *et al*., 2006). The main vegetation type of this region is the swamp forest, which is however currently very fragmented due to human pressure (e.g., Singh *et al*., 1995). Along its southern side, the Niger Delta swamp forests are separated from the Atlantic Ocean by a band of mangroves, which can reach up to 10 km inland and that are the largest mangrove belt of the whole continent (Singh *et al*., 1995). In front of the mangrove belt and close to the sea are coastal barrier islands often characterized by transitional vegetation. These coastal barrier islands are virtually unknown in ecological terms, and even their vertebrate faunas have never received any attention by scientists. Although in recent years there has been considerable scientific research focused on community ecology of amphibians and reptiles in the Niger Delta (e.g., Akani *et al*., 1999, 2008; Luiselli & Akani, 2002; Luiselli *et al*., 2006), studies on coastal barrier island forests are virtually lacking. However, a recent paper examined the herpetofauna community structure of another Niger Delta coastal area (Akani & Luiselli, 2010).

Our aim in this study was to investigate the community composition, and its variations in relation to seasonality (wet versus dry seasons), of reptiles and amphibians in the coastal barrier island forests of Brass Island (Bayelsa State, Nigeria) and to compare these data with previous studies conducted in other vegetation zones of the Niger Delta. This study may be also of interest because the study area is currently under development due to the establishment of the Brass Liquefied Natural Gas (LNG) project, that is one of the main industrial project of the whole region being a joint venture of the Federal Republic of Nigeria with Nigerian National Petroleum Corporation and the international oil companies Chevron-Texaco, ConocoPhillips, and ENI International. Presently the vegetation is generally mature (see below for more details), and after the construction of the LNG it is likely that the herpetological community composition, distribution and abundance may change drastically. So this study can serve as an ecological reference of what was available before the LNG was built. Increase in human and industrial activities will certainly affect the ecology of the area and the habitats of both amphibians and reptiles (e.g., Heinen, 1992; Germano *et al*., 2003; Todd *et al*., 2007). Indeed, a very large area (over 2,280 hectares) is needed for various facilities of the LNG (i.e., storage tank areas, loading areas, pipelines, industrial areas, offices, residential areas, etc), hence very serious alteration to the current habitat structure may be expected.

MATERIALS AND METHODS

STUDY AREAS

The field study was conducted in the onshore area of Brass Island (Long 6° 13' to 6° 16' E, Lat 4° 16' to 4° 18'N), in the Brass Local Government Area (Bayelsa State, Nigeria) (Fig. 1). The sampling locality, coordinate ranges and dominant vegetation type for each study site are given in Table I. The study area is characterized by an equatorial climate, with a wet season (April to October) and a dry season (November to March), and with rather constant ambient temperatures (27-34°C) year-round.

Four distinct vegetation types are distinguishable as one moves from the onshore towards the inland : (i) littoral strand vegetation, (ii) freshwater swamp forest, (iii) mangrove swamp, and (iv) lowland forest. The littoral strand vegetation marks the littoral zone, and protects the beach ridge forest from the open ocean environment. It is characterized by small woody plants (e.g., *Alchornea cordifolia*, *Oncoba spinosa,* and *Chryobalanus icaco*) and low-growing scandent shrubs and herbs such as *Dalbergia escastaphyllum*, *Ipomoea mauritiana*, *Paspalum vaginatum*, *Conocarpus erectus*, and *Hibiscus tiliaceus*. This strand vegetation covers only 50 hectares or 2 % of the sampled area.

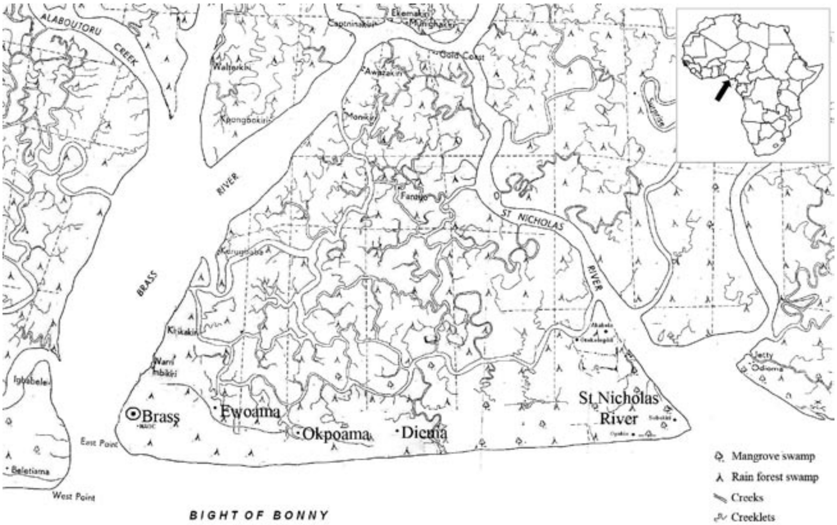

Figure 1. — Map of Brass, including the study sites.

TABLE I

Details of sampled stations, including local name, coordinates, and dominant vegetation characteristics

Site (local name)	Coordinate range	Dominant vegetation
NAOC (Twon Brass)	N419595.49 / E 33190.86	Freshwater swamp and lowland forest
Ewoama	N422017.82 / E32689.05 and N422017.90 / E32729.58	Littoral strand vegetation / mangrove, swamp
Okpoama	N424159.36 / E33922.19 and N424160.14 / E33962.02	Freshwater swamp and lowland forest
Diema	N423198.24 / E32785.42 and N423198.24 / E32744.71	Littoral strand vegetation, swamp forest
St. Nicholas River	N433867.10 / E37279.03 and N439675.02 / E34803.14	Littoral strand/ swamp /mangrove swamp

The freshwater swamp forest is a major vegetation type of the area, covering about 1848 hectares or 81 % of the study area. The forest is seasonally flooded, exhibits only a single dominant stratum of trees such as *Sacoglottis gabonensis*, *Parinaria excelsa*, *Elaeis guineensis*, *Cleistopholis patens*, *Allanblekia floribunda*, *Macaranga spinosa*, *Lophira alata*, *Raphia hookeri*, *Hallea ciliata*, and *Xylopia villosa*. Because of the diverse timber-producing species here, this type of habitat is highly exploited for timber.

The mangrove swamp occupies about 138 hectares or 6 % of the study area. Although smaller scattered patches occur in the central and western parts at Ewoama and Okpoama, it is located mainly in the eastern part, that is, St. Nicholas River area from where it spreads extensively towards the hinterland. The vegetation is co-dominated by pure stands of *Rhizophora racemosa* and *Avicennia africana*. Two distinct zones are noticeable : the *Avicennia* zone along the seaward side, and the *Rhizophora* zone, on the hinterland, above the high-tide level. Also of high frequency of occurrence in this swamp is the screw pine, *Pandanus candelabrum*, followed by the exotic palm *Nypa fructicans*. The swamp is highly disturbed through anthropogenic activities, as mangroves are favorite sources of fuel wood.

The lowland forest covers an estimated 243 hectares or 11 % of the study area. This forest holds a high diversity of tree species and is primarily located around Okpoama area. The forest shows three distinct storeys and the canopy is typically 5-6 m high, with occasional emergent trees up to 50 m. In general, there are wide shady patches within this habitat type. Among the frequently occurring woody plants of the forest are *Elaeis guineensis, Anthostema aubreyanum, Hallea ciliata, Lophira alata, Symphonia globulifera, Uapaca heudelotii,* etc. The undergrowth is thick, and the forest floor is usually covered with thick cushions of leaf litter by dry season, that make favorable habitat for ground-dwelling and burrowing species.

PROTOCOL

Field samplings were conducted during both dry and wet seasons in 2007 and 2008. Overall, a team of 9 people did the field work, from 0800 h to 1800 h daily, for 10 consecutive days in the dry seasons of 2007 and 2008 (total dry season sampling days = 20) and 10 consecutive days in the wet seasons of 2007 and 2008 (total wet season sampling days = 20). Researches were suspended during night-time because of security reasons ; Brass is indeed in the middle of a politically unstable area (International Crisis Group, 2007). Each day the team was split into two : while one team inspected, counted, and released trapped individuals in the drift fences and pitfalls, the other team walked along forest footpaths and edges searching for arboreal and ground-dwelling species, and lifting logs, planks, panels, leaf litter for any hiding reptile/amphibian.

Two methods were used to detect amphibians and reptiles. These included drift fences with pitfall traps and visual encounter surveys (VES). We also report individuals opportunistically captured by local people, although these observations were not used in statistical analyses. Concerning drift fences with pitfalls, a total of 19 transects were established and randomly distributed to reflect two major habitats in Brass. Ten haphazard transects were established in the seasonal rainforests situated behind NAOC Administrative Base at Twon-Brass, Ewoama, Okpoma, Diema while nine transects were located around the mangrove swamp and dry forest patches at the fishing settlements towards St. Nicholas River (Fig. 1). Along each transect, a wooden drift fence, about 30 m long and 61 cm high was constructed with 10 pitfall traps distributed at intervals of 3 m on either sides of the fences. Into each pitfall trap a large, black, plastic bucket (measuring 75 cm in diameter and 1.2 m deep) was lowered. A total of 133 pitfall traps were inspected daily. All trapped animals were identified to species, individually marked (toe clipping for lizards and amphibians ; ventral scale clipping for snakes ; scute notching for turtles and tortoises) in order to avoid pseudo-replication, and released.

VES were conducted along line transects laid at five sites in Brass Island. One sampling site was close to the industrial installations of Nigerian Agip Oil Company (NAOC site). This area is characterized by heavy human impact due to truck and ship movements, oil spills, and residential settlements. Main vegetation was secondary forest and forest-derived grasslands. The other four areas (Ewoama, Okpoama, Diema, and St. Nicholas River) are sited on the coastal barrier island of Brass at different linear distances from NAOC installations. All of these sites are characterized by mature coastal rain forest habitat, with different levels of human impact. Anthropogenic disturbance at each site was proportional to the relative distance from industrial installations. Field samplings were carried out both on sunny and on cloudy days. Daily research was suspended when it was heavily showering. During line transects, conducted along predefined tracks, all the encountered specimens of amphibians and reptiles were captured by hand. The captured animals were identified to species, sexed, individually marked, and then released at the capture point. For some genera (*Hyperolius*, *Afrixalus*, and *Typhlops*), as identification in the field to species level might have been questionable due to unresolved taxonomic issues, we only considered the genus level for our analyses. In this case we applied a 'morpho-species' approach. We did not collect vouchers for the problematic species because for the purposes of this study we did not get authorization to kill specimens from the competent governmental authorities.

Taxonomy of Afrotropical amphibians and reptiles is still a controversial issue for many species, and even genera and families. Thus, many taxa are often unstable in terms of their taxonomic position. For instance, a recent study changed the taxonomic status and nomenclature for many Afrotropical genera (Frost *et al.*, 2006), but many of these changes have been considered unacceptable and the value of the whole paper has been questioned (Wiens, 2007). Here we present for the problematic taxa both nomenclatures (Tab. II). Concerning the families, there is complication with one amphibian and one reptilian families. The frog genus *Ptychadena* is here placed in the family Ptychadenidae instead of Ranidae, whereas for five species of snakes representing different lineages within the old family 'Colubridae' (i.e., species of the genera *Grayia, Thelotornis, Psammophis, Mehelya*, and *Gastropyxis*), we still consider them as belonging to a same family, waiting for a more stable taxonomy of this controversial snake family.

Herpetofauna community composition of the different sites was compared in a UPGMA dendrogram by calculating their dissimilarity in terms of Euclidean distance (single linkage) based on the relative specific abundance. In order to evaluate the effect of seasonality (Gardner, 2007), we analysed separately data collected during dry and wet seasons. A quantitative biodiversity analysis of each study area was done according to the following indices : Species diversity was calculated using Margalef's Diversity Index (Magurran, 2004) :

$$D_{Mg} = (S-1)/\ln N$$

where S is the total number of species and N is the total number of individuals. We also calculated the Shannon's index :

$$H = -\sum\left[n/N \log(n/N)\right]$$

where n is the number of individuals observed for each species and N is the total number of individuals observed in each study area.

Evenness index of each study area was calculated by Pielou's formula :

$$e = H/\log S$$

with H representing Shannon's index and S the total number of species in each study area.

All tests were two-tailed, and alpha was set at 0.05. Interseasonal differences in terms of frequencies of individuals sampled were assessed by χ^2 test.

RESULTS

Including all sites, we captured 31 species belonging to 17 families (Tab. II). For amphibians, we collected one species of Pipidae and Ranidae, and two of Ptychadenidae, Bufonidae, and Hyperoliidae. For reptiles, we captured one species of Agamidae, Varanidae, Chamaeleonidae, Typhlopidae, Viperidae, and Pelomedusidae, two of Boidae, Testudinidae and Crocodylidae, three of Scincidae and Elapidae, and five of Colubridae *sensu lato*.

Amphibians showed a strong among-species variation in terms of number of observed individuals, with the most abundant species being captured 596 times (i.e., *Silurana tropicalis*), and with the least abundant species being found just 3-4 times (e.g., *Hyperolius* sp. and *Afrixalus* sp.) (Tab. II). All of the amphibian species were more abundant during the wet season ($\chi^2 = 556.93$, $p < 0.001$). Nonetheless, there were remarkable differences among species : for instance, *Ptychadena mascareniensis* was 2.25 times more abundant in wet than in dry season ($\chi^2 = 16.98$, $p < 0.001$), whereas *Silurana tropicalis* during the wet season was 22.8 times more abundant than in dry season ($\chi^2 = 500.19$, $p < 0.001$), and the few individuals of *Hyperolius* sp. and *Afrixalus* sp. were observed during the wet season only. Some species appeared widespread within our study area : for instance, *Amietophrynus maculatus* was observed at all sites. On the contrary, *Ptychadena oxyrhynchus*, *Hyperolius* sp., and *Afrixalus* sp. were encountered in two sites only.

With regards to reptiles (Tab. II), *Agama agama* and *Trachylepis affinis* were the most abundant and widespread species, being observed with very high numbers of individuals (184 and 292 respectively) in all of the sites. On the contrary, only one specimen of *Python sebae* and one of *Python regius* were observed, while two individuals of *Trachylepis maculilabris*, *Chamaeleo gracilis*, *Typhlops* sp., and *Crocodylus suchus* were collected. Reptiles were generally significantly more abundant during the dry season ($\chi^2 = 21.38$, $p < 0.001$), with the exception of two chelonians (*Kinixys homeana* and *Pelusios niger*), which did not show differences between dry and wet season ($\chi^2 = 0.11$, $p = 0.74$ and $\chi^2 = 2.58$, $p = 0.11$), and *Varanus ornatus*, which was three times more abundant in the wet season ($\chi^2 = 6.00$, $p < 0.05$). In addition, the few specimens of *Trachylepis maculilabris*, *Chamaeleo gracilis*, and *Crocodylus suchus* were encountered in the wet season.

In general, the highest number of species and individuals was observed in NAOC, Ewoama, and Okpoama, both in dry and wet seasons. Nevertheless, we observed seasonal differences in biodiversity indexes : that is, NAOC had the highest number of species and individuals in wet season but, at the same time, relatively low diversity (particularly *H*) and evenness (Tab. III). On the contrary, in wet season, Diema had fewer species and individuals but a relatively high diversity (mainly *H*) and evenness (Table III). Differently, St. Nicholas River had low number of species and individuals, as well as low diversity and evenness, both in dry and in wet seasons. These seasonal differences in terms of number of species and biodiversity parameters were more evident for amphibians than reptiles. In fact, in wet season the number of amphibian species increased, but the evenness decreased. On the contrary, for reptiles the general increase of number of individuals in dry season did not affect the biodiversity parameters, which remained relatively stable between dry and wet seasons. A similar pattern of stability was also observed in the number of species.

TABLE II

Summary of the number of individuals of the herpetofaunal species captured at each study site, during both the wet and the dry seasons, in the Niger Delta, Nigeria

	Species	Family	NAOC (dry)	Ewoama (dry)	Okpoama (dry)	Diema (dry)	St. Nicholas R (dry)	NAOC (wet)	Ewoama (wet)	Okpoama (wet)	Diema (wet)	St. Nicholas R (wet)
Amphibia	*Amietophrynus* (= *Bufo*) *maculatus*	Bufonidae	11	8	5	2	3	42	17	15	7	3
	Amietophrynus (= *Bufo*) *regularis*	Bufonidae	7	0	2	0	0	19	3	8	0	4
	Ptychadena mascareniensis	Ptychadenidae	27	2	5	1	0	53	25	18	3	0
	Ptychadena oxyrhynchus	Ptychadenidae	2	0	0	0	0	10	0	0	2	0
	Hoplobatrachus occipitalis	Ranidae	4	7	0	0	0	32	19	0	0	0
	Silurana tropicalis	Pipidae	16	9	0	0	0	429	14	128	0	0
	Hyperolius sp.	Hyperoliidae	0	0	0	0	0	3	0	1	0	0
	Afrixalus sp.	Hyperoliidae	0	0	0	0	0	1	0	0	2	0
Reptilia	*Agama agama*	Agamidae	56	16	38	2	1	32	9	20	7	3
	Trachylepis affinis	Scincidae	27	31	57	43	16	15	28	25	19	31
	Trachylepis maculilabris	Scincidae	0	0	0	0	0	0	2	0	0	0
	Lepidothyris (= *Lygosoma*) *fernandi*	Scincidae	0	13	28	3	2	0	5	23	3	0
	Varanus ornatus	Varanidae	4	6	6	0	0	7	2	9	0	0
	Chamaeleo gracilis	Chamaeleonidae	0	0	0	0	0	2	0	0	0	0
	Typhlops sp.	Typhlopidae	0	2	0	0	0	0	0	0	0	0
	Causus maculatus	Viperidae	3	0	5	2	0	0	0	2	1	0
	Thelotornis kirtlandii	Colubridae	5	1	2	3	0	1	1	1	1	0
	Grayia smythii	Colubridae	0	0	5	0	0	0	0	2	0	0
	Psammophis phillipsii	Colubridae	1	0	1	0	0	2	0	0	0	0
	Mehelya poensis	Colubridae	0	1	3	0	0	0	0	1	0	0
	Gastropyxis smaragdina	Colubridae	0	0	2	0	0	0	0	2	0	0
	Dendroaspis jamesoni	Elapidae	0	2	0	0	1	0	3	0	0	0
	Naja (= *Boulengerina*) *annulata*	Elapidae	0	3	1	0	0	0	1	0	0	0
	Naja nigricollis	Elapidae	2	0	1	0	0	0	0	0	0	0
	Python sebae	Boidae	1	0	0	0	0	0	0	0	0	0
	Python regius	Boidae	1	0	0	0	0	0	0	0	0	0
	Kinixys erosa	Testudinidae	5	4	2	0	0	2	2	3	0	0
	Kinixys homeana	Testudinidae	1	2	1	0	0	2	0	3	0	0
	Pelusios niger	Pelomedusidae	4	0	2	0	0	7	3	3	0	0
	Osteolaemus tetraspis	Crocodylidae	0	0	0	2	0	0	1	0	1	0
	Crocodylus suchus	Crocodylidae	0	0	0	0	0	0	2	0	0	0

TABLE III

Summary of the biodiversity indices calculated for the study areas (for more details, see text)

AMPHIBIANS	NAOC (dry)	Ewoama (dry)	Okpoama (dry)	Diema (dry)	St. Nicholas R (dry)	NAOC (wet)	Ewoama (wet)	Okpoama (wet)	Diema (wet)	St. Nicholas R (wet)
Number of amphibians species	6	4	3	2	1	8	5	5	4	2
Number of amphibians individuals	67	26	12	3	3	589	78	170	14	7
Amphibians' Margalef (*S*)	1.189	0.921	0.805	0.910	0.000	1.097	0.918	0.779	1.137	0.514
Amphibians' Shannon - Wiener (*H*)	1.260	1.594	1.744	0.877	0.737	0.410	1.146	1.052	1.079	0.403
Amphibians' Evenness (*E*)	0.703	1.150	1.588	1.265	-	0.197	0.712	0.654	0.779	0.581

REPTILIA	NAOC (dry)	Ewoama (dry)	Okpoama (dry)	Diema (dry)	St. Nicholas R (dry)	NAOC (wet)	Ewoama (wet)	Okpoama (wet)	Diema (wet)	St. Nicholas R (wet)
Number of reptiles species	12	11	15	6	4	9	12	12	6	2
Number of reptiles individuals	110	81	154	55	20	70	59	94	32	34
Reptiles' Margalef (*S*)	2.340	2.276	2.779	1.248	1.001	1.883	2.698	2.421	1.443	0.284
Reptiles' Shannon - Wiener (*H*)	0.440	0.577	0.475	0.116	0.136	0.149	0.424	0.326	0.083	0.000
Reptiles' Evenness (*E*)	0.177	0.241	0.176	0.065	0.098	0.068	0.171	0.131	0.046	0.000

Regarding the differences in community composition among sites, we observed that NAOC holds a unique community, very different from those in the other sites both in dry and in wet season (Fig. 2). Also Okpoama showed a relatively unique community, which differed from the others just slightly less than NAOC. This was particularly true for reptiles, which showed a constant pattern of similarities among sites in dry and wet seasons (Fig. 2). On the contrary, for amphibians a certain seasonal effect was evidenced. In fact, only NAOC maintained its strong differences in the two seasons, while the other sites changed their relative similarity from dry to wet season (Fig. 2).

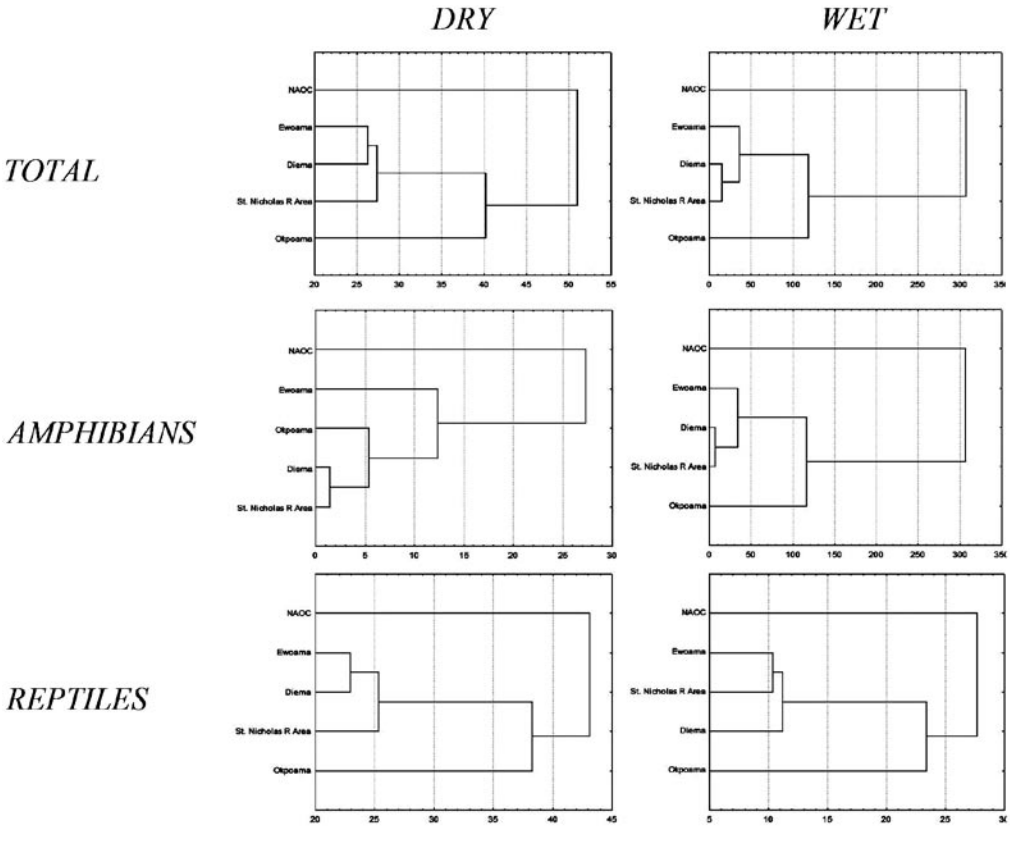

Figure 2. — UPGMA dendrogram showing the relative distance among sites, during both the dry and the wet seasons in terms of community composition for both reptiles and amphibians.

DISCUSSION

Overall, our study revealed that the herpetofaunal communities of the Niger Delta coastal barrier island forests have some remarkable differences from those observed in other main vegetation zones of the same geographic region. The first main aspect is that the community is composed by a relatively low number of species (just 31 including both reptiles and amphibians). On the other hand, species richness was much higher in other Niger Delta sites with different habitats : for instance, 47 amphibians and 18-24 snakes were recorded in forests and forest derived habitats (Akani *et al.*,1999, 2004). In this regard, it should be mentioned that these other sites were located on the mainland, and hence a higher species richness should also be expected there because islands typically have lower diversity than mainland sites (e.g., MacArthur & Wilson, 1967). Notably, the coastal barrier forests are not inhabited by typical ground-dwelling forest inhabitants (for instance, the snakes *Bitis gabonica, Bitis nasicornis, Atractaspis* spp., *Calabaria reinhardtii*, etc), that are locally abundant in swamp forest sites and are known to persist even in cultivated lands (Akani *et al.*, 1999, 2008). The same is also true for the chameleons, given that we observed just one species (*Chamaeleo gracilis*) instead of the at least 4 species that commonly occur in southern Nigerian forests (Luiselli, 2007). We suppose that the reduced number of species is due to the presence of the wide mangrove zone that separates the coastal barrier island forest zone 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 the typical forest-dwelling species towards the coastal barrier island forests. Indeed, several ground-dwelling forest species are very sedentary and habitat specialists (e.g., Luiselli, 2006a, 2007). However, we should be careful before stressing firm conclusions concerning the reduced number of species found in the coastal barrier island of Brass. Indeed, there are some possible shortcomings associated to our sampling that may have affected the results. For instance, the fact that we captured only six frog species may depend on that we sampled by VES only during the day, whereas tropical frogs tend to be active particularly at night. However, our pitfall traps would have captured animals also at night, thus lowering the eventual biases depending on our diurnal transect sampling. Hence, we have likely underestimated the local species richness, particularly with concerns to arboreal anurans (families Hyperoliidae and Rhacophoridae) and lizards (Gekkonidae), but possibly also some nocturnal snakes (e.g., *Lamprophis* species). Although bucket traps may provide data on nocturnal species as well they are highly selective, usually only selecting for ground-dwelling or burrowing species (e.g. Arthroleptidae, Bufonidae) and migrating pipids (e.g. *Silurana tropicalis*). Plus they are not very efficient in capturing smaller and/or very mobile taxa (cf. e.g., Rödel & Ernst, 2004). Other species that were expected to occur into the coastal barrier island forests (for instance the forest cobra, *Naja melanoleuca*) were not detected during this study, but we assume that this was due unsatisfactory field effort rather than to a true absence. However, it is noteworthy that we found the water cobra, *Naja annulata*, in the water bodies of the coastal barrier island forests. This large snake is very rare in Nigeria, and indeed was not recorded in this country until recent years (e.g., Romer, 1953; Butler & Reid, 1990).

Another interesting aspect concerns the phenology of the herpetofauna species in the coastal barrier island forests of Nigeria. Concerning the amphibians, we found a considerably higher diversity of species and a higher number of individuals during the wet season. This finding mirrors exactly with previous studies done in tropical Africa (e.g., Barbault, 1976, 1977, 1987, 1991; Luiselli, 2006b; Garner *et al.*, 2007; Behangana & Luiselli, 2008; Behangana *et al.*, 2008). Amphibians were encountered more in rainy season as it was their breeding season and the humid condition favored them so they could come out in high numbers. On the contrary, in reptiles, a higher species richness and a higher number of individuals were encountered during the dry season. This is certainly surprising, as in general also the reptiles follow the same patterns as the amphibians (e.g., Akani *et al.*, 1999; Luiselli & Akani, 2002). Our data are still insufficient to explain this unusual phenology pattern in reptiles.

Our study has also some conservation implications, given that, according to the ranking of Federal endangered species list of Nigeria (Act 11 of 1985 Schedules 1 and 2), Brass is inhabited by five species falling into the Schedule 1 category, which includes only critically endangered species that should not be removed by anybody. These species are the crocodiles *Crocodylus suchus* (listed as *Crocodylus niloticus* in the Schedule 1 act) and *Osteolaemus tetraspis*, the lizard *Varanus ornatus*, and the snakes *Python sebae* and *Python regius*). On the contrary, none of the species recorded in Brass falls into Schedule 2, which includes those species that could be taken with permit from appropriate wildlife authorities after signing by the head of State. The presence of five species of high conservation concern and the strong environmental pressure which is caused and will be even more caused in the next future by oil companies do make Brass a 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 Brass, 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 *et al*., 2001).

In conclusion, it should be stressed that the incoming works for the LNG project will considerably alter the ecological structure of the herpetological communities in Brass. Therefore, we would invite the pertinent authorities to officially gazette a conservation area which should include the Okpoma forest up to River St. Nicholas, where the majority of the species detected during this study were recorded.

ACKNOWLEDGEMENTS

We are grateful to Niger Delta Wetland Centre (NDWC) for logistic support and hospitality. The Federal Department of Forestry in Yenagoa released authorizations to capture the specimens used in this study. We are indebted to our field assistants – Dimie, Otufu, Dabbo, and several local hunters, especially Simon and Begold, for companionship and for giving us useful information on the habitat history of the study area as well as helping us to set the drift fences and pitfall traps. Anonymous reviewers substantially improved an early draft of this manuscript. The study was financially supported by Ente Nazionale Idrocarburi (ENI International), through 2004, 2005, and 2006 funds to LL.

REFERENCES

AJAO, E.A. & ANURIGWO, S. (2002). — Land-based sources of pollution in the Niger Delta, Nigeria. *Ambio,* 31 : 442-445.

AKANI, G.C., BARIEENEE, I.F., CAPIZZI, D. & LUISELLI, L. (1999). — Snake communities of moist rainforest and derived savanna sites of Nigeria : biodiversity patterns and conservation priorities. *Biodiv. Conserv*., 8 : 629-642.

AKANI, G.C., EBERE, N., LUISELLI, L. & ENIANG, E.A. (2008). — Community structure and ecology of snakes in fields of oil palm trees (*Elaeis guineensis*) in the Niger Delta, southern Nigeria. *Afr. J.Ecol.,* 46 : 500-506.

AKANI, G.C. & LUISELLI, L. (2010). — Aspects of community ecology of amphibians and reptiles at Bonny Island (Nigeria), an area of priority relevance for petrochemical industry. *Afr. J.Ecol.,* 48 : in press ; DOI : 10.1111/j.1365-2028.2009.01195.x

AKANI, G.C., POLITANO, E. & LUISELLI, L. (2004). — Amphibians recorded in forest swamp areas of the River Niger Delta (southeastern Nigeria), and the effects of habitat alteration from oil industry development on species richness and diversity. *Appl. Herpetol*., 2 : 1-21.

BAKER, L. & TOOZE, Z. (2003). — Status of the Sclater's Guenon (*Cercopithecus sclateri*) in southeastern Nigeria. *Am. J. Primatol.,* 60 (Suppl. 1) : 88-89.

BAKER, L.R. & OLUBODE, O.S. (2007). — Correlates with the distribution and abundance of endangered Sclater's monkeys (*Cercopithecus sclateri*) in southern Nigeria. *Afr. J. Ecol*., 46 : 365-373.

BARBAULT, R. (1976). — Étude quantitative des peuplements d'Amphibiens et des Reptiles d'une savane arbustive de la région de Bouaké (Côte d'Ivoire) : densités et cycles saisonniers d'abondance. *Ann. Univ. Abidjan Ser. E*, 9 : 143–152.

BARBAULT, R. (1977). — Structure et dynamique d'une herpétocénose de savane (Lamto, Côte d'Ivoire). *Geol. Ecol. Trop*., 1 : 309–334.

BARBAULT, R. (1987). — Pression de prédation et évolution des stratégies démographiques en zone tropicale : le cas des lézards et des amphibiens. *Rev. Zool. Afr*., 101 : 301–327.

BARBAULT, R. (1991). — Ecological constraints and community dynamics : linking community patterns to organismal ecology. The case of tropical herpetofaunas. *Acta Oecol.,* 12 : 139–163.

BEHANGANA, M. & LUISELLI, L. (2008). — Habitat niche community-level analysis of an amphibian assemblage at Lake Nabugabo, Uganda. *Web Ecol.,* 8 : 125-134.

BEHANGANA, M., KASOMA, P.M.B. & LUISELLI, L. (2008). — Ecological correlates of species richness and population abundance patterns in the amphibian communities from the Albertine Rift, East Africa. *Biodiv. Conserv*., 15 : 2855-2873.

BUTLER, J. & REID, J. (1994). — Records of Snakes from Nigeria. *Nigerian Field,* 55 : 19-40.

FCNL (2004).— *Environmental impact assessment of East Area Expansion Project : Natural Gas Liquid (NGL) II of Exxon-Mobil Producing Nigeria unlimited at Finima, Bonny*. Final Report submitted to Exxon-Mobil by FUGRO Consultants Nigeria Limited.

FCNL (2006). — *LNG / IPP Environmental impact assessment – baseline study, nearshore / offshore area of Exxon-Mobil Producing Nigeria unlimited at Finima, Bonny*. Final Report submitted Exxon-Mobil by FUGRO Consultants limited.

Frost, D.R., Grant, T., Faivovich, J., Bain, R.H., Haas, A., Haddad, C.F.B., De Sá, R.O., Channing, A., Wilkinson, M., Donnellan, S.C., Raxworthy, C.J., Campbell, J.A., Blottol, B.L., Molerm, P., Drewes, R.C., Nussbaum, R.A., Lynch, J.D., Green, D.M. & Wheeler, W.C. (2006). — The amphibian tree of life. *Bull. Amer. Mus. Nat. Hist.,* 297 : 1-291.

Gardner, T.A. (2007). — Spatial and temporal patterns of abundance and diversity of an east African leaf litter amphibian fauna. *Biotropica,* 39 : 105-113.

Germano, J.M., Sanders, J.M., Henderson, R.W. & Powell, R. (2003). — Herpetofaunal communities in Grenada : A comparison of altered sites, with an annotated checklist of Grenadian amphibians and reptiles. *Carib. J. Sci.,* 39 : 68-76.

Heinen, J.T. (1992). — Comparisons of the leaf litter herpetofauna in abandoned cacao plantations and primary rain forest in Costa Rica : Some implications for faunal restoration. *Biotropica,* 24 : 431-439.

International Crisis Group (2007). — Nigeria - Ending the unrest in the Niger Delta. *Africa Report* 135 (5^{th} December) : 1-1.

Luiselli, L. (2006a). — Site occupancy and density of sympatric Gaboon viper (*Bitis gabonica*) and nose-horned viper (*Bitis nasicornis*). *J. Trop. Ecol.*, 22 : 555-564.

Luiselli, L. (2006b). — Interspecific relationships between two species of sympatric Afrotropical water snake in relation to a seasonally fluctuating food resource. *J. Trop. Ecol.,* 22 : 91-100.

Luiselli, L. (2007). — Nonrandom co-occurrence patterns of rainforest chameleons. *Afr. J. Ecol.*, 45 : 336-346.

Luiselli, L. & Akani, G.C. (2002). — An investigation into the composition, complexity and functioning of snake communities in the mangroves of south-eastern Nigeria. *Afr. J. Ecol.*, 40 : 220-227.

Luiselli, L., Akani, G.C. & Politano, E. (2006). — Effects of habitat alteration caused by petrochemical activities and oil spills on the habitat use and interspecific relationships among four species of Afrotropical freshwater turtles. *Biodiv. Conserv.*, 15 : 3751-3767.

Luiselli, L., Angelici, F.M. & Akani, G.C. (2001). — Food habits of *Python sebae* in suburban and natural habitats. *Afr. J. Ecol.*, 39 : 116-118.

MacArthur, R.H. & Wilson, E.O. (1967). — *The theory of island biogeography*. Princeton University Press, Princeton.

Magurran, A. (2004). — *Measuring biological diversity*. Blackwell Publishing, Malden, MA.

Moffat, D. & Linden, O. (1995). — Perception and reality : Assessing priorities for sustainable development in the Niger River Delta. *Ambio,* 24 : 527-538.

Rödel, M.-O. & Ernst, R. (2004). — Measuring and monitoring amphibian diversity in tropical forests. I. An evaluation of methods with recommendations for standardization. *Ecotropica,* 10 : 1-14.

Romer, J.D. (1953). — Reptiles and amphibians collected in the Port-Harcourt area of Nigeria. *Copeia,* 1953 : 121-123.

Singh, J., Hewawasam, I. & Moffat, D. (1995). — *Nigeria, strategic options for redressing industrial pollution*. Vol. 145. Industry and Energy division, West and Central Africa Dept. World Bank, Washington D.C.

Todd, B.D., Rothermel, B.B., Reed, R.N., Luhring, T.M., Schlatter, K., Trenkamp, L. & Gibbons, J.W. (2007). — Habitat alteration increases invasive fire ant abundance to the detriment of amphibians and reptiles. *Biol. Inv.,* 10 : 539-546.

Wiens, J.J. (2007). — Review : The amphibian tree of life. *Quarterly Rev. Biol.*, 82 : 55-56.