Community structure and ecology of snakes in fields of oil palm trees (*Elaeis guineensis*) in the Niger Delta, southern Nigeria

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Abstract

Aspects of community structure and ecology of snakes were studied in the years 2004–2006 in fields of oil palm trees (*Elaeis guineensis*) of three study areas in Southern Nigeria. A total of 284 individual snakes, belonging to twelve species of three families (seven Colubridae, four Elapidae, one Viperidae), were recorded, including both sighted and captured individuals (not including in this count the individuals that escaped before identification to species level could be made). All the study areas were nearly identical in terms of species composition. Most snakes (about 67%) were recorded during the dry season months, when the fruits of the oil palm ripe, thus attracting lots of organisms that are potential prey for snakes. The most important food items for oil palm snakes were *Agama* lizards, birds and rodents, but they also fed on skinks, geckos, fruit bats and tree frogs. Snakes were spotted climbing with peak frequencies occurring in the range of 16–18 m above the ground level. In general, oil palm trees within the range of 16–27 m high harboured higher number of snakes. Climbing snakes were nonrandomly positioned on the trees: the highest percentage of snakes (68%) was lodged between the leaf bases and oil palm fruit bunches. The general implications of the given data are discussed.

Key words: community ecology, diet, Nigeria, oil palm tree, snake diversity

Résumé

Divers aspects de la structure communautaire et de l'écologie des serpents ont été étudiés entre 2004 et 2006 dans des champs de palmiers à huile (*Elaeis guineensis*) du sud du Nigeria. On a rapporté un total de 284 individus appartenant à 12 espèces de trois familles (7 Colubridae, 4 Elapidae, 1 Viperidae), y compris des individus aperçus et capturés (ne sont pas inclus dans ce calcul les individus qui se sont échappés avant que l'on puisse en identifier l'espèce). Toutes les zones de l'étude présentaient une composition des espèces presque identique. La plupart des serpents (près de 67%) ont été enregistrés au cours des mois de saison sèche, lorsque les fruits du palmier à huile mûrissent, ce qui attire de nombreux organismes qui sont des proies potentielles pour les serpents. Les proies principales des serpents des palmiers à huile étaient les agames, les oiseaux et les rongeurs, mais ils se nourrissaient aussi de scinques, de geckos, de roussettes et de grenouilles arboricoles. On a aperçu des serpents qui grimpaient, la hauteur la plus fréquentée étant entre 16 et 18 mètres au-dessus du sol. Ce sont en général les palmiers qui culminaient entre 16 et 27 mètres qui recelaient le plus grand nombre de serpents. Les serpents grimpeurs ne se répartissaient pas au hasard dans les arbres : le plus fort pourcentage (68%) d'entre eux se positionnaient entre la base des feuilles et le régime de fruits. Les implications générales des données sont discutées.

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Introduction

Snake community ecology has received a growing research interest by scientists during the recent years, and especially the species-rich tropical communities have proven a fertile field of investigation, especially after it has been demonstrated that many of them are shaped by nonrandom assembly rules and by interspecific competition (Luiselli, 2006a). In this sense, studies on snake communities from African tropical forests have been particularly important for the tests of some key questions on the assemblage functioning of snake communities (Luiselli, 2003, 2006a). The rainforests of southern Nigeria are certainly the better investigated African habitats, as for snake community ecology (Luiselli, Akani & Capizzi, 1998a; Akani *et al.*, 1999; Luiselli *et al.*, 2005; Luiselli, 2006a). These forests are inhabited by a wide variety of snakes, with some species being forest floor dwellers, some being fossorial, others aquatic or semi-aquatic, and others being arboreal (up to over twenty sympatric species at a site, see Luiselli *et al.*, 2005). Arboreality has evolved independently into a variety of snake families, including several lineages of Colubridae, Elapidae and Viperidae (Chippaux, 2006). Although there are some specific studies addressing the ecological aspects of single arboreal species from African rainforests (Luiselli, Akani & Barieenee, 1998b; Luiselli, Akani & Angelici, 2000a; Luiselli, Angelici & Akani, 2000b; Akani, Angelici & Luiselli, 2002, 2005), knowledge of the ecology of arboreal snakes at the community level is still much incomplete. In this research, we studied aspects of community ecology of snakes inhabiting a special type of arboreal habitat, i.e. the trees of oil palm plantations that constitute one of the most characteristic, largely human-managed, forest habitat type in West Africa. Indeed, the oil palm tree (*Elaeis guineensis*) is one of the dominant trees in the humid and secondary forests of southern Nigeria, its density in most localities of southern Nigeria exceeding 24 individuals per hectare (Hopkins, 1974; Reading, Thompson & Millington, 1995). A fully mature oil palm tree possesses an elaborate crown of 30–45 green fronds, each 5–9 m long, at the top of its cylindrical trunk or stem, which may reach a height of 25–30 m, and the crown provides a canopy of 5–7 m across (Jacquemard, 1998). Oil Palms are ecologically very important in the equatorial rainforest: for instance, these trees provide one of the most favourable nesting sites and weaving materials for birds, and also bats may roost on them in massive numbers (Okon, 1974; Fumilayo, 1976). Thus, oil palms are important foraging habitats for carnivorous animals (snakes, birds of prey, genets, etc; see also Angelici & Luiselli, 2005) because, when bearing fruits at least once a year and with fruits being often ripe during the drier months, these trees attract an array of small prey animals (e.g., snails, insects, spiders, squirrels, rats, mice, lizards, geckoes and birds) for the predators.

Materials and methods

Study areas

The field study was carried out in oil palm plantations of three distinct rural communities in southern Nigeria: (i) around Port Harcourt city (04°45′N, 07°01′E, Rivers State); (ii) Yenagoa (4°54′N, 06°15′E, Bayelsa State); and (iii) Eket (04°50′N, 07°59′E, Akwa-Ibom State). In Port Harcourt, the site included an area of 1550 hectares between the villages Rumuosi and Rumuigbo in Obio/Akpor Local Government Area of Rivers State. The study area in Yenagoa, partially flooded during the wet season in some years, was about 1280 hectares and was situated between the villages Swali, Gbaraun and Zarama Epie in the Northern flank of the state. The study area around Eket included an area of 1215 hectares located between the villages Okon-Eket and Ibeno. All these study areas lie in the coastal plain, with a climate being essentially of the equatorial type (Von Chi-Bonnardel, 1973), with a wet season from May to October and a dry season from November to April. Annual temperature range is small, often less than 4°C. Mean monthly maximum temperatures vary between 27 and 34°C, and mean minima vary between 22 and 24°C. Relative humidity values are frequently high ranging from 68% in dry season to 98% or more in wet season. The study area is also characterized by high rainfall regime with an average of more than 3500 mm annually, and peaks occurring in the months of July and September.

Protocol

For this study, we considered only individual snakes that had climbed on oil palm trees at the time of sighting. Thus, we did not consider individuals/species of snakes that although were observed inside oil palm fields/plantations, were found at the ground level or below ground (for instance, we did not consider several individuals of *Causus maculatus*, *Bitis gabonica*, *Bitis nasicornis* and *Atractaspis* spp. in this study).

Field research was conducted in both dry and rainy seasons of 2004–2006, using two independent methods. A first method, applied only during 2004 and 2005, was by engagement of professional oil palm fruit harvesters who were asked to provide the specimens encountered during their professional works. These workers routinely kill all the snakes as they encounter (G.C. Akani *et al.*, unpublished observations), thus they were asked to keep the specimens for our examination, without however being paid for this to avoid active killing of free-ranging individuals for the purpose of getting money. The palm fruit harvesters were also further interviewed about the site of capture, daily time, and type of activity exhibited by the snake at the capture time. In each station, the search for snakes by oil palm tapers lasted for about 4 weeks per season; thus there was three dry season and three rainy season sampling trips per station. An initial reconnaissance survey was conducted in all the stations, during which permission to enter into the palm bush was sought from the chiefs in whose area of jurisdiction, our proposed sampling stations extended. It also enabled us to inform the rural communities with our research mission and to explain to the oil palm tapers/harvesters the methods to be applied. For each snake gotten from the tapers, we determined species and sex, and the height from the ground, and girth of the palm (at breast height) on which the snake was collected was measured. Total length (TL, in cm) of the snakes was also taken, and then the specimens were preserved in formalin, and conserved in the collections of the Zoology Research laboratory, Rivers State University of Science and Technology, Port Harcourt, where they were dissected also for determining their stomach contents and gonad conditions.

The second method was by scrupulous screening of the oil palm crowns, with high power binoculars (Fujiyama Model) between 08.00 and 16.00 hours Nigerian time. Each palm screening lasted for 15 min, from convenient angles of observation, with more attention on the drooping and vertical fronds, the apical foliage, as well as gaps between the bunches of palm fruits, where snakes often position themselves for basking (Akani *et al.*, unpublished observations). Whenever we sighted a specimen, the snake was identified to species level and its activity was monitored until it crawled out of our view. A balanced field effort was performed among study areas to avoid the possibility of getting biased results among sites.

Statistical analyses

Data from locals were pooled to those collected by us only after having verified that no statistical differences existed between the two sources of data. We conducted all statistics by SPSS (version 11.0, SPSS Inc., New York, NY) PC package, with all tests being two-tailed and alpha set at 5%. Non-normal variables were log-transformed to achieve normality, and then parametric tests were used. To minimize data pseudoreplication, we conducted our surveys in such a way to avoid re-sampling of the same study tree twice in different days during the course of the study.

Results

General observations

A total of 284 snake specimens were recorded during the present research study, including both sighted and captured individuals (not including in this count the individuals that escaped before identification to species level could be made). Of this total, 82.0% came from binocular sightings, while 18.0% (n = 51) was killed and presented to us for dissection by tapers in all the three stations (Appendix). Some of the oil palm trees had more than one snake sighted, but overall nearly 17% of the screened palms had at least one snake. In total eleven snake species were observed at least once: seven were Colubridae (*Boiga blandingi*, *Philothamnus* sp., *Gastropyxis smaragdina*, *Dasypeltis fasciata*, *Thelotornis kirtlandii*, *Dispholidus typus* and *Rhamnophis aethiopissa*), four were Elapidae (*Dendroaspis jamesoni*, *Naja nigricollis*, *Naja melanoleuca* and *Pseudohaje goldii*), and one was a Viperidae (*Atheris squamiger*). The list of snake individuals observed at each study area is given in Table 1. All the study areas were nearly identical in terms of species composition, with all species being present in all study areas apart from the colubrid *Rhamnophis aethiopissa* (Table 1).

About 67% of the oil palm tree snakes collected during this study (Appendix) were killed in the dry season

Table 1 Snake individuals captured at oil palm tree plantations in three study areas from South-eastern Nigeria

Snake species	Yenagoa	Port Harcourt	Eket	Total
Gastropyxis smaragdina	10	19	23	52
Boiga blandingii	15	12	19	46
Philothamnus sp.	13	5	5	23
Thelotornis kirtlandii	6	9	2	17
Dispholidus typus	6	3	8	17
Rhamnophis aethiopissa	3	0	0	3
Dasypeltis fasciata	7	6	14	27
Dendroaspis jamesoni	7	13	7	27
Naja nigricollis	4	7	12	23
Naja melanoleuca	9	3	8	20
Pseudohaje goldii	2	5	2	9
Atheris squamiger	4	11	5	20
Total	86	93	105	284

months, when mature large branches of ripe oil palm fruits occur. The excess of snake captures during the dry season than in rainy season was statistically significant in all the stations ($P < 0.05$ at chi-squared test).

There was no statistical difference between tapers' data and our data concerning the mean girth size of the oil palm trees where snakes were found ($P = 0.681$, one-way ANOVA on log-transformed data). Snakes coming from tapers' collections ranged 97–216 cm TL, and the girth of the oil palm trees ranged from 31.2–48.1 cm (Appendix). There was no correlation between log-transformed girth size and log-transformed snake total length ($r = 0.109$, adjusted $r^2 = -0.08$, n = 52, $P = 0.441$).

Prey items of oil palm snakes

A total of 32 prey items were detected from the dissected snakes (Table 2) The most important food items for oil palm snakes were rainbow lizards (*Agama agama*), birds and rodents, but also skinks of the genus *Mabuya* (=*Trachylepis*), geckos, fruit bats and tree frogs were eaten. Among the birds identified in the snake digestive tracts were the sunbirds, weavers and palm swifts, while the rodents were primarily murids.

Position of climbing snakes on oil palm trees

In all the study areas, climbed snakes had similar distribution in terms of their height above ground (Table 3), with peak frequencies occurring in the range of 16–18 m high. It was also obvious that oil palm trees within the range of 16–27 m high harboured more snakes than those outside this range (Table 3).

Table 3 Distribution of the number of snakes seen climbed on oil palm trees by study area and by height class above ground

Height (m) classes of oil palm trees	Port Harcourt	Yenagoa	Eket
13–15	3	0	6
16–18	50	39	45
19–21	36	32	22
22–24	11	17	26
25–27	6	11	9
28–30	4	1	2
31–33	0	1	0
Total	110	101	110

Note that the numbers of snakes per study area given in this table exceed the totals reported in Table 1. This depends on the fact that here we include both captured and noncaptured individuals, and also individuals that were nonidentified to species level.

Climbing snakes were nonrandomly positioned on the trees. This was demonstrated by the uneven distribution of sightings (after pooling all snake species) across the various parts of the trees (differences among tree-spot types, $P < 0.05$ at chi-squared test). Indeed, of the snakes spotted on the oil palm trees, the statistically highest percentages (68%) were lodged between the leaf bases and oil palm fruit bunches, whereas snakes located on the older drooping palm fronds constituted 24%, and 8% occurred on the younger and vertical olive green foliage. Whereas the bulk of the snakes observed in the two last categories were recorded between 09.30 and14.00 hours as they were basking, those specimens that were lodged between the leaf bases and oil palm fruit bunches were seen at nearly every hour of the daytime. It should be remarked that this area of the oil palm has a lot of dry organic matter and is often

Table 2 Food items found in dissected oil palm snakes at three study areas in South-eastern Nigeria

Species	Agama	Mabuya	Gecko	Rodents	Birds	Bats	Tree frog	Unid. food	Empty
Gastropyxis smaragdina	3	1	1				1		2
Boiga blandingi					2	3			2
Philothamus sp.		2						1	4
Naja nigricollis	3		2						
Thelotornis kirtlandii	1				2				
Dispholidus typus			1		2				2
Atheris squamiger								1	
Rhamnophis aethiopissa								1	1
Dasypeltis fasciata									2
Dendroaspis jamesoni				2	2		1	2	
Pseudohaje goldii	1		2						
Total	8	4	2	6	8	3	1	4	16

humid because of water from rains trapped there. Thus, it is likely that snakes (and perhaps also their preys) may find in this part of the trees an excellent microclimatic spot from the trapped water reserve, where they may control their body temperature to avoid overheating.

Discussion

Two main patterns emerging from the present study are that snake communities of oil palm fields in Southern Nigeria are (i) relatively species-poor, but (ii) relatively high density if compared to other habitats of the same geographic territory. In terms of species richness, oil palm fields housed only twelve sympatric snake species, that is much less than the number of sympatric species observed in seasonally flooded swamp-forests (24 species, see Akani *et al.*, 1999), mangroves formations (eighteen species, see Luiselli & Akani, 2002) and even forest-derived savannahs (eighteen species, see Akani *et al.*, 1999). However, we considered here only snakes climbed or using the oil palms, whereas in these other studies, the whole community composition was considered, thus clearly underestimating the snake species richness of oil palm fields as the case in our study. The apparent population density of snakes observed in this study (i.e. about 17% of palms being occupied by at least one snake individual) is likely to be substantially high, and is also a further demonstration that early literature claiming that snake biomass is particularly depressed in African forests compared to similar habitats in other continents (Janzen, 1976) was not fully correct, given that there are some types of wet forests in tropical Africa where the abundance of snakes may be high as well (Luiselli *et al.*, 2005; Luiselli, 2008).

Another evidence of our study is that, despite a poorer species diversity of snakes in oil palm tree habitat than in other forest habitats of River Niger Delta, the range of their prey types is still very wide, being inclusive of small mammals, birds, other reptiles and amphibians. As some of the organisms preyed upon by snakes are well known to feed directly on the oil palm fruit, and as some of the snakes found in this habitat were observed while being preyed upon by birds of prey, we may build a hypothetical model of food web for the oil palm forest habitat (Fig. 1). By this model, it is evident that snakes are near the top of the food chain, and should also be the crucial organisms for the organization of the whole ecological system of the oil palm tree habitat given that their density may be remarkably high (as shown by the extrapolated density of

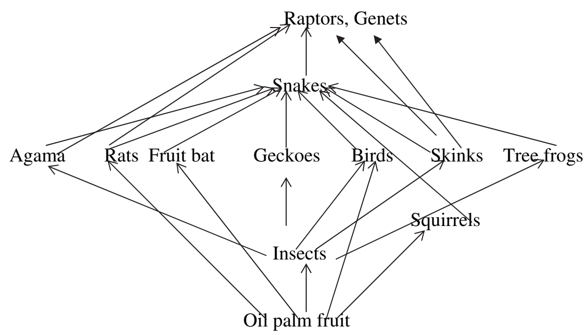

Fig 1 Hypothetical trophic chain for oil palm trees habitat in the Niger Delta, southern Nigeria

17% of palms being occupied by at least one snake individual). Concerning the food records of snakes, all the prey items observed in this study were congruent with the dietary preferences already known for the various snake species (Luiselli, 2006c), thus demonstrating that snakes do not shift their usual food habits when using oil palm trees as their habitat. However, it is noteworthy that all the dietary records of Goldie's tree cobras (*Pseudohaje goldii*) from oil palms were lizards (Table 2), whereas this species is a generalist predator with a preference for amphibians and fishes (Akani *et al.*, 2005). Thus, tree cobras may be the only species of snakes exhibiting some dietary shifts when in oil palm fields habitat compared to other forest habitats in southern Nigeria. Our sample size is, however, too small to be sure and further data are required before stressing firm conclusions.

It is also interesting to note that snake activity on oil palm trees peaked during the dry season, clearly in coincidence with the fruits being ripe. This is relevant because snake activity is conversely much less intense during the dry season than during the wet season in other habitats inside the rainforest area of Nigeria (and in the whole tropical Africa as well) because of the dry general conditions (Luiselli, 2001, 2006b). Thus, oil palms may furnish ideal microhabitats for snakes and their preys also during the climatically suboptimal dry season. It is possible that this may have some consequences for snake reproductive success: for instance, if individuals inhabiting oil palm fields may have a more prolonged activity than conspecifics from other habitats throughout the year, they may be able to feed more intensely and may then convert their increased food supply into a higher reproductive output ('capital breeding', see Madsen & Shine, 1999a,b). However, this hypothesis should be tested by *ad hoc* experiments in the future before being accepted.

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Appendix

List of the snake specimens collected by oil palm tapers in Port Harcourt, Eket and Yenagoa rainforests, during the survey period. This table includes also some basic natural history data collected from each specimen, including diet (=stomach contents) and number of eggs in gravid females. E, empty; R, rat; Bd, bird; L, lizard; Bt, bat; Sk, skink; G, gecko; U, unidentified food; S, squirrel; Tf, tree frog.

Date	Study area	Snake species	Sex	Total length, TL (cm)	Stomach content/ diet	Eggs	Height (m) of palm tree	Girth (cm) of palm tree
13/1/2004	Port Harcourt	*Gastropyxis smaragdina*	F	101	E	–	15	34.4
27/1/2004	Port Harcourt	*Dendroaspis jamesoni*	F	165	R	–	17	22
10/2/2004	Port Harcourt	*Boiga blandingi*	M	126	BD	–	25	38.8
17/2/2004	Port Harcourt	*Gastropyxis smaragdina*	F	107	L	8	28	33.7
25/3/2004	Yenagoa	*Naja nigricollis*	M	175	R	–	32	42.3
29/3/2004	Yenagoa	*Philothamnus* sp	M	97	E	–	19	38.8
2/4/2004	Yenagoa	*Pseudohaje goldii*	M	197	R	–	21	31.2
7/4/2004	Eket	*Dispholidus typus*	M	181	E	–	24	40.4
18/6/2004	Eket	*Boiga blandingi*	F	188	E	5	17	31.8
23/6/2004	Eket	*Boiga blandingi*	M	159	Bt	–	19	48.1
9/7/2004	Eket	*Dendroaspis jamesoni*	F	158	R	–	23	40.7
15/7/2004	Eket	*Naja melanoleuca*	F	184	E	–	18	38.5
19/8/2004	Port Harcourt	*Dendroaspis jamesoni*	M	172	E	–	20	36.4
2/9/2004	Port Harcourt	*Naja nigricollis*	F	152	L	–	17	36.1
8/10/2004	Port Harcourt	*Pseudohaje goldii*	M	162	R	–	25	39.9
21/11/2004	Eket	*Gastropyxis smaragdina*	F	105	E	–	22	35.1
25/11/2004	Eket	*Philothamnus* sp	F	102	Sk	–	24	32.7
30/11/2004	Eket	*Thelotornis kirtlandii*	M	155	Bd	–	18	31.9
27/11/2004	Yenagoa	*Rhamnophis aethiopissa*	M	142	U	–	15	33.7
29/11/2004	Yenagoa	*Gastropyxis smaragdina*	F	96	L		21	40.3
3/12/2004	Yenagoa	*Gastropyxis smaragdina*	M	99	Tf	–	23	38.5
9/12/2004	Yenagoa	*Boiga blandingi*	M	196	Bd	–	17	33.7
15/12/2004	Yenagoa	*Dendroaspis jamesoni*	F	155	Bd	9	19	40.2
7/1/2005	Port Harcourt	*Philothamnus* sp	F	88	U	–	25	43.5
11/1/2005	Port Harcourt	*Naja nigricollis*	F	180	R	–	16	35.8
24/1/2005	Port Harcourt	*Dispholidus typus*	M	183	E	–	19	38.8
29/1/2005	Port Harcourt	*Dasypeltis fasciata*	M	98	E	–	18	39.2
5/3/2005	Port Harcourt	*Atheris squamiger*	M	166	L	–	24	38.1
12/3/2005	Yenagoa	*Philothamnus* sp	M	102	Sk	–	16	40.4
17/3/2005	Eket	*Gastropyxis smaragdina*	M	105	G		28	42.5
20/3/2005	Eket	*Boiga blandingi*	F	176	E	7	23	36.9
25/3/2005	Eket	*Dendroaspis jamesoni*	F	138	Bd	–	19	36
25/3/2005	Eket	*Philothanmus* sp	M	98	E	–	27	41.2
2/4/2005	Eket	*Philothanmus* sp.	M	100	U	–	24	37.6
4/4/2005	Eket	*Dasypeltis fasciata*	M	101	E	–	21	33.8
6/1/2005	Eket	*Dipholidus typus*	M	157	Bd	–	19	34.9
17/4/2005	Port Harcourt	*Boiga blandingi*	F	185	Bt	–	16	40.7
19/4/2005	Port Harcourt	*Naja nigricollis*	M	138	L	–	18	38.2
26/4/2005	Port Harcourt	*Dendroaspis jamesoni*	F	149	E	9	24	40.5
8/5/2005	Port Harcourt	*Dipholidus typus*	M	166	G	–	17	36.9
11/6/2005	Port Harcourt	*Philothamnus* sp.	M	97	E	–	25	40.8
17/6/2005	Port Harcourt	*Naja melanoleuca*	F	216	S	–	27	37.5
26/6/2005	Yenagoa	*Rhamnophis aethiopissa*	M	96	E	–	18	35.9
9/7/2005	Yenagoa	*Gastropyxis smaragdina*	M	98	S	–	16	38.1
21/7/2005	Yenagoa	*Thelotornis kirtlandii*	F	158	L	–	25	41.7
23/8/2005	Yenagoa	*Dendroaspis jamesoni*	F	140	U	–	28	39.4
2/9/2005	Port Harcourt	*Boiga blandingi*	F	181	Bt	–	21	36.6
23/9/2005	Port Harcourt	*Naja nigricollis*	M	156	L	–	17	38.9

