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Ecological and conservation considerations on the reptile fauna of the eastern Niger Delta (Nigeria)

Betrachtungen zu Ökologie und Schutz der Reptilienfauna des östlichen Niger Deltas (Nigeria)

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KURZFASSUNG

Qualitative und quantitative Daten zur Reptilienfauna des östlichen Niger-Deltas (Port Harcourt, Rivers State) werden präsentiert. 60 Reptilienarten wurden im Untersuchungsgebiet festgestellt: 3 Krokodile, 7 Schildkröten, 13 Echsen und 37 Schlangen. Die quantitativen Angaben zur Diversität der Reptilien beruhen auf Fang-Wiederfang-Daten entlang von zehn Transekten, die jeweils verschiedene Spektren von Biotoptypen umfaßten und sich hinsichtlich der Diversität, Dominanz und Abundanz der vorkommenden Reptilienarten signifikant unterschieden. Grundsätzlich beherbergten trockene und sumpfige primäre und sekundäre Regenwälder eine weit größere Artenzahl als die Mangroven. Echsen waren die häufigsten Reptilien. Dabei waren Individuen der Gattung *Mabuya* zahlenmäßig vorherrschend, außer auf landwirtschaftlichen Flächen und im Siedlungsbereich, wo *Agama agama* die dominierende Echse war. An den meisten Standorten war die Vielzahl der Schlangenarten bemerkenswert, doch nur sechs (*Gastropyxis smaragdina, Psammophis phillipsi, Naja nigricollis, Python regius* in terrestrischen Biotopen und *Afronatrix anoscopus, Grayia smythii* in aquatischen Biotopen) waren regelmäßig anzutreffen.

Die Anzahlen der je Transekt festgestellten Biotoptypen und Reptilienarten waren positiv korreliert ($p < 0.05$), doch war dieses allgemeine Muster durch die Schlangen bestimmt. Die Dominanzindizes von Reptilien und die Anzahl der je Transekt festgestellten Reptilienarten waren nicht signifikant korreliert. Dieser Befund ist nicht einleuchtend. Man würde erwarten, daß mit steigender Anzahl verfügbarer Biotoptypen die Dominanz einer einzelnen Art abnehmen sollte. Bei Ausschluß von *Mabuya* aus dieser Berechnung war die zu erwartende negative Beziehung zwischen den Variablen gegeben ($p < 0.05$).

Einige negative Auswirkungen der industriellen Förder- und Transportaktivitäten für Gas und Öl auf die Diversität und Häufigkeit von Reptilien im Niger-Delta werden genannt. *Crocodylus niloticus* und *C. cataphractus* scheinen außerordentlich selten zu sein. Um eine Verarmung der Reptiliendiversität zu vermeiden, sollten die Förderindustrien ihre Öl- und Gasleitunsanlagen nicht mehr in primären oder sekundären Waldflächen verlegen, da diese die arten- und individuenreichsten Reptiliengemeinschaften beherbergen.

ABSTRACT

Qualitative and quantitative data on the reptile fauna of the eastern Niger Delta (Port Harcourt, Rivers State) is presented. 60 reptile species were found in the study areas, 3 crocodiles, 7 turtles, 13 lizards, and 37 snakes. Quantification of reptilian diversity was based on capture-mark-recapture procedures along ten transects which covered different spectra of habitat types each and varied significantly in terms of reptile species diversity, dominance, and abundance. As a rule, both dry and swampy primary and secondary rain forests housed a significant excess of species as compared with the mangroves. Lizards were the most abundant reptiles. Species of the genus *Mabuya* were numerically dominant except in cultivated lands and suburbia where *Agama agama* was the dominant lizard. In most localities there was a remarkable variety of snake species, but only six (*Gastropyxis smaragdina, Psammophis phillipsi, Naja nigricollis, Python regius* in terrestrial habitats and *Afronatrix anoscopus, Grayia smythii* in aquatic habitats) were regularly found.

The number of habitat types and the number of reptile species registered per transect were positively correlated ($p < 0.05$), but this general pattern was mainly due to the snakes. Dominance index of reptile species and number of habitat types registered per transect were not significantly correlated. This is a counter-intuitive result as one would expect: the higher the number of macrohabitats available, the lower the dominance of a single species. When *Mabuya* was excluded from this analysis, the expected negative relationship between these variables was obtained ($p < 0.05$).

Some negative effects of industrial gas and oil transmission and extraction activities on the biodiversity and abundance of reptiles in the Niger Delta area are indicated. *Crocodylus niloticus* and *C. cataphractus* appear to be extremely rare. To avoid impoverishment of reptilian diversity, industry companies should no longer lay their oil and gas transmission installations through primary and secondary rain forest patches, which house both the highest diversity of taxa and the highest densities of reptile specimens.

KEY WORDS

Niger Delta, Nigeria; reptile communities, species diversity, dominance, abundance, ecology, habitat, impact of gas and oil industries on reptile populations, threat, conservation

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INTRODUCTION

Nigerian oil and gas industry activities concentrate mainly on the Niger Delta which, concurrently, represents one of the worldwide largest wetlands (more than 20,000 km^2) and harbours a remarkable number of reptile taxa in a variety of ecologically different habitats.

In spite of that, the herpetofauna of the Niger Delta is poorly known although African rain forests have frequently been subject to careful research during the recent years. However, data on reptile communities are scarce, and quantitative studies on the functioning of these communities remained at an embryonic stage (SCOTT 1982; but see LUISELLI & al. 1998). Some collective information on Amphibians and Reptiles of the Niger Delta is presented in classical monographs of West African herpetofaunas or in specific papers on Nigerian species (e.g., ROMER 1953; GRANDISON 1956, 1968; BLACKWELL 1967; SCHIØTZ 1967, 1969; ARNOULT & LAMOTTE 1968; EKUNDAYO & OTUSANYA 1969; DUNGER 1967a, 1967b, 1967c, 1968, 1971a, 1971b, 1972a, 1972b, 1973; VILLIERS 1975; ROMAN 1976; VAN EIJSDEN 1978; JOGER 1979, 1981; HUGHES 1983; LOUMONT 1984; GARTSHORE 1985; BUTLER & REID 1986; REID 1986; SODEINDE & KUKU 1989; SODEINDE & OGUNJOBI 1994). In all this literature, however, very little is reported on ecological distribution and eco-ethology of the various taxa. Moreover, in a recent survey in which an environmental development strategy for the Niger Delta is defined (SINGH & al. 1995), only five representatives of the reptiles (three crocodilians and two pythons) are listed.

The present research constitutes the first attempt to describe the composition of the reptile fauna of several Niger Delta localities both in terms of quality and quantity and in relation to the variation of habitats available. Considerations on the threats to the reptile fauna and immediate management needs are presented in the light of potential adverse effects of the fast developing gas and oil transmission and extraction activities.

Aim of this paper is neither to present exhaustive faunistic records nor to review the reptilian zoogeography of the region, but just to give a commented summary of over two years of intensive field explorations in a country which, mainly because of internal problems limiting the foreigners' access (e.g. political misunderstanding between the Federal Government of Nigeria and the western countries, and presence of organized criminality), is still largely unknown from the zoological point of view. The quantitative data in this paper have already been presented in an unpublished report by the authors to the company "T.S.K.J. Nigeria Ltd.".

STUDY AREA AND METHODS

Study area

The quantitative analyses in this paper are based on field data collected in the eastern Niger Delta (Port Harcourt region, Rivers State, southeastern Nigeria) during the wet seasons of 1996 through 1997, and the dry season of 1997 (fig. 1). Additional qualitative data (e.g. presence/absence of taxa) were, however, collected also during the wet and the dry season of 1998.

The environment of the study region is extremely heterogenous in that water and soil patchily alternate. The variation of the salinity level of waters (due to concomitant presence of freshwater and tidal water) is an important factor. Most parts of the area are heavily populated, with hundreds of towns and villages surrounding Port Harcourt City.

Both dry and swamp forest patches are interspersed in a mosaic of farmland and cultivations (mainly cassava, oil palms, bananas and plantains). Dryland rainforests can be assigned to one of three categories: primary forest, secondary forest, and shrubland. Periodically and permanently flooded freshwater swamp forests may be primary or secondary. Mangrove formations (dominated by *Avicennia* and *Rhizophora*) are present in an arboreal (high mangroves) and bushy (low mangroves) form.

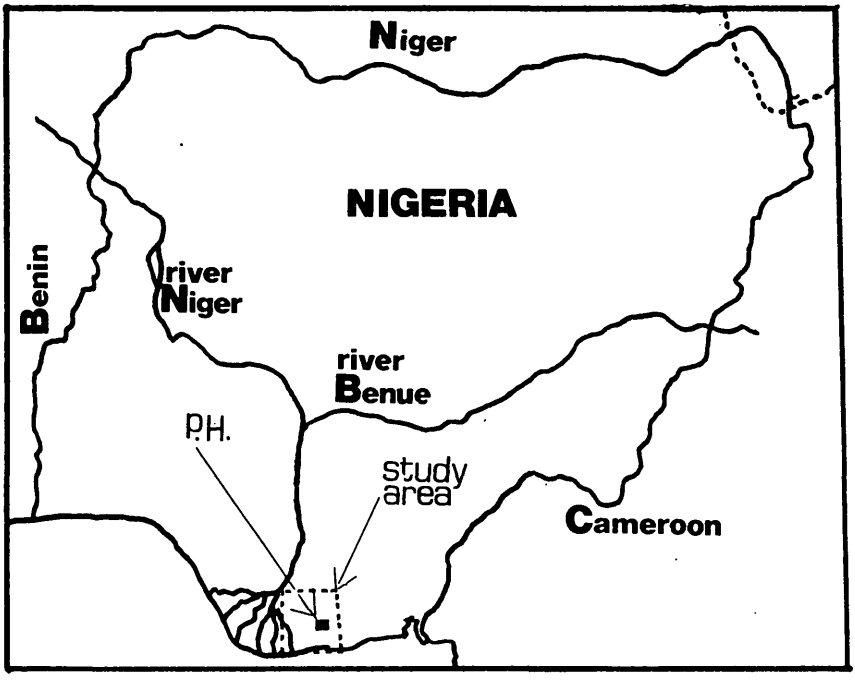

Fig. 1: The study area in the southeastern Niger Delta (Nigeria). P.H. - Port Harcourt City.
Abb. 1: Das Untersuchungsgebiet im südöstlichen Niger Delta (Nigeria). P.H. - Port Harcourt City.

Methods

General survey procedures. Our survey is based on (i) original observations in the field, (ii) examination of preserved specimens in the collections of the Department of Biological Sciences of Port Harcourt University of Science and Technology, and (iii) original interviews with selected persons from the main villages of the area. With regard to point (i), most observations were made in forested areas of the Port Harcourt region (see POLITANO 1997); others were done in villages, at the borders of roads where local people were involved in marketing animals (AKANI & al. 1998), and along the course of rivers (Bonny, New Calabar, Sambreiro, Orashi). With regard to point (iii), we considered only interviews in which the interviewed person was able to doubtlessly describe the observed species (especially snakes), as well as a typical behavioural display of that species (e.g. typical defensive display of snakes, basking postures of lizards, etc).

Various observation techniques were applied. Reptiles were searched for by walking along random routes leading through all habitat types available. Due to logistic problems, field work was predominantly restricted to the daylight hours (08.00 to 18.00) which is of course not the best time for finding Amphibians and Reptiles in African rain forests, as several of these species have their above-ground activity peaks early in the morning and late in the afternoon (BRANCH 1988). Most animals encountered during our surveys were captured by hand, drift fences or pitfall traps and photographed.

To avoid unrecognized recaptures, lizards were marked by toe-clipping and snakes by ventral scale clipping. Crocodiles were not captured and remained unmarked. Turtles were marked by unique sequences of notches filed into the marginal scutes.

Quantitative survey procedures. Ten study sites were selected along the

Table 1: Transects studied in the region of Port Harcourt (Rivers State, Nigeria) including local names and geographic coordinates of the study areas.

Tab. 1: Die untersuchten Transekte im Gebiet Port Harcourt (Rivers State, Nigeria) sowie die Ortsnamen und geographischen Koordinaten der Untersuchungsgebiete.

Transect	Name of Place / Ortsname	Latitude / Breite	Longitude / Länge
T1	Kreigeni	N 05°17'59.2	E 006°37'41.3
T2	Abarikpo	N 05°08'11.9	E 006°37'45.7
T3	Otari	N 04°53'22.3	E 006°41'19.7
T4	Rumuji	N 04°57'19.3	E 006°46'28.1
T5	Orubiri	N 04°42'25.6	E 007°01'13.6
T6	Soku - Elem Sangama	N 04°40'39.8	E 006°40'54.2
T7	Tombia Forest	N 04°46'34.9	E 006°53'56.9
T8	Tombia Mangrove	N 04°46'50.9	E 006°51'53.9
T9	Orashi River	N 04°44'43.1	E 006°38'10.1
T10	Peterside (Bonny)	N 04°29'14.9	E 007°10'04.8

"LNG Nigeria Gas Transmission System Project" pipe-line (AA.VV. 1997) in such a way that the various natural habitats present along this pipe-line were equally represented. Detailed methods describing the selection criteria of these ten study sites are given elsewhere (POLITANO 1997). In general, every possible effort was made to avoid unbalanced surveying in the various habitats.

Geographic coordinates and the name of each study site are indicated in table 1, the main habitat types present in these localites are given in table 2. In each study site, a study transect was determined which passed through the various habitat types present in this location. The transects were approximately 7 km long each, and were walked along only in one direction and once per day to avoid multiple counts of individuals per observation unit. To avoid sampling differences between study sites, we walked along the transects always at the same time of the day (from 09.00 to 13.00, Lagos time), maintaining constant velocity. Only those reptile specimens which were clearly visible to us (i.e. not hidden under covering objects, etc) were counted for the quantitative analyses. The specimens which were found hidden within the transects (this was the case especially in snakes) were recorded for describing the faunal composition of the site, but were not used for quantitative statistical inter site comparisons. Exclusion of hidden specimens was done under the assumption that the proportion of active (visible) specimens should be the same in all study transects (given that the time of surveying was the same in all cases) and because the probability to find covered animals might have been different in the various sites (e.g., because of different frequencies of objects on the ground, etc).

These records formed the basis for the quantitative estimation of biodiversity in each study site. *Mabuya* specimens encountered during these standardized surveys were not identified to species level. Records of reptile specimens from outside the transects were excluded from the quantitative biodiversity analysis, but were used to describe the reptile fauna composition of each study site (see "Reptile taxa of the study transects"). In general, at least 40 hours were spent in the field in each study transect.

We calculated both species diversity and species dominance of each area which are important parameters for any biodiversity analysis (DODD 1992).

Species diversity (D) was calculated using MARGALEF's Diversity Index (MAGURRAN 1988):

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

where S represents the number of species and N the number of individuals (sampled) in the area under study.

Species dominance (d) was assessed using the BERGER-PARKER Index (MAGURRAN 1988):

$$d = N_{max} / N$$

where N represents the number of indi-

Table 2: Main habitat types present in study transects T1 to T10 of the Port Harcourt region (Rivers State, Nigeria). NH - Number of habitat types; NI - Number of individuals; NT - Number of taxa; NTH - Number of transects in which a given habitat type was found. Data under NI and NT exclusively represent the the results of the standardized sampling for the quantitative analyses.

Tab 2: Die wichtigsten Biotoptypen der Untersuchungstransekte T1 bis T10 im Port Harcourt Gebiet (Rivers State, Nigeria). NH - Anzahl Biotoptypen; NI - Anzahl Individuen; NT - Anzahl Taxa; NTH - Anzahl Transekte, in denen ein gegebener Biotoptyp angetroffen wurde. Die Werte unter NI und NT sind ausschließlich Ergebnisse der standardisierten Aufsammlungen für die quantitativen Analysen.

Habitat type / Biotoptyp	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	NTH	NI	NT
Primary dry Rainforest / Primärwald	-	-	X	-	-	-	-	-	-	X	2	19	7
Secondary dry Rainforest / Sekundärwald	X	-	X	-	-	X	X	-	X	X	6	119	13
Shrubland / Buschland	X	X	-	X	X	-	X	-	X	X	7	57	8
Primary Swamp-forest / Primärer Sumpfwald	-	-	-	-	-	X	-	-	-	-	1	15	6
Secondary Swamp Forest Sekundärer Sumpfwald	-	-	X	-	-	X	X	-	-	X	4	52	13
High Mangrove / hohe Mangrove	-	-	-	-	-	-	-	X	-	-	1	43	5
Low Mangrove / niedrige Mangrove	-	-	-	-	X	-	X	-	-	X	3	7	3
Farmland and cultivations/ landwirtschaftliche Flächen	X	X	X	X	X	X	X	-	X	X	9	107	3
Freshwater body / Süßwasserkörper	X	-	X	-	-	X	-	-	X	X	5	7	3
NH	4	2	5	2	3	5	5	1	4	7			
NI	26	11	48	36	13	26	81	43	90	52			
NT	6-7	3-4	5-6	4-5	1-2	4-5	7-8	5-6	7-8	7-8			

viduals and N_{max} the number of individuals of the most abundant species (sampled) in the area under study.

An increase in the value of $1/d$ (the reciprocal form of the index) indicates an increase in diversity and a decrease in dominance (MAGURRAN 1988). In order to determine whether inclusion of juveniles influenced the values of diversity and dominance, separate indices were calculated (i) with juveniles included and (ii) excluded. Since non-parametric matrix correlation Mantel tests did not show evident differences between corresponding indices (i) and (ii) in any study transect (in all cases: $P > 0.4$), the pertinent indices were pooled. Recaptured individuals were excluded from calculations of diversity and dominance.

Several methodological factors may have biased the results: e. g., vegetation and landscape characteristics permit easier localization of reptiles in secondary forests than in primary forests. Thus, the lower number of taxa detected in the latter might reflect rather field constraints than true differences.

Notwithstanding that weak points may limit the accuracy of our method, the present investigation is one of the few quantitative approaches to study the reptile fauna of an Afrotropical rainforest region, and the first one for Nigeria (comp. SCOTT 1982).

Statistical analyses

Statistical tests were done by means of SAS® (Statistical Analysis System) and STATISTICA® PC packages. All tests were two-tailed, with alpha set at 5%. Data were tested for normal distribution by Kosmogorov-Smirnov tests before applying parametric statistical procedures, otherwise non-parametric statistical tests were used.

RESULTS AND DISCUSSION

Reptile taxa of the region

Based on the methods applied, we registered the presence of the following 60 reptile taxa on the territory under study (3 crocodilians, 7 chelonians, 13 saurians, 37 snakes). The list includes only taxa which were observed by the authors (i. e. interview results are not considered).

Crocodiles: *Crocodylus niloticus suchus* GEOFFROY, 1807, *C. c. cataphractus* CUVIER, 1789, *Osteolaemus t. tetraspis* COPE, 1861.

Turtles: *Pelomedusa subrufa olivacea* (SCHWEIGGER, 1812), *Pelusios c. castaneus* (SCHWEIGGER, 1812), *P. niger* DUMÉRIL & BIBRON, 1835), *Trionyx triunguis* (FORSKÅL, 1775), *Kinixys belliana nogueyi* (LATASTE, 1886), *K. erosa* (SCHWEIGGER, 1812), *K. homeana* BELL, 1827.

Saurians: *Varanus niloticus ornatus* (DAUDIN, 1803), *Chamaeleo g. gracilis* HALLOWELL, 1842, *Ch. owenii* GRAY, 1831, *Agama a. agama* LINNAEUS, 1758, *Hemidactylus brooki angulatus* HALLOWELL, 1854, *H. fasciatus fasciatus* GRAY, 1845, *H. mabouia* (MOREAU DE JONNÈS, 1818), *Lygodactylus conraui conraui* TORNIER, 1902, *L. fischeri* BOULENGER, 1890, *Mabuya affinis* (GRAY, 1839), *M. maculilabris maculilabris* (GRAY, 1845), *Mochlus (Riopa) fernandii* (BURTON, 1836), *Panaspis togoensis* WERNER, 1902.

Snakes: *Calabaria reinhardti* (SCHLEGEL, 1848), *Python regius* (SHAW, 1802), *P. sebae* (GMELIN, 1788), *Dispholidus t. typus* (SMITH, 1829), *Thelotornis kirtlandii* (HALLOWELL, 1844), *Rhamnophis a. aethiopissa* GÜNTHER, 1862, *Grayia smythii* (LEACH, 1818), *Philothamnus h. heterodermus* (HALLOWELL, 1857), *Natriciteres fuliginoides* (GÜNTHER, 1858), *N. v. variegata* (PETERS, 1861), *Afronatrix anoscopus* (COPE, 1861), *Mehelya crossi* (BOULENGER, 1895), *M. guirali* (MOCQUARD, 1887), *M. poensis* (SMITH, 1847), *Gastropyxis smaragdina* (SCHLEGEL, 1837), *Hapsidophrys lineatus* FISCHER, 1856, *Aparallactus m. modestus* (GÜNTHER, 1859), *Lamprophis virgatus* (HALLOWELL, 1854), *Bothrophthalmus l. lineatus* (PETERS, 1863), *Meizodon coronatus* (SCHLEGEL, 1837), *Toxicodryas blandingi* (HALLOWELL, 1844), *T. pulverulenta* (FISCHER, 1856), *Dipsadoboa duchesnii* (BOULENGER, 1901), *Crotaphopeltis hotamboeia* (LAURENTI, 1768), *Psammophis phillipsi* (HALLOWELL, 1844), *Polemon collaris brevior* (WITTE & LAURENT, 1947), *Dasypeltis fasciata* SMITH, 1849, *Dendroaspis j. jamesoni* (TRAILL, 1843), *Naja melanoleuca* HALLOWELL, 1857, *N. n. nigricollis* REINHARDT, 1843, *Pseudohaje goldii* (BOULENGER, 1895), *Atheris squamiger* (HALLOWELL, 1854), *Causus maculatus* (HALLOWELL, 1842), *Bitis nasicornis* (SHAW, 1802), *B. g. gabonica* (DUMÉRIL & BIBRON, 1845), *Atractaspis aterrima* GÜNTHER, 1863, *A. corpulenta leucura* MOCQUARD, 1885.

Various other taxa, the presence of which in the study area is either verified by other sources or is strongly to be suspected, were not found during our survey: e.g. *Melanoseps occidentalis* (PETERS, 1877) which was captured by ROMER (1953) in the Port Harcourt area; *Chamaeleo cristatus* STUTCHBURY, 1837 which was captured by us in the surroundings of Eket (Akwa-Ibom State, approximately 100 km east of Port Harcourt) and by REID (1986) in the surroundings of Calabar (Cross River State, about 170 km east of Port Harcourt) and, thus, could potentially be present in the studied region. With regard to snakes, BUTLER & REID (1986) cited *Rhinotyphlops crossii* (BOULENGER, 1893) and *Typhlops punctatus* (LEACH, 1819) as being present in the Calabar area of south-eastern Nigeria. These taxa might thus be found in the Port Harcourt region. However, *T. punctatus* is a savannah species, unlikely to occur in Calabar, where the forest species *T. congestus* (DUMÉRIL & BIBRON, 1844) is rather to be expected (B. HUGHES, personal communication). Specimens of *T. congestus*, captured in the Niger Delta, are in fact stored in the collection of the British Museum (Natural History), London (B. HUGHES, pers. comm.). Other snake species might have "escaped" our attention: *Atractaspis i. irregularis* (REINHARDT, 1843), *Pseudohaje nigra* GÜNTHER, 1858, *Thrasops flavigularis* (HALLOWELL, 1852), *T. occidentalis* PARKER, 1940, and *Dasypeltis scabra* (LINNAEUS, 1758). *Dendroaspis viridis* (HALLOWELL, 1844) was reported to occur in the Niger Delta (VILLIERS, 1975); the same is true for the savannah form of the Nile Monitor *Varanus n. niloticus* (LINNAEUS, 1766) (BÖHME & ZIEGLER 1977) but these taxa are unlikely to be present in the Niger Delta.

Species diversity of the reptile fauna of Rivers State is remarkably high since both Afrotropical widespread taxa (e.g. *Pelomedusa subrufa*, *Naja melanoleuca*, *N. nigricollis*, *Dispholidus typus*) and taxa which are typically confined to the rain forests of West Africa (e.g. *Calabaria reinhardti*) are present.

Most of the above-cited reptile taxa are widespread and locally abundant in the eastern Niger Delta region. However, the large crocodiles (*Crocodylus cataphractus*

and *C. niloticus*) appear to be rare and very endangered (AKANI & al. 1999), while other taxa, which are regularly found, might soon suffer rapid population decline because of habitat loss and human hunting activities (*Kinixys* spp., *Python sebae*).

Reptile taxa of the study transects

The habitat types found in the various study transects are roughly presented in table 2 (for a more detailed description, see POLITANO 1997).

Transect 1 (T1) - *Agama agama, Mabuya affinis, M. maculilabris, Mochlus fernandii, Python sebae, P. regius, Dispholidus typus, Psammophis phillipsi, Gastropyxis smaragdina, Grayia smythii, Crotaphopeltis hotamboeia, Dendroaspis jamesoni, Naja nigricollis.*

Transect 2 (T2) - *Agama agama, Mabuya affinis, Mochlus fernandii, Python regius, Psammophis phillipsi, Crotaphopeltis hotamboeia, Naja nigricollis.*

Transect 3 (T3) - *Osteolaemus tetraspis, Pelusios castaneus, P. niger, Pelomedusa subrufa, Kinixys belliana, K. homeana, Agama agama, Mabuya affinis, M. maculilabris, Mochlus fernandii, Panaspis togoensis, Hemidactylus fasciatus, H. mabouia, Varanus niloticus, Chamaeleo owenii, Ch. gracilis gracilis, Calabaria reinhardti, Python sebae, P. regius, Dispholidus typus, Toxicodryas blandingi, T. pulverulenta, Thelotornis kirtlandii, Grayia smythii, Afronatrix anoscopus, Natriciteres fuliginoides, N. variegata, Dasypeltis fasciata, Crotaphopeltis hotamboeia, Psammophis phillipsi, Gastropyxis smaragdina, Philothamnus heterodermus, Pseudohaje goldii, Dendroaspis jamesoni, Naja melanoleuca, Naja nigricollis, Atheris squamiger, Bitis nasicornis, B. gabonica.*

Transect 4 (T4) - *Pelusios castaneus, Pelomedusa subrufa, Trionyx triunguis, Kinixys homeana, Chamaeleo owenii, Agama agama, Mabuya affinis, M. maculilabris, Mochlus fernandii, Hemidactylus fasciatus, Varanus niloticus, Calabaria reinhardti, Python regius, P. sebae, Dispholidus typus, Toxicodryas blandingi, T. pulverulenta, Grayia smythii, Afronatrix anosco pus, Natriciteres fuliginoides, N. variegata, Psammophis phillipsi, Gastropyxis smaragdina, Crotaphopeltis hotamboeia, Pseudohaje goldii, Dendroaspis jamesoni, Naja nigricollis, N. melanoleuca, Bitis gabonica.*

Table 3: Reptile species including numbers of specimens (n) and their proportional shares (%n) as found in the quantitative biodiversity analysis in transects T1 to T10.

Tab. 3: Die in der quantitativen Biodiversitätsanalyse in den Transekten T1 bis T10 festgestellten Reptilienarten, ihre Individuenzahlen (n) und deren Prozentanteile (%n).

	Species / Art	n	%n
T1	*Agama agama*	2	7.69
	Mabuya sp.	18	69.23
	Mochlus fernandii	2	7.69
	Dendroaspis jamesoni	2	7.69
	Dispholidus typus	1	3.84
	Grayia smythii	1	3.84
	Sum / Summe T1	26	100
T2	*Mabuya* sp.	6	54.54
	Mochlus fernandii	3	27.27
	Agama agama	2	18.18
	Sum / Summe T2	11	100
T3	*Mabuya* sp.	32	66.67
	Mochlus fernandii	1	2.08
	Agama agama	12	25.00
	Dendroaspis jamesoni	1	2.08
	Naja melanoleuca	2	4.16
	Sum / Summe T3	48	100
T4	*Mabuya* sp.	24	66.66
	Mochlus fernandii	1	2.78
	Agama agama	8	22.22
	Gastropyxis smaragdina	3	8.33
	Sum / Summe T4	36	100
T5	*Mabuya* sp.	13	100
T6	*Mabuya* sp.	21	80.76
	Dendroaspis jamesoni	3	11.54
	Natriciteres variegata	1	3.85
	Naja nigricollis	1	3.85
	Sum / Summe T6	26	100
T7	*Agama agama*	38	46.91
	Mabuya sp.	32	39.51
	Panaspis togoensis	3	3.70
	Varanus niloticus	1	1.23
	Thelotornis kirtlandii	3	3.70
	Dendroaspis jamesoni	2	2.46
	Natriciteres variegata	2	2.46
	Sum / Summe T7	81	100
T8	*Mabuya* sp.	21	48.83
	Agama agama	17	39.53
	Varanus niloticus	1	2.32
	Grayia smythii	2	4.65
	Naja nigricollis	2	4.65
	Sum / Summe T8	43	100
T9	*Mabuya* sp.	47	52.22
	Agama agama	31	34.44
	Mochlus fernandii	4	4.44
	Psammophis phillipsi	2	2.22
	Gastropyxis smaragdina	3	3.33
	Naja nigricollis	2	2.22
	Python regius	1	1.11
	Sum / Summe T9	90	100
T10	*Mabuya* sp.	40	76.92
	Agama agama	4	7.69
	Varanus niloticus	2	3.85
	Gastropyxis smaragdina	3	5.77
	Naja melanoleuca	1	1.92
	Naja nigricollis	1	1.92
	Bitis gabonica	1	1.92
	Sum / Summe T10	52	100

Transect 5 (T5) - *Crocodylus niloticus, Kinixys homeana, Agama agama, Mabuya affinis, Varanus niloticus, Python sebae, Grayia smythii, Natriciteres fuliginoides, Dispholidus typus, Thelotornis kirtlandii, Gastropyxis smaragdina, Psammophis phillipsi, Naja melanoleuca, N. nigricollis, Bitis gabonica.*

Transect 6 (T6) - *Crocodylus niloticus, Osteolaemus tetraspis, Pelusios castaneus, P. niger, Kinixys erosa, K. homeana, Mabuya affinis, M. maculilabris, Mochlus fernandii, Panaspis togoensis, Hemidactylus fasciatus, H. mabouia, Varanus niloticus, Chamaeleo owenii, Ch. gracilis, Calabaria reinhardti, Python regius, P. sebae, Toxicodryas blandingi, Aparallactus modestus, Grayia smythii, Afronatrix anoscopus, Natriciteres fuliginoides, N. variegata, Bothrophthalmus lineatus, Crotaphopeltis hotamboeia, Gastropyxis smaragdina, Philothamnus heterodermus, Rhamnophis aethiopissa, Psammophis phillipsi, Dendroaspis jamesoni, Pseudohaje goldii, Naja melanoleuca, N. nigricollis, Atheris squamiger, Bitis gabonica, B. nasicornis, Atractaspis aterrima.*

Transect 7 (T7) - *Agama agama, Lygodactylus conraui, Mabuya affinis, M. maculilabris, Varanus niloticus, Python regius, P. sebae, Grayia smythii, Dispholidus typus, Psammophis phillipsi, Gastropyxis smaragdina, Crotaphopeltis hotamboeia, Dendroaspis jamesoni, Naja nigricollis, Bitis gabonica, Causus maculatus.*

Transect 8 (T8) - *Agama agama, Mabuya affinis, Varanus niloticus, Python regius, P. sebae, Thelotornis kirtlandii, Toxicodryas blandingi, T. pulverulenta, Afronatrix anoscopus, Gastropyxis smaragdina, Psammophis phillipsi, Dendroaspis jamesoni, Naja nigricollis.*

Transect 9 (T9) - *Crocodylus cataphractus, C. niloticus, Osteolaemus tetraspis, Pelomedusa subrufa, Pelusios castaneus, P. niger, Kinixys belliana, K. erosa, K. homeana, Agama agama, Mabuya affinis, M. maculilabris, Mochlus fernandii, Hemidactylus fasciatus, H. mabouia, Varanus niloticus, Chamaeleo owenii, Calabaria reinhardti, Python sebae, P. regius, Thelotornis kirtlandii, Toxicodryas blandingi, Grayia smythii, Afronatrix anoscopus, Natriciteres fuliginoides, N. variegata, Bothrophthalmus lineatus, Crotaphopeltis hotamboeia, Aparallactus modestus, Dasypeltis fasciata, Gastropyxis smaragdina, Psammophis phillipsi, Dendroaspis jamesoni, Pseudohaje goldii, Naja nigricollis, N. melanoleuca, Bitis gabonica, B. nasicornis.*

Transect 10 (T10) - *Pelusios castaneus, P. niger, Agama agama, Mabuya affinis, Mochlus fernandii, Varanus niloticus, Python regius, P. sebae, Dispholidus typus, Toxicodryas blandingi, Grayia smythii, Afronatrix anoscopus, Crotaphopeltis hotamboeia, Gastropyxis smaragdina, Philothamnus heterodermus, Psammophis phillipsi, Naja melanoleuca, N. nigricollis.*

Diversity of reptilian species and diversity of available habitats

High numbers of reptile taxa were found in transects T3, T4, T6, and T9 whereas the other transects housed much small numbers of reptile taxa. These data indicate that high taxonomic diversity was associated with the presence of rainforest patches, whereas low taxonomic diversity was associated with cultivated lands and areas subject to intensive human activity.

There was a positive correlation between the number of environmental types per study transect and the corresponding number of species found ($r = 0.331$, $n = 10$, $P < 0.05$; fig. 2). This general pattern was caused by the snakes as the lizard species diversity proved to be rather independent on the habitat heterogeneity of each study transect (snakes versus lizards: ANCOVA to both slopes and ordinate intercepts, $P < 0.01$). The numbers of crocodile and chelonian taxa were too small to permit any statistical comparison of this type.

Quantitative biodiversity parameters

Table 3 presents the results of the quantitative surveys along the study transects T1 to T10; in table 4 their biodiversity indexes are entered.

During our quantitative surveys, we recorded a total of 426 reptile individuals. In general, and despite the remarkable differences observed between the various transects, lizards represented the majority of the reptile individuals. Among lizards, the scincids of the genus *Mabuya* were by far

Table 4: Values of MARGALEF's diversity index (*D*), and BERGER-PARKER's species dominance index (*d*) for the study transects T1 to T10.

Tab. 4: Die Werte von MARGALEFs Diversitätsindex (*D*) und BERGER-PARKERs Dominanzindex (*d*) in den Untersuchungstransekten T1 bis T10.

Transect	*D*	*d*
T1	1.538	0.692
T2	0.834	0.545
T3	0.465	0.667
T4	0.837	0.667
T5	0.000	1.000
T6	0.920	0.807
T7I	2.733	0.469
T8	1.063	0.488
T9	4.050	0.522
T10	1.800	0.769

the most abundant ones, however, *Agama* was dominating in some transects, especially in the vicinity of small villages and roads.

When we plotted the dominance indexes of reptile species in transects T1 to T10 (d in table 4) against the number of habitat types available in each transect, there was no significant correlation between these variables ($r = 0.253$, $n = 10$, $P > 0.2$; fig. 3a). The absence of a significantly negative correlation between the two variables is surprising, as one would expect: the higher the number of habitat types available, the lower the dominance of one single taxon versus all others. When we excluded *Mabuya* from this analysis, the expected negative correlation between these variables was obtained ($r = -0.38$, $n = 9$, $P < 0.05$). This shows that the expected pattern was indeed present in the Niger Delta area, but was masked by the abundance and apparent habitat generalism of *Mabuya*. With regard to the habitat generalism of *Mabuya*, the specimens of this genus were not distinguished and pooled in our analyses.

Mabuya lizards and *Agama agama* were the most abundant species in almost all places of the Niger Delta territory, not only along the transects accurately surveyed for quantitative biodiversity, but also in all other spots visited. In general, *Mabuya* species were the dominant lizards in natural habitats, whereas *Agama* was the dominant lizard in towns and villages, including Port Harcourt City. In fact, synecy of *Agama* and human populations is well known (BUTLER 1986; ANIBALDI & al. 1998).

Impact of gas and oil transmission and extraction systems

The following effects of gas and oil transmission and extraction activities which can adversely affect reptile populations were observed in the Niger Delta.

(1) industrial effluents can contaminate waste water; this risk is even higher in Nigeria than elsewhere because of the habit of some local people to broach oil transmission pipes, and sell oil and fuel on the black market; (2) habitat loss, fragmentation or partial destruction due to deforestation; (3) modification of the river characteristics (i. e. deviations of the courses, destruction of the original vegetation on the banks, modification of the aquatic vegetation when pipes are laid in the water); (4) mortality of animals caused by working persons and machines; (5) essential acoustic disturbance: presence of men (and their machines) at work, and resulting habitat loss; (6) starting of new cultivations, and (7) opening of new access roads to forest and mangrove sites; this can stimulate people to use these prepared areas for their activities (i. e. cultivating, marketing, etc).

To avoid progressive impoverishment of the reptilian diversity in the Niger Delta area, we would suggest that, as a general rule, oil and gas companies should no longer lay their oil and gas transmission installations through or in the vicinity of primary and secondary rain forest patches, which house both the highest diversity of taxa and the highest densities of reptile specimens. River tracts and creaks surrounded by primary forest patches deserve special attention because of the presence of scattered populations of *C. niloticus* and *C. cataphractus*, which are among the most threatened reptile species in the Niger Delta (AKANI & al. 1999). In this regard, we strongly suggest to avoid any further interference with the environ ment of the Orashi river course (from Emabu village to the upper course) and of the Sambreiro river course (from Degema and Abonnema villages to the upper course), where pristine forest patches are still present.

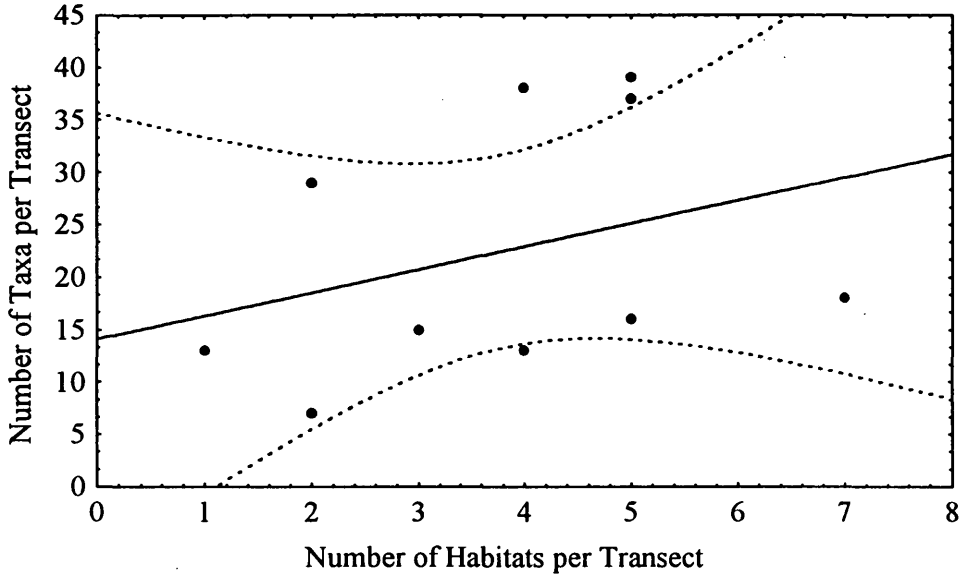

Fig. 2: Correlation between number of habitat types and number of reptile taxa as found in ten transects along the studied liquefied gas pipe-line in the eastern Niger Delta (Nigeria).
Abb. 2: Die Beziehung zwischen der Anzahl der Biotoptypen und der Reptilientaxa in zehn Untersuchungstransekten entlang einer Flüssiggas-Pipeline im östlichen Niger Delta (Nigeria).

The mangroves represent another essential habitat type in the ecosystem of the eastern Niger Delta. However, the reptile species diversity (number of taxa) found in this habitat type was relatively small in comparison with that of the forest patches (e.g. compare transect T8 with transect T3) and, contrary to what we observed in forest patches, there is not a single taxon which is found exclusively in mangrove formations.

Considering that the extension of mangrove formations is still enormous in the Niger Delta region (SINGH & al. 1995; POLITANO 1997), we think that - at the local scale of the Delta - mangroves are currently less threatened than the rainforests. Where ever it is absolutely necessary to take a choice between mangrove and rainforest (and always in conformity with the needs of defending the mangrove habitat which is one of the most threatened in the whole world), we suggest that environmentalists working for the main oil companies should give priority to the conservation of the few remaining rainforest patches. In any case, where possible and as a general rule, already altered dry land should be used for planning industry installations in this fragile ecosystem, also because of the risks of large scale pollution to aquatic biota when water bodies are used.

Enormous areas of mangroves with conspicuous reptile populations are present along the New Calabar river (from the sea to approximately Orubiri village), the Bonny river, and the Sambreiro river (from the sea to approximately Idama village).

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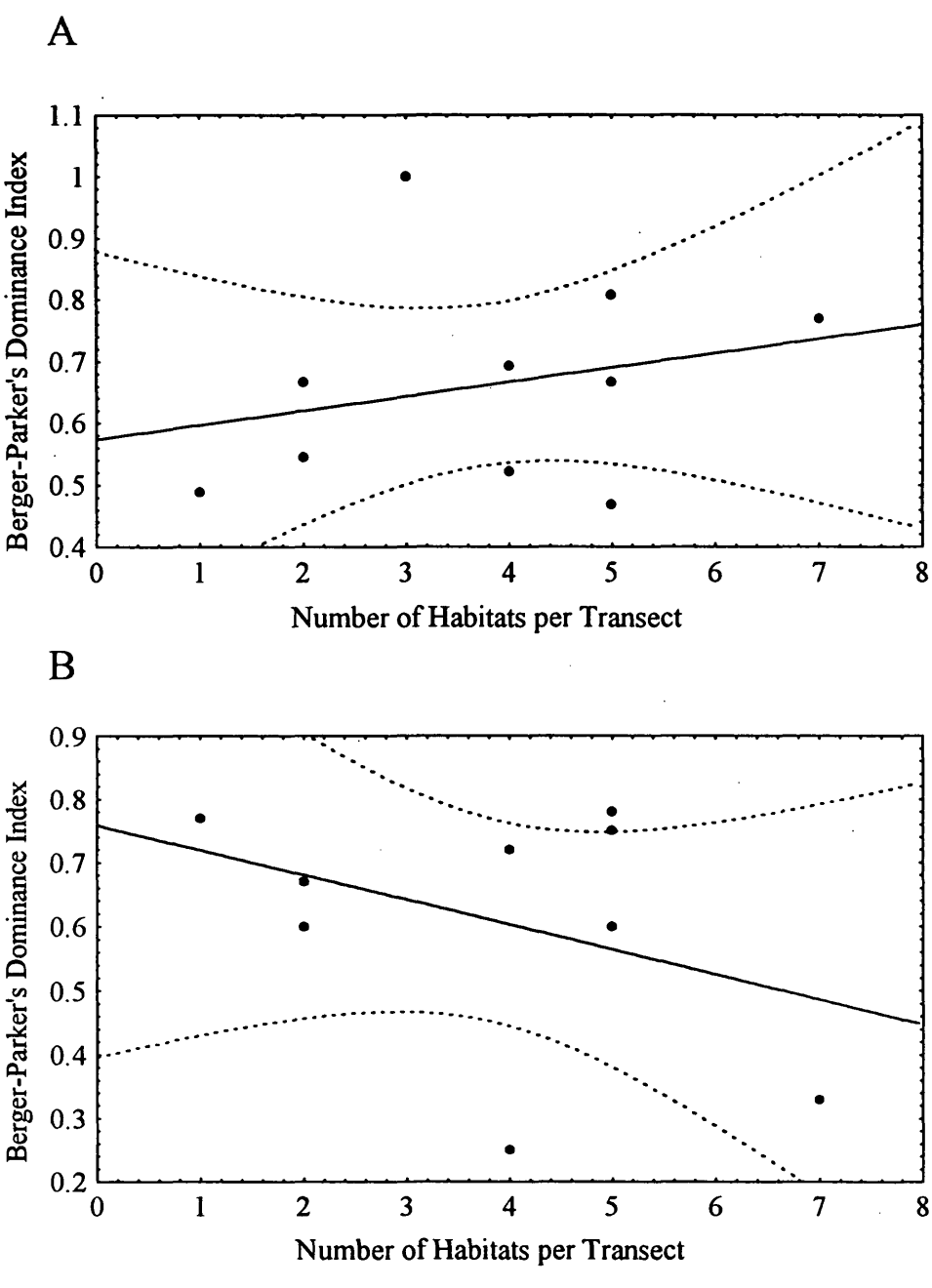

Fig. 3. Correlation between number of habitat types and dominance index of reptiles as found in ten transects along the studied liquefied gas pipe-line in the eastern Niger Delta (Nigeria).
A - all taxa included in computation; B - genus *Mabuya* excluded from computation.

Abb 3: Die Beziehung zwischen der Anzahl verfügbarer Biotoptypen und dem Dominanzindex für Reptilien in zehn Untersuchungstransekten entlang einer Flüssiggas-Pipeline im östlichen Niger Delta (Nigeria).
A - unter Einbeziehung und B - unter Ausschluß der Gattung *Mabuya* von der Berechnung.

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