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THE ROLE OF PLANTATIONS OF THE AFRICAN PALM (*ELAEIS GUINEENSIS* JACQ.) IN THE CONSERVATION OF SNAKES IN COLOMBIA

Las plantaciones de palma africana (*Elaeis guineensis* Jacq.) y las poblaciones de serpientes en Colombia

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ABSTRACT
Monocultures of the African oil palm (*Elaeis guineensis* Jacq.) were studied between 2006 and 2013 so as to determine which species of snakes frequented them and to estimate the abundances of each species encountered. Thirty five species of snakes (three boas, one coral, 27 colubrids, one tropidophid, one typhlopid, and two vipers) were captured within *palmeras.* Palm plantations are revealed to (1) augment the densities of ten species of snakes well beyond the densities found by collectors in natural and/or relatively transformed habitats and (2) to not offer benefits to at least 75% of the snake community found in the vicinities of palm plantations. The majority of snake species (60%) found in *palmeras* are nocturnal species. The most common species (defined by having 15 or more captures) were *Atractus univittatus, Bothrops asper, B. atrox, Epicrates maurus, Leptodeira annulata, Liophis melanotus, Ninia atrata, Oxyrhopus petolarius, Pseudoboa neuwiedii,* and *Tantilla melanocephala.* Palm plantations permit substantial local population sizes for a fraction (< 25%) of the local snake community. Internal practices of such plantations could be modified so as to protect a larger share of the fauna by means of two practices: (1) construction and maintenance of *paleras* as well as (2) creating a mosaic of palm plantations enclosing "islands" of secondary forests.

Key words. African oil palm, microhabitats within plantations, snake abundances, snake communities.

RESUMEN
Los monocultivos (plantaciones) de la palma de aceite Africana (*Elaeis guineensis* Jacq.) fueron estudiados entre el 2006 y 2013, para determinar cuáles especies de serpientes se podrían encontrar, y también para estimar las abundancias de cada especie encontrada. Treinta cinco especies de serpientes (tres güíos, una coral, 27 colúbridos, un tropidófido, un tiflópido y dos vipéridos) fueron capturadas dentro de las palmeras. El trabajo de campo en estas plantaciones revela que: (1) aumenta la densidad de diez especies de serpientes, más que la densidad encontrada en hábitats naturales o moderantemente transformados y (2) pero no hay beneficios para los 75% de la comunidad de serpientes encontradas en los alrededores de la plantacion. La mayoría de especies de serpientes encontradas (60%) son de actividad nocturna. Las especies más comunes (definido por tener 15 o más capturas) son *Bothrops asper, B. atrox, Epicrates maurus, Leptodeira annulata, Liophis melanotus, Ninia*

atrata, Oxyrhopus petolarius, Pseudoboa neuwiedii y *Tantilla melanocephala.* Las plantaciones de palma permite la subsistencia de poblaciones locales de tamaños sustanciales, lo cual corresponde a una fracción (< 25%) de la comunidad local de serpientes. Las prácticas internas de las plantaciones pueden ser modificadas para proteger una fracción mayor de la fauna; implicando dos cambios: (1) la construcción y el mantenimiento de paleras y (2) la creación de un mosaico de parcelas de palma intercalada con "islas" de bosque secundario.

Palabras clave. Abundancias de serpientes, comunidades de serpientes, la palma de aceite africana, microhábitats dentro de plantaciones.

INTRODUCTION

Snakes constitute a biological group under serious threat in Colombia. The principal threats are (1) destruction of the native habitats and (2) the indiscriminate killing of snakes by persons living or working in rural areas (Lynch, 2013). In the developed and populated part of Colombia, few national parks exist but there are some regional parks maintained by municipalities or private concerns. Some eight years ago, I realized that a cultivation, that of the African oil palm, might play a major role in snake conservation.

The African Palm was introduced into Colombia some 40-45 years ago and has become a growth industry. New plantations are created on lands that have had recent use as banana or rice cultivations, pasturelands, or natural vegetation (usually represented by secondary forests). The reactions of biologists, conservationists, and ecologists to the expanding palm plantations have been negative, reflecting either distaste for mono-cultures or the invasion of this agricultural frontier into natural habitats (or both). In my personal experience (Santander, 2007), I have seen parcels of *rastrojo alto* burned and shortly thereafter planted with this invasive species. African palm has been introduced even into areas never forested (savannahs in eastern Meta and in Vichada). However, plantations of mature African palm occur in areas that once supported humid tropical forest or dry tropical forest.

I first visited a plantation in 2004 but, aside from catching some caecilians and a few snakes there, remained indifferent (or antagonistic) towards the industry until 2006 (see below). Perhaps as a result of the biases of biologists against the industry, biological investigations of *palmeras* do not exist eventhough, in Colombia, the geographic extension grew by 41,000 Ha in 2010, summing 402,000 Ha (Fedepalma, 2011) and continues to expand (to 452,400 Ha en 2013, El Tiempo, 2 dic. 2013, p. 20).

Snake studies in African palm plantations are rare; I am aware of one study in Nigeria that focused upon the snake community of climbing snakes (Akani *et al.,* 2007).

Part of the problem with having Neotropical snakes as an object of study has been the view that they are uncommonly encountered even when one is actively searching for them. My experiences collecting in the tropics of Colombia and Ecuador (1967-2005) were such that finding three snake individuals in one day made that day memorable (until 2006). However, memories are not scientific data; fortunately, I can consult my fieldnotes so as to measure the rate of success. In 1983, I collected specimens along the Rio Calima, below Lago Calima, in Valle del Cauca, and later participated in the II Expedición Botánica in the Tayrona National Park (Magdalena). These were two of my most successful trips (based on memories). From my fieldnotes, I collected for 13 days at each

place. In May-June, I collected in natural forests along the middle part of the Rio Calima (Valle del Cauca) and captured 48 snakes (20 preserved, fourteen delivered live to the Instituto Nacional de Salud, and 14 liberated) of fourteen species at a rate of 3.6 snakes/ day. In June-July, I collected within the Parque Nacional Natural Tayrona (Magdalena) and secured 32 specimens (22 preserved and ten delivered live to the Instituto Nacional de Salud) of thirteen species at a rate of 2.5 snakes/ day. Excepting our field trip to Antioquia and that to Casanare, fieldtrips to *palmeras* resulted in better successes of 3.3-13.1 snakes/ day (Table 1)

Table 1. Species lists and numbers taken within *palmeras.* When the *Departamento* lies outside of the known and inferred distribution of the species, "na" = Not available. When the number of individuals bears an asterisk (in Antioquia, Cesar, Meta, and Santander, it means that the species was also collected in natural or transformed habitats.

Species	**ANT**	**BOL**	**CAS**	**CES**	**MAG**	**MET**	**NAR**	**SAN**	**N**
Atractus elaps	na	na	0	na	na	3	na	na	**3**
Atractus univittatus	na	na	3	na	na	44	na	na	**47**
Boa constrictor	0	0	0	1	3	0	0	0	**4**
Bothrops asper	0	7	na	8	5	na	4	2*	**26**
Bothrops atrox	na	na	1	na	na	68*	na	na	**69**
Chironius carinatus	0	0	1	0	0	2	0	3	**6**
Clelia clelia	0	0	0	2	1	0	0	0	**3**
Coralus hortulanus	0	0	0	0	0	0	0	2*	**2**
Enilius flavotorques	0	1	na	0	3	na	na	0	**4**
Enilius sclateri	0	0	na	0	0	na	na	1	**1**
Epicrates maurus	0	5	2	7*	14	7	0	1	**36**
Erythrolamprus bizona	0	0	0	0	0	1*	0	0	**1**
Eunectes murinus	na	na	1	na	na	0	na	na	**1**
Helicops angulatus	na	na	0	na	na	1*	na	na	**1**
Helicops danieli	0	1	na	0	0	na	na	1*	**2**
Leptodeira annulata	1*	14	0	5*	51	9*	9	5*	**94**
Leptophis ahaetulla	0	2	0	0	0	0	0	1*	**3**
Liophis epinephelus	0	0	na	0	0	na	3	0	**3**
Liophis melanotus	0	27	0	3*	12	0	na	3*	**45**
Liotyphlops albirostris	0	0	na	0	4	na	0	0	**4**
Lygophis lineatus	1	0	0	0	1	0	na	3*	**5**
Mastigodryas bifossatus	na	na	0	na	na	1	na	na	**1**
Mastigodryas boddaertii	2	0	0	0	0	6	0	1*	**9**
Mastigodryas pleei	0	1	0	0	0	na	na	0	**1**
Micrurus dumerilii	0	2	na	0	0	na	2	2*	**7**
Ninia atrata	7*	8	0	0	2	145*	0	5*	**167**
Ninia sp.	0	0	0	0	0	0	6	0	**6**
Oxyrhopus petolarius	4	6	0	3	9	29*	2	1	**54**
Oxyrhopus vanidicus	na	na	0	na	na	4	na	na	**4**
Pseudoboa neuwiedii	0	2	0	3*	0	2	na	7*	**15**
Tantilla melanocephala	0	0	0	0	1	14	0	1	**16**
Tantilla semicincta	na	0	na	1	0	na	na	0	**1**
Trachyboa boulengeri	0	na	na	na	na	na	2	na	**2**
Typhlops reticulatus	0	0	0	0	0	2*	0	3	**5**
Urotheca euryzona	0	0	na	0	0	na	3	0	**3**
Total collected	**15**	**76**	**8**	**33**	**106**	**340**	**31**	**42**	
Number of species	**5**	**12**	**5**	**9**	**12**	**16**	**8**	**17**	
Days invested	**6**	**10**	**6**	**10**	**11**	**26**	**3**	**10**	
Snakes/ day	**2.5**	**7.6**	**1.3**	**3.3**	**9.6**	**13.1**	**10.3**	**4.2**	

In my explorations of African Palm plantations (2006-2013), I have acquired an impression (incidentally) of the natural history of this introduced species where it exists as plantations. Initially, small plants are planted in a matrix lacking ground cover beyond grasses. The palms begin to be productive at four to six years after planting but the ground between palms remains exposed to full sunlight (ecologically equivalent to a pasture—dry, with a fluctuating temperature regieme). By the time the plants are eight to ten years old (after planting), the canopy closes resulting in higher humidity near ground level and a more homogeneous temperature regieme. Although the plants can live a very long time, practices in Colombian *palmeras* restrict their accumulated ages to 30 to 35 years after planting (facilitating the extraction of fruits). After this time, the plantation is cleared and the cycle re-initiated. Larger plants produce not only more fruits, they also produce more leaves (fronds) that must be cut so as to gain easy access to the fruit clumps. Cut fronds fall to the ground where they are gathered into piles within the plantation so that they do not interfere with the collection, fertilization, and fumigation activities of workers. Frond piles (*paleras*) guard even higher levels of humdity and the discarded plant parts initiate decomposition creating a density gradient (of humidity and humus) from the outside of the pile to its base. The trunk of the palm during the first third of its productive life is studded with the petiole bases of cut fronds and accumulates a cloak of epiphytes. Trees fifteen to twenty years of age have advanced the decomposition of the petiole studs to the point that the weight of the cloak begins to sag toward the base of the palm, leaving a relatively smooth trunk. The work of my students and I in *palmeras* reveals that the best place to find snakes within a *palmera* is in the frond piles, followed by the cloak or the accumulated debris at the base of the trunks. We had our least success searching in other facies of the palm plantation (canopy, open spaces under the shade of the canopy, and trunks).

African Palm plantations are not distributed uniformly within the country (Fedepalma, 2011) and for many regions where cultivation has begun, production is so low that no extraction plants have been constructed (meaning that cultivations are too young or not yet of a sufficient density). Planning fieldtrips in 2011-13 took into consideration whatever might indicate older palms (extraction plants) so as to improve our chances of finding snakes.

At present, the productive African palm industry of Colombia is distributed mostly within the populated and productive triangle of Colombia (below 500 m elevation above sea level, Appendix 1). This region is also the most severely transformed (ecologically). The Andean zone (slopes of the Andes) is likewise severely transformed ecologically but the impact on snake communities is reduced because snake diversity declines sharply with increased altitude (Lynch, 2013). Within the transformed lowlands few areas are protected (the National Parks of Macuira and Tayrona and the Salamanca Santuary) but available biological data on snake communities for these protected areas are scarce (because most biological collections of the country are younger than 30-50 years). Valuable snake collections were obtained by the Museo de La Salle in the first half of the 20th century and summarized by Nicéforo María (1942) but transformation of these areas had occurred centuries previously, eliminating the dry tropical forest and severely reducing the extent of the wet tropical forest; the latter remnants were cut early in the early part of the second half of the 20th century.

For much of the transformed part of Colombia, the habitats offered are drier and experience brusk changes in temperatures during 24 hours (owing to the reduction in vegetative cover). Snake species are known from these regions

(Nicéforo María, 1942), but there, snakes are subjected to intense human persecution and vehicular traffic; such specimens rarely are deposited in scientific collections. My impression is that African palm plantations mimic the moderating climates of the dry and wet tropical forests that once covered these transformed lowlands (IGAC, 1962; Espinal, 1977). Additionally, these plantations offer refuges from human persecution and vehicular traffic, at least for species of crepuscular and/or nocturnal activities (the majority of tropical snake species).

It was into this strange world that I was drawn in May of 2006. My students and I were looking for lizards under these piles of fronds that we found in the shady recesses of a palm plantation (Palmeras del Meta, vereda Casteñada, municipio de San Martín, Meta) then aged at 20 years since planting. During three half-days (three to four hours of searching per day), we captured 46 snakes (six species: *Atractus univittatus, Bothrops atrox, Epicrates maurus, Leptodeira annulata, Ninia atrata,* and *Oxyrhopus vanidicus*) as well as a variety of frogs and lizards. Our capture-rate was so unexpected (by me) and so novel (as many as six snakes per hour) that I decided to continue investigating palm plantations as a means of access to sufficient snake specimens as to permit populational studies in the tropics. In October of the same year, we had the opportunity to spend more time in the same *palmera* (five days) and collected an additional 87 snakes of eight species (*Atractus elaps, A. univittatus, Bothrops atrox, Epicrates maurus, Leptodeira annulata, Ninia atrata, Oxyrhopus petolarius,* and *Tantilla melanocephala*), confirming my intellectual speculation. In 2012, we briefly collected again in the same *palmera* securing 33 snakes of five species (*Atractus univittatus, Bothrops atrox, Ninia atrata, Oxyrhopus petolarius,* and *Tantilla melanocephala*), the five most abundant species taken in 2006 of the total of nine species found in this *palmera.*

MATERIALS AND METHODS

This study was undertaken so as to learn the generality of my 2006 discoveries of notable snake abundances in the Neotropics and the lack of seasonal effects on those abundances. Subsequently, an effort was made to determine the importance of such plantation in the conservation of snakes within Colombia. The study is not an ecological study although I use some terms used frequently by ecologists. It is a study of how common are encounters of individual snakes in the experience of a collector of natural history specimens in different habitats, including that of a cultivated species (*Elaeis guineensis*) in Colombia, and inferences concerning their conservation.

All specimens collected are deposited in the collections of the *Instituto de Ciencias Naturales* of the *Universidad Nacional de Colombia* or form part of the live snake collection of the *Serpentario del Instituto Nacional de Salud*. Collecting methods have changed during the course of the investigations during these seven years. Initially, we merely removed the decomposing fronds in our frenzy to collect and, later, also excavated the moist soil beneath the mound to a depth of 10-15 centimeters. We subsequently began to restore the pile after searching for specimens. Restoration of piles is ecological sound because it restores a habitat that has fostered snake collecting and it is wise to continue that fostering. It is also a courtesy to those who gave permission to search for snakes in their property. Subsequently, we also searched the accumulated rubble at the base of palm trunks. Much later (2011), during a fieldtrip to Cesar, we began to strip the vegetative cloak on palm trunks. To facilitate our searches, we pay close attention to the abundance of potential prey items under piles of fronds (worms, soft-bodied insects and spiders, frogs, and rodents) because we expect (and have had) little success in a snake search when we fail to detect appreciable quantities of prey items.

Fieldwork has been carried out in palm plantations in the departments of Antioquia (one), Bolívar (two), Casanare (four), Cesar (four), Cundinamarca (one), Magdalena (three), Meta (eight), Nariño (two), and Santander (four), covering the geographic extent of productive plantations in Colombia.

The taxonomy followed here is conservative or traditional and does not admit molecular genera unless these are corroborated by at least one other class of data/evidence. Hence, I do not follow Adalsteinsson *et al.* (2009), Hedges *et al.* (2014), or Zaher *et al.* (2009) for their molecular genera, in part for reasoning advanced by Curcio et al (2009) and Myers (2011). Likewise, I do not adopt the recognition of molecular species within widespread taxa when corroborating morphological evidence has not been presented.

RESULTS

In the course of the fieldtrips during 2006-2013, I and my students have visited 30 palm plantations varying in size from five hectáreas to more than 20,000 Ha. These include privately held *palmeras* as well as those of organized companies. Success-rates varied widely (generally less success during the dry season than during the wet season and greater success when the *palmeras* had some internal policies that indirectly, and unintentionally, favored snake collecting and snake density). Fieldwork in the departments of Bolívar, Casanare, Cundinamarca, and Magdalena was carried out during very dry seasons resulting in little (Casanare), or no (Cundinamarca) success as well as very successful visits (Bolívar and Magdalena). Our success-rate was not diminished when we collected in the aseasonal climates of the *Chocó biogeográfico* (Nariño). Unsurprisingly, species lists do vary geographically.

In all of the collections made in *palmeras,* a total of 35 species of snakes was taken (Table 1). There are several species of lowland snakes that are known (or expected) to occur in all parts of the country (*Boa constrictor, Clelia clelia, Corallus hortulanus, Imantodes cenchoa, Leptophis ahaetulla, Ninia atrata, Oxyrhopus petolarius, Tantilla melanocephala,* and the species pairs of *Bothrops asper* or *B. atrox, Epicrates cenchria* or *E. maurus,* and *Leptodeira annulata* or *L. septentrionalis*). Although two species of *Leptodeira* are currently recognized for the country (Duellman, 1958), I here treat these as a single species; documentation of this proposal will be defended elsewhere. Seven other species (*Chironius carinatus, Erythrolamprus bizona, Lampropeltis triangulum, Mastigodryas boddaertii, M. pleei, Sibon nebulatus,* and *Typhlops reticulatus*) occur across the regions sampled but do not occupy all lowlands of Colombia. All of these except *Imantodes cenchoa, Lampropeltis triangulum,* and *Sibon nebulatus* were captured in at least one *palmera*. In most local regions visited (in *palmeras*), the snake group also collected in other situations (*bananeras, fincas,* native vegetation, pastures, *rastrojos,* towns, and along degraded streams with some sort of gallery forest beside them). No species of snake known from Colombia is distributed exclusively in palm plantations (hardly surprising, given that the African Palm is a recently introduced species in the American tropics).

During our visits to Bolìvar, Casanare, Magdalena, and Nariño, little or no effort was invested in natural or transformed habitats. During our visit to Antioquia (November 2011) where we collected 15 snakes in *palmeras,* we also collected in natural and transformed habitats, finding 24 snakes of 10 species, eight of which (*Bothrops asper, Epicrates maurus, Imantodes cenchoa, Liophis melanotus, Mastigodryas pleei, Micrurus dumerilii, Porthidium lansbergi,* and *Pseudoboa neuwiedii*) were not found in the *palmera.* In our visit to Cesar (September 2011) where we collected 33 snakes of nine

species, we also collected in natural and transformed habitats, finding 25 snakes of 12 species, eight of which (*Corallus hortulanus, Enilius flavotorques, Helicops danieli, Imantodes cenchoa, Leptotyphlops goudotti, Liotyphlops albirostris, Porthidium lansbergi,* and *Thamnodynastes gambotensis*) were not found in local *palmeras.* During seven of the visits to Meta when we had time to search natural and transformed habitats we collected 340 snakes of 16 species in *palmeras*; in the natural and transformed habitats, we also collected 165 snakes of 15 species, of which seven (*Atractus major, Dyrmoluber dichrous, Imantodes cenchoa, Leptophis ahaetulla, Micrurus hemprichii, Siphlophis compressus,* and *Thamnodynastes pallidus*) were not found in local *palmeras.* In three visits to the western lowlands of Santander (March 2007, March 2008, and August 2011) where we collected 42 snakes in *palmeras,* we also collected in natural/ transformed habitats finding 32 snakes of 14 species, two of which (*Imantodes cenchoa* and *Thamnodynastes gambotensis*) were not found in local *palmeras.*

Of the 35 species of snakes captured in *palmeras*, only fourteen show some diurnal activity. *Chironius carinatus, Leptophis ahaetulla,* the two *Liophis, Lygophis lineatus,* and the three *Mastigodryas* are exclusively diurnal snake species. The two *Enilius, Erythrolamprus bizona,* and *Urotheca euryzona* are best described as crepuscular/ diurnal (Savage, 2002). *Clelia clelia* is normally active at night but is also frequently encountered active by day. *Eunectes murinus* is also crepuscular and aquatic; its activity cycle cannot be described as diurnal or nocturnal. *Typhlops reticulatus* is a burrower but can be found above ground as well even during daylight hours. The remaining 21 species are exclusively nocturnal organisms.

Our visits to palm plantations were normally in the course of a single fieldtrip (fewer than 14 days). Palm plantations in Meta were visited on five distinct occasions: twice in 2006 (6 ½ days), once in 2011 (2 ½ days), once in 2012 (13 days), and once in 2013 (4 ½ days**)**. Visits to palm plantations in Santander occurred twice (for three days in 2007 and for 7 days in 2011). The only plantation visited more than once was Palmeras del Meta (three visits, data separated in Fig. 3). Collecting success varies greatly among the eight departaments visited in terms of number of species captured (Fig. 1) and number of individuals captured (Fig. 2), each calibrated in terms of days invested in searches. There is a positive correlation to time invested in the active search for snakes and capture success. The number of

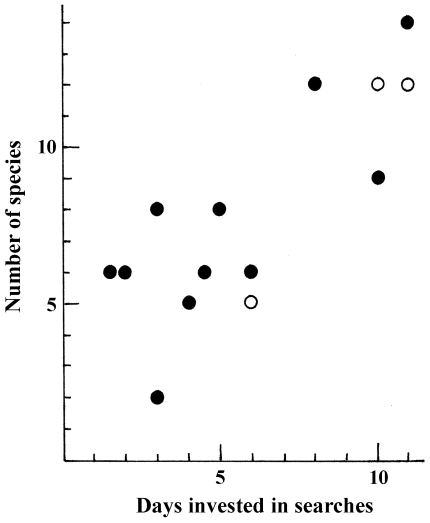

Figure 1. Relationship of number of species captured based on number of days invested in active searches. Sites with 12 species are combinations of two or three *palmeras* in the same municipality. That with five species in six days combines *palmeras* in the municipality of Villanueva, Casanare, and extreme northern Meta. The three day search yielding eight species combines two *palmeras* in Nariño. That with nine species combines two municipalities (San Alberto and San Martìn) in Cesar (four *palmeras*). Open symbols represent *palmeras* collected during the dry season.

species found in a given *palmera* is positively correlated with the total number of individuals captured (Fig. 3). During each field trip, five or six persons participated in discovery and capture of specimens for between four and six hours/ day.

In several *palmeras* visited during this investigation, we experienced very poor results in terms of snake captures (in Bolívar, municipality of María La Baja, two private *palmeras*; in Casanare, municipality of Villanueva: Palmeras del Oriente, Palmera Santa Ana, and Palmeras del Casanare and a private *palmera,* finca Rio Grande; in Cesar, municipality of San Martín, Palmeras de Cesar; in Cundinamarca, municipality of Paratebueno, private *palmera,* Hacienda La Europa; in Meta, municipality of Barranca de Upia, Palmera Guaicaramo; in municipality of Cumaral, Hacienda La Cabaña; municipality of Villavicencio, Palmera Borrego). These sites of poor results (Table 2) appear to me to derive from two or three causes (not mutually exclusive): (1) Hacienda La Cabaña and Palmera Borrego may well have produced little result because each is an island of palms within a matrix of pastures, not connected to forest remnants, which might serve as sources for species requiring forested habitat; (2) additionally, at Hacienda La Cabaña and Palmeras de Cesar, we found intense application of insecticides; (3) at the remaining poor sites, *paleras* were not formed or were so shallow as to allow the discarded fronds to dry out completely and few prey items were seen. Because we found few prey items, we abandoned our searches as soon as practical when possible. Nonetheless, we were "trapped" in Hacienda La Cabaña and Palmera Borrego (for lack of transport) and spent nearly two days in Palmeras del Oriente.

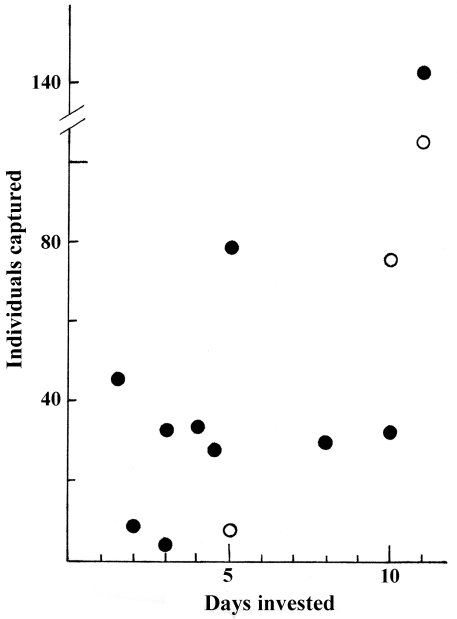

Figure 2. Relationship of number of individuals captured and days invested in active searches. Symbols can be from single *palmeras* or a combination of two to four nearby *palmeras*. Open symbols represent *palmeras* collected during the dry season.

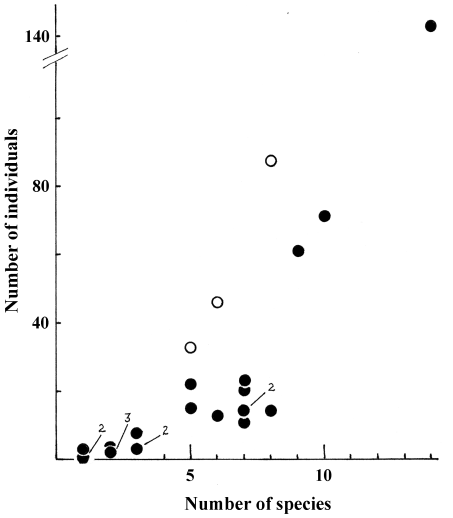

Figure 3. Relationship between number of individuals captured and number of species obtained. Each symbol represents a single visit to a single *palmera* except for the three open symbols which represent sequential visits to *Palmeras del Meta* en San Martín, Meta.

Table 2. Results of collecting efforts in palm plantations with poor results.

Palmera	Snakes captured	Prey abundances
Bolívar, María La Baja: private *palmera*	0	None seen
Bolívar, María La Baja: private *palmera*	0	A few lizards
Casanare, Villanueva, *Palmeras del Oriente*	3	A few frogs
Casanare, Villanueva, *Palmera Santa Ana*	0	A few frogs
Casanare, Villanueva, *Palmeras del Casanare*	0	A few frogs
Casanare, Villanueva, *finca Rio Grande*	3	Moderate, caecilians
Cesar, San Martín, *Palmeras de Cesar*	2	Very few frogs & rodents
Cundinamarca, Paratebueno, *Hda La Europa*	0	A few lizards
Meta, Barranca de Upia, *Guaicaramo*	2	Some frogs
Meta, Cumaral, *Hacienda La Cabaña*	4	Very scarce, few seen
Meta, Villavicencio, *Palmera Borrego*	0	Moderate in amphibians

DISCUSSION

To date, there are no confiable data on population sizes of any snake species in Colombia. In point of fact, the impression of collectors is that densities are very low, impressions that are contradicted by our work in *palmeras*. Collecting in natural habitats (Vichada, 2013) has produced success rates equivalent or superior to our work in *palmeras.*

Fieldwork in *palmeras* is sometimes as poorly productive as fieldwork in natural or transformed habitats but, in four of the eight departments sampled, can be impressively successful in terms of number of individuals captured/ day (Table 1). In general, looking across these past seven years, my impression is that population sizes of snakes in *palmeras* are elevated in comparison to natural or transformed habitats. Furthermore, in the only *palmera* visited repeatedly (Palmeras del Meta), the most abundant species in each of the two visits in 2006, remained the most abundant species in 2012 (in the same order of relative abundance: *Ninia atrata* > *Atractus univittatus* > *Oxyrhopus petolarius* > *Tantilla melanocephala* > *Bothrops atrox*), suggesting that relative abundances of species have not changed between 2006 and 2012 (Table 3).

That said *palmeras* do not represent a panacea for conservation because some species apparently do not use *palmeras.* A case in point is *Imantodes cenchoa,* a relatively common snake species in both natural and transformed habitats but absent from *palmeras*. Two other snake species, *Dipsas catesbyi* and *Sibon nebulatus,* each common in its habitat, were not found in our explorations of *palmeras.* These apparent absences, like that of *Imantodes cenchoa,* may reflect the absence of critical prey species.

Table 3. Snake collections made in *Palmeras del Meta* on three occasions (Most abundant species in boldface).

Species	May 2006	Oct. 2006	Oct.-Nov. 2012	Totals
Atractus elaps	0	2	0	2
Atractus univittatus	**9**	**21**	**10**	**40**
Bothrops atrox	**1**	**3**	**1**	**5**
Epicrates maurus	1	1	0	2
Leptodeira annulata	2	1	0	3
Ninia atrata	**32**	**35**	**19**	**88**
Oxyrhopus petolarius	**0**	**15**	**2**	**17**
Oxyrhops vanidicus	1	0	0	1
Tantilla melanocephala	**0**	**9**	**1**	**10**
Totals	46	87	33	166

Lynch (2013) estimated the sizes of snake communities for most ecogeographic regions of Colombia. Fieldwork in Antioquia, Cesar, and Santander corresponds to the Middle Magdalena, a once humid tropical forest and that in Bolívar and Magdalena to areas of dry tropical forest. Lynch (2013) estimated each snake fauna at 45 species. Given that, fieldwork within *palmeras* during the Antioquia fieldtrip recovered only 13% of the estimated regional snake community, the Bolívar and Magdalena trips 27%, the Cesar trip 20%, and the Santander fieldtrips 38%. Against those percentages, one might conclude that African palm plantations do not seem important. However, I emphasize, that in Colombia, no one has ever estimated population sizes for any snake species and that, based on available data (number of preserved records) and our own experiences, many species are rarely collected, either because collectors have not yet learned to capture them or because their population sizes are very small.

For the other three departments, it is more difficult to estimate community size. Nariño is very imperfectly known for lack of collecting effort; the problem for Casanare and Meta is that each department is near the base of a peninsula (the piedmont of the eastern grasslands) and the faunal reduction (the peninsular effect of Brown & Lomolino, 1998; Simpson, 1965) requires calibration for tropical snakes. Additionally, Casanare was nearly our worst fieldtrip (poorest results). For Meta, after eight visits to *palmeras,* our results seemed stable (although, in our last visit, we added *Erythrolamprus bizona* to the list of species taken in *palmeras*). Meta lies near the base of the ecological peninsula and has a snake fauna of 60 species (substantially fewer than Amazonia, Lynch, 2013). Our efforts there (in *palmeras*) secured only 25% of the anticipated snake fauna.

Beyond the common species (*Dipsas, Imantodes,* and *Sibon*) *not* using *palmeras,* there are a number of other species collected in natural or transformed habitats within a few kilometers of *palmeras* that have not been found in *palmeras*. Their absences do not appear to be caused by lack of appropriate prey species and I suggest that their absences from *palmeras* is a result of the very limited number of microhabitats to be found within a monoculture of African Palm. Even transformed habitats are richer in the number of microhabitats available although including probably fewer microhabitats that natural habitats. Our fieldwork in Chocó and in Vichada was restricted to natural and/ or transformed habitats and resulted in 20 or more snake species during each visit, contrasting sharply with the observation that we never found more than 14 species (representing 143 individuals captured) in a single *palmera*. While intensity of effort (days invested) seems to explain diversity, combining the data for the three visits to Palmeras del Meta (San Martín, Meta) yields only nine species representing 166 individuals), suggesting that local diversity (within a *palmera*) may be controlled by local conditions.

For the six departments for which it is possible to estimate snake community sizes, the mean value of species found in *palmeras* is only 25% of the estimated snake community. This means that although *palmeras* do enable larger than expected population sizes for certain species, they do not protect snake species diversity even so well as secondary forests (probably for the improverishment of microhabitat diversity). If my argument is sound, that suggests a strategy for improving palm plantations as protectors of snake diversity. That strategy is against extensive monoculture and in favor of a mosaic, with patches of secondary forest interspersed among parcels of monoculture.

The Colombian African palm industry could be a major factor in conservation biology of

snakes in Colombia where mortality caused by rural workers exceeds 100 million snakes/year and no fewer than 50,000 snakes die/year due to vehicular traffic (Lynch, 2013). However, to be a partner in conservation will require two changes in the industry: (1) that all waste fronds be piled into mounds (*paleras*) within the plantation and allowed to decompose slowly. This provides refuges for snakes (as well as easy access to prey) and reduces encounters by humans (reducing snake bites and reducing movements which can result in mortality on roads), and (2) that *palmeras* cease to convert *rastrojos* (parcels of secondary forest) in more monoculture of palms. Doing so provides a source fauna (the parcels of *rastrojo*) as well as increasing the number of microhabitats (and the prey base). Each of these activities contributes to preserving the snake fauna (either by elevating population sizes or, most likely, by increasing local species diversity).

Palm plantations do represent the best of the monocultures available in Colombia because some snake species do quite well within palm plantations (in contrast to other monocultures: *Acacia, Eucalyptus*, pine, and teka plantations as well as bananas, pasturelands, and rice fields). This affirmation is based not upon systematic field work but on my successes catching snakes in Colombia during the past 35 years.

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Appendix 1. Vouchers of snake species collected in *palmeras* (2006-2013). The snakes are deposited in ICN-R or await cataloguing there (field numbers of TAS: Teddy Angarita, RC: Rances Caicedo, and JDL: John D. Lynch).

Antioquia, Chigorodó: finca Tipaná, 40 m 07° 46' N, 76° 40' W 18-19, 21, 23 Nov. 2011
Leptodeira annulata (JDL 30091), *Lygophis lineatus* (JDL 30100), *Mastigodryas boddaerti* (JDL 30051, 30055), *Ninia atrata* (JDL 30052, 30063-64, 30092, 30097-99), *Oxyrhopus petolarius* (JDL 30053-54, 30093-94).

Bolívar, María La Baja: 3 Km E, 7 Km S cabecera, Palmeras Aguas Blancas, 15 m 09° 56' N, 75° 20' W 28 Feb 2012
Helicops danieli (JDL 30294), *Liophis melanotus* (JDL 30245-46), *Liotyphlops albirostris* (JDL 30247).

Bolívar, María La Baja: vereda Pasa Tiempo, 30 m 09° 59' N, 75° 16' W 29 Feb-8 March 2012
Bothrops asper (8 live to INS), *Enilius flavotorques* (JDL 30311), *Epicrates maurus* (JDL 30280, 30325, 30341, 30369, RC 1388), *Leptodeira annulata* (JDL 30268, 30288, 30303-06, 30324, 30333, 30357, 30365-66, 30407-08, RC 1381), *Liophis melanotus* (JDL 30265-66, 30308-09, 30321-23, 30330-32, 30354-56, 30359-64, 30391-92, 30409-10, RC 1379-80), *Mastigodryas pleei* (JDL 30353), *Micrurus dumerilii* (two live to INS), *Ninia atrata* (JDL 30267, 30310, 30320, 30334, 30368, 30411-12), *Oxyrhopus petolarius* (JDL 30279, 30307, 30329, RC 1382-84), *Pseudoboa neuwiedii* (JDL 30326, RC 1387).

Casanare, Villanueva: vereda El Encanto, finca Rio Grande, 280 m 04° 38' N, 72° 59' W, 3-4 Feb 2012
Atractus univittatus (JDL 30165-66, 30206).

Casanare, Villanueva: Palmeras del Oriente, 220 M 04° 30' N, 72° 50' W 3 Feb 2012
Chironius carinatus (JDL 30175), *Epicrates maurus* (JDL 30177), *Eunectes murinus* (JDL 30176).

Cesar, San Alberto: INDUPALMA, 95 m 07° 42' N, 73° 27' W 26-29 Feb, 1 Oct 2011
Bothrops asprer (four live to INS), *Clelia clelia* (JDL 29896), *Epicrates maurus* (JDL 29825, 29898), *Leptodeira annulata* (JDL 29824, 29838, 29890), *Liophis melanotus* (JDL 29841), *Oxyrhopus petolarius* (JDL 29836, 29897), *Pseudoboa neuwiedii* (JDL 29837).

Cesar, San Martín: Palmas de Cesar, 90 m 07° 51' N, 73° 29' W 24 Sept 2011
Boa constrictor (JDL 29771), *Epicrates maurus* (JDL 29772).

Cesar, San Martín: Palmera La Cacica, 85 m 07° 42' N, 73° 21' W 22 Sept 2011
Epicrates maurus (JDL 29746).

Cesar, San Martín: PROMIPALMA, 90 m 07° 57' N, 73° 34' W, 23, 25-26 Sept, 2 Oct 2011
Bothrops asper (two live to INS), *Clelia clelia* (JDL 29902), *Epicrates maurus* (JDL 29761, 29799, 29901), *Leptodeira annulata* (JDL 29788-89), *Liophis melanotus* (JDL 29763, 29790), *Oxyrhopus petolarius* (JDL 29792-93), *Pseudoboa neuwiedii* (JDL 29791), *Tantilla semicincta* (JDL 29794).

Magdalena, Aracataca: barrio Macondo, 50 m 10° 35' N, 74° 12' W, 8, 12, 14-16 Dec 2012
Bothrops asper (four live to INS), *Enilius flavotorques* (JDL 30868), *Epicrates maurus* (JDL 30875-76), *Leptodeira annulata* (JDL 30867, 30874), *Liophis melanotus* (JDL 30857, 30897), *Ninia atrata* (JDL 30900), *Oxyrhopus petolarius* (JDL 30858-60, 30871-73, 30898-99).

Magdalena, El Reten, vereda Las Flores, finca El Vogal, 40 m 10° 35' N, 74° 13' W 6-11 Dec 2012
Boa constrictor (JDL 30737, 30774-75), *Enilius flavotorques* (JDL 30737), *Epicrates maurus* (JDL 30658-59, 30682, 30755-57, 30776-79, 30782), *Leptodeira annulata* (JDL 30622-27, 30647-52, 30710-22, 30749-54, 30765-67), *Liophis melanotus* (JDL 30654-55, 30729-34), *Lygophis lineatus* (JDL 30653), *Ninia atrata* (JDL 30657), *Oxyrhopus petolarius* (JDL 30656), *Tantilla melanocephala* (JDL 30738).

Magdalena, El Reten: Hacienda La María, 30 m 10° 35' N, 74° 12' W 13-14 Dec 2012
Clelia clelia (JDL 30856), *Enilius flavotorques* (JDL 30831), *Leptodeira annulata* (JDL 30823-30, 30835-41), *Liophis melanotus* (JDL 30821-22), *Liotyphlops albirostris* (JDL 30832, 30842-44) .

Meta, Barranca de Upià, 7 Km E Barranca de Upià, Palmera Guaicaramo 200 m 04° 27' N, 72° 58' W 2 Feb 2012
Bothrops atrox (JDL 30160), *Epicrates maurus* (JDL 30178).

Meta, Cumaral: Hacienda La Cabaña, 310 m 04° 18' N, 73° 21' W 7, 19 June 2011
Bothrops atrox (JDL 30107, two live to INS), *Oxyrhopus petolarius* (JDL 29388).

Meta, Puerto Gaitàn, vereda Alto Manacacías, Palmera Sapuga 04° 10' N, 72° 02' W
Erythrolamprus bizona (TAS 1126), *Mastigodryas bifossatus* (TAS 1137), *Ninia atrata* (TAS 1104.05, 1118-21, 1136, 1140-42, 1148, 1162-64), *Oxyrhopus vanidicus* (TAS 1116-17), *Tantilla melanocephala* (TAS 1139).

Meta, Puerto Gaitàn, vereda Alto Manacacías, Palmera Sillalava 04° 10' N, 72° 02' W
Atractus univittatus (TAS 1155), *Ninia atrata* (TAS 1154), *Tantilla melanocephala* (TAS 1156-57).

Meta, San Martín: vereda La Casteñada, Palmeras del Meta, 320 m 03° 35' N, 73° 35' W May 2006, October 2006, 27, 29-31 October, 4 November 2012
Atractus elaps (ICN-R 10935, 10976), *Atractus univittatus* (ICN-R 10747-55, 10920-27, 10939, 10963, 10968-70, 10974, 10996-11002, JDL 30462-63, 30472-73, 30482-83, 30584-87), *Bothrops atrox* (ICN-R 10796, 10934, 10956, 10975, JDL 30582), *Epicrates maurus* (ICN-R 10788, 10987), *Leptodeira annulata* (ICN-R 10793-94, 10964), *Ninia atrata* (ICN-R 10756-87, 10916-19, 10940-52, 10965-67, 10972-73, 10977-81, 10988-95, JDL 30454, 30456-61, 30468-71, 30475-81, 30583), *Oxyrhopus petolarius* (ICN-R 10954-55, 10971, 10982, 11003-13, JDL 30453, 30484), *Oxyrhopus vanidicus* (ICN-R 10789), *Tantilla melanocephala* (ICN-R 10928-33, 10953, 10983-84, JDL 30588).

Meta, San Martín: vereda La Casteñada, Palmasol, 320 m 03° 32' N, 73° 32' W 26 Oct-6 Nov 2012
Atractus elaps (JDL 30567), *Boa constrictor* (JDL 30507, 30616), *Bothrops atrox* (JDL 30432-35, 30451, 30465-66, 30474, 30500-01, 30508-09, 30511, 30518, 30576-81, 30596-99, 30612-15, 31 live to INS), *Chironius carinatus* (JDL 30437, 30506) , *Epicrates maurus* (JDL 30441, 30505, 30512, 30518, 30575), *Helicops angulatus* (JDL 30595), *Leptodeira annulata* (JDL 30442, 30452, 30494-95, 30572, 30617-18), *Mastigodryas boddaerti* (JDL 30427, 30436, 30444, 30496, 30600), *Ninia atrata* (JDL 30418-26, 30438-40, 30455, 30467, 30485-93, 30504, 30510, 30513, 30516, 30561-64, 30569-75, 30590-93, 30619), *Oxyrhopus petolarius* (JDL 30428-30, 30497-98, 30517, 30573-74, 30594, 30604, 30620), *Oxyrhopus vanidicus* (JDL 30568), *Pseudoboa neuwiedii* (JDL 30601-02), *Tantilla melanocephala* (JDL 30499, 30621), *Typhlops reticulatus* (JDL 30443, 30611).

Meta, San Martín, vda La Casteñada, finca Malasia 5 November 2012
Bothrops atrox (JDL 30607), *Ninia atrata* (JDL 30605-06).

Nariño, Tumaco: Km 63, Palmera Santa Elena, 4 Km NW Llorente, 125 m 01° 24' N, 78° 33' W, 9-10 April 2010
Leptodeira annulata (JDL 29170), *Ninia* sp (JDL 29171, 29221-23), *Urotheca euryzona* (JDL 29150, 29224-25).

Nariño, Tumaco: 1 Km S "Km 28", 25 m 01° 37' N, 78° 44' W 11-13 April 2010
Bothrops asper (JDL 29301-02, 29309-10), *Leptodeira annulata* (JDL 29256-59, 29265-66, 29305-06), *Liophis epinephalus* (JDL 29275-76, 29308), *Micrurus dumerilii* (JDL 29303-04), *Ninia* sp (JDL 29261-62), *Oxyrhopus petolarius* (JDL 29260, 29307), *Trachyboa boulengeri* (JDL 29278-79).

Santander, Puerto Wilches: corregimiento Sogamoso, vereda Puente Sogamoso, Palmeras Las Brisas 07° 15' N, 73° 48' W 19-21 August 2011
Bothrops asper (two live to INS), *Chironius carinatus* (JDL 29525-26), *Liophis melanotus* (JDL 29494, 29583), *Lygophis lineatus* (JDL 29580-81), *Pseudoboas neuwiedii* (JDL 29495-96, 29578-79), *Tantilla melanocephala* (JDL 29582).

Santander, Puerto Wilches: ca 2 Km ESE Puerto Wilches, 110 m 07° 20' N, 73° 53' W 20 August 2011
Corallus hortulanus (JDL 29524).

Santander, Puerto Wilches: vereda El Vaivén, finca El Vaivén, 110 m 07° 20' N, 73° 52' W 22-23, 27 August 2011
Helicops danieli (JDL 29623), *Leptodeira annulata* (JDL 29617-19, 29631), *Leptophis ahaetulla* (JDL 29622), *Lygophis lineatus* (JDL 29629), *Micrurus dumerilii* (JDL 29630), *Pseudoboa neuwiedii* (JDL 29620-21, 29633), *Typhlops reticulatus* (JDL 29615-16, 29632).

Santander, Sabana de Torres: vereda Agua Bonita, 155 m 07° 21' N, 73° 28`W 25 March 2007
Corallus hortulanus (JDL 28149), *Enilius sclateri* (JDL 28148).

Santander, Sabana de Torres: vereda Km 36, 140 m 07° 22' N, 73° 36`W March 2007, 18 August 2011
Chironius carinatus (JDL 29492), *Epicrates maurus* (ICN-R 11279), *Leptodeira annulata* (JDL 28236), *Liophis melanotus* (JDL 29493), *Mastigodryas boddaerti* (ICN-R 11278), *Ninia atrata* (ICN-R 11273-76, JDL 29485), *Oxyrhopus petolarius* (ICN-R 11277).