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First inventory of Ants (Hymenoptera: Formicidae) with detection of potentially invasive species in National Park of Ehotilés islands, Côte d'Ivoire

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Abstract

Estuarine and wetland ecosystems are becoming increasingly altered by the concentration of human population near the coastline. A major threat to biodiversity related to this is the introduction of invasive alien species. This is particularly the case for isolated ecosystems like islands where the invasion of non-native species is often harmful. The National Park of Ehotilés Islands is an archipelago of 6 islands and a RAMSAR site subjected to disturbances, namely agriculture, illegal fisheries, and tourism. These factors often act as an accelerator for the introduction of invasive species. However, there is a lack of research on insects, specifically ants, on these islands. This study aimed to inventory the present ant fauna and estimate the vulnerability to tramp and potential invasive ant species. Ants were collected using Winkler, pitfall, and funnel traps on five islands. In total, 76 ant species were recorded. These species are distributed into 20 genera and five subfamilies: Dolichoderinae (5 species), Formicinae (11 species), Myrmicinae (49 species), Ponerinae (11 species) and Proceratiinae (1 species). We also detected two tramp and potentially invasive species: the ghost ant *Tapinoma melanocephalum* and the big-headed ant *Pheidole megacephala*. Ant communities are dominated by six species, namely *Odontomachus troglodytes*, *Oecophylla longinoda*, *Nylanderia lepida*, *Pheidole* sp.2, *Monomorium invidium,* and the invasive ghost ant *Tapinoma melanocephalum*. This work is the first to inventory ants on the Islands of Ehotilés National Park and may serve as a basis for conservation decisions as it demonstrates that this park is not spared from the introduction of invasive ant species.

Introduction

The National Park of Ehotilés Islands (PNIE) is an archipelago of 6 islands (722 ha) which emerges from the Aby lagoon in the south-east of Côte d'Ivoire, between 3°16'43"-3°18'52" W and 5°9'45"-5°11'12" N (Figure 1). Five islands, namely Assokomonobaha (Assoko), Balouaté, Elouamin, Méha, and Nyamouan are clustered and located 1 Km from the coastline, while the 6th island, Bosson-Assoun, is more isolated and located far to the East. These islands were declared a national park at the request of the local population "Ehotilés" in 1974, who were keen to preserve their cultural and historical value and the unique nature of the present ecosystems (Malan, 2008). In addition, the Park was declared a RAMSAR site in 2005 and is currently on a World Heritage waiting list.

The climate regime is cataloged within the equatorial transition type, with four seasons: the long rainy season from March to July, the short dry season in August, the short rainy season from September to November, and the long dry season from December to February. The average annual rainfall varies from 1,800 to 2,000 mm, and the average annual temperature is 26.4 °C with a variation of 3 °C. PNIE lies in an estuarine area with vegetation similar to the coastal sector of the Guinean domain. The variety of edaphic conditions induces a mosaic of diverse vegetation types (evergreen, marshy, and littoral). The flora is unique and dominated by dryland forests, swamp forests, riparian forests, Mangroves, and a grass carpet (Figure 2). Each island is dominated by native plant species like *Stephania dinklagei* (Engl.) Diels; *Diospyros soubreana* F. White; *Listrostachys pertusa* (Lindl.) Rchb.f. ; *Cryptolepis eburnea* (Pichon) Venter; *Barteria pubescens* (Sol. ex R. Br.) Byng & Christenh *;* *Rourea solanderi* Baker.

The Ehotilés Islands have been inhabited since 1600, even long before being declared a national park (Polet, 1988; Malan, 2008). In the past, local people did farming and fishing on these islands (Kwassi, 2002; Bango, 2005). The population around the park has known a significant explosion with urbanization and migration, with 83547 inhabitants in 2014 and 88,005 in 2021 (RGPH 2014; RGPH 2021). In addition, the park is an important tourist site, being an estuarine and seaside area (Malan, 2007). The beach economy and urbanization are booming and consequently could be a trigger for the entry of tramp and invasive species like some invasive ant species (Hulme, 2009; Kouakou et al., 2018).

Ants are one of the most ecologically diverse groups of social insects (Hölldobler & Wilson, 1990). They are wildly diverse in terrestrial ecosystems and contain some of the most widespread and impactful invasive alien species (Holway et al., 2002). Invasive ant species thrive first in urban areas and disturbed habitats, where they are introduced by human activities like trade, tourism, and commodities shipping (Ward et al., 2006; Kouakou et al., 2018).

Prior to this study, we were not aware of any research that had been conducted on insects before. This study aimed to conduct a first inventory of ants to provide a comprehensive species list. We also wanted to study the community composition of the ant fauna and identify ant species that may cause problems and threats to the native fauna in the National Park of Ehotilés Islands.

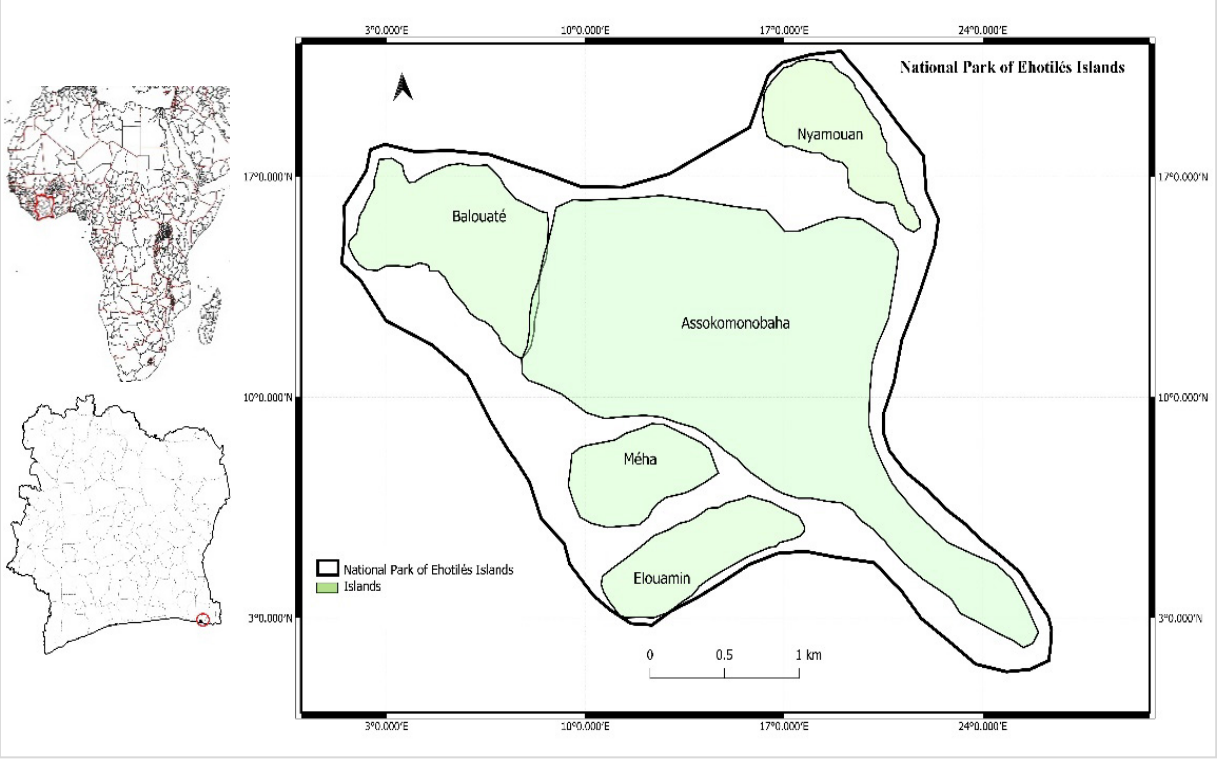

Fig 1. Map of National of Ehotilés Islands.

Material & Methods

The study was conducted on five Islands: Balouaté, Méha, Nyamouan, and Elouamin (Table 1). Fifteen sites were sampled between May 2021 and April 2022 using Winklers, pitfall traps (Agosti et al., 2000), and Funnel traps baited with tuna and milk on the same transect (Yode et al., 2020). At each sampling site, samples were collected at 10 m intervals along a 200 m transect line. Each sample was stored in an Eppendorf tube containing 90% Ethanol.

Ant identification was made at the Ecology Station of Lamto. The specimens were observed using an OLYMPUS SZ8 microscope. Ant workers were pinned and primarily identified at the genus level using Fisher and Bolton (2016).

Fig 2. Vegetation types of the National Park of Ehotilés Islands. A) swamp, B) dryland forest, C) Mangroves, D) swamp forest.

Then the species level identification was made using keys of Bolton (1976, 1980, 1982, and 1987), the personal ant reference collection from Yeo (2006), and the reference collection on urban and invasive ants from Kouakou (2018) located in Lamto Ecological Station. Online resources like AntWeb (www.antweb.org) and Ant Catalogue (www.Antcat.org) were used for correct and up-to-date taxonomy and species names. All identified pinned specimens, as well as specimens in ethanol, are deposited at Lamto Ecological Research Station, Côte d'Ivoire.

Table 1. Coordinates of sampling transects in National Park of Ehotilés Islands.

Island name	Transect Coordinates	Habitats	Size in hectare
Baloubaté	T1: N 05º 10' 36.2" W 003º18' 35.5"	Dryland forest	75 ha
	T2: N 05º 10'32.2» W 003º 18' 33.4"	Dryland forest	
	T3: N 05º 10'34.4» W 003º 18' 31.2"	Pandanus forest	
Méha	T1: N 05º 09'43.8» W 003º 17'42.0"	Swamp forest	45 ha
	T2: N 05º 09'45.5» W 003º 17'43.3"	Dryland forest	
	T3: N 05º 09'48.2» W 003º17'45.7"	Swamp forest	
Nyamouan	T1: N 05º 10' 46.5» W 003º 17'08.7"	Dryland forest	47,5 ha
	T2: N 05º 10'47.7» W 003 º 17' 06.2"	Dryland forest	
	T3: N 05º 10' 45.6» W 003º 17' 06.3"	Dryland forest	
Elouamin	T1: N 05º 09'53.5» W 003º 17'17.2"	Swamp forest	22,5 ha
	T2: N 05º 09'26.5» W 003º 17'45.4"	Dryland forest	
	T3: N 05º 09' 25.8» W 003º 17'41.9"	Old coconut farm	
Assokomonobaha	T1: N 05°09'52.8" W 003°17'17.5"	Dryland forest	327,5 ha
	T2: N 05°09'49.9" W 003°17'28.8"	Dryland forest	
	T3: N 05°09'57.2" W 003°17'17.1"	Swamp forest	

Data analysis was performed by combining samples from winklers, pitfall, and funnel traps for more complete information on the ant community composition. Presence/absence data were used for abundance rather than the number of workers. Graphs were plotted in Microsoft tool Excel and PAST v 4.09. In addition, ANOVA tests were performed with PAST v4.09 to compare species richness and abundance between islands.

Results and Discussion

The study provides important baseline data on ant community composition. It also highlights the vulnerability of coastal protected areas such as the Ehotilés Islands National Park (PNIE) to the introduction of invasive species. It allowed us to inventory 76 ant species (including morphospecies) for the island archipelago (Table 2). The species belong to 20 genera and five subfamilies (Dolichoderinae with five species, Myrmicinae with 48 species, Formicinae with 11 species, Ponerinae with 11 species and the Proceratiinae with one species). Assokomonobaha (Assoko) Island recorded the highest ant species richness (40 species), followed by Baloubaté (33 species), Nyamouan (32 species), and Méha (26 species). The lowest number of species was recorded on Elouamin Island (16 species; Figure 3). The comparison of species richness indicated a significant difference in number of species between different Islands (ANOVA: $F = 4.462$; $df = 4$; $p = 0.0011$).

These results suggest that despite the isolation of these islands, the ant fauna is rich, and the composition of Subfamilies is quite similar to the fauna described by other inventories conducted in nearby coastal ecosystems like in Banco National Park of Abidjan by Yeo et al. (2016) and Kouakou et al. (2018a).

The high diversity can also be explained by the regeneration of formerly disturbed coconut farms, resulting in more stable ecosystems like secondary forests. At Elouamin Island, where the impact of disturbance still seems high, and the vegetation is regenerating, only recently, as the coconut farms were just abandoned, the diversity is lower than on the other islands. Other studies confirmed this and reported that former agricultural land can regenerate and provide a solution for biodiversity conservation (Chadzon et al., 2020). Another study showed that the recovery of ant communities after a disturbance could be fast in the ancient forest (Hoenele et al., 2023). Such conditions prevent the establishment of invasive species.

Nevertheless, this study allowed the detection of two potential invasive ant species: the widely aggressive African big-headed ant *Pheidole megacephala* and the ghost ant *Tapinoma melanocephalum*. These two tramp ant species detected by Kouakou (2018) as introduced and potentially invasive in open urban areas are considered highly invasive (Wang & Luo, 2011; Wetterer, 2009; 2012). The occurrence of these ant species may be explained by touristic activities (Anderson et al., 2015) and probably originates from the disturbances created by old coconut farms in the past (Vonshack & Gordon, 2015).

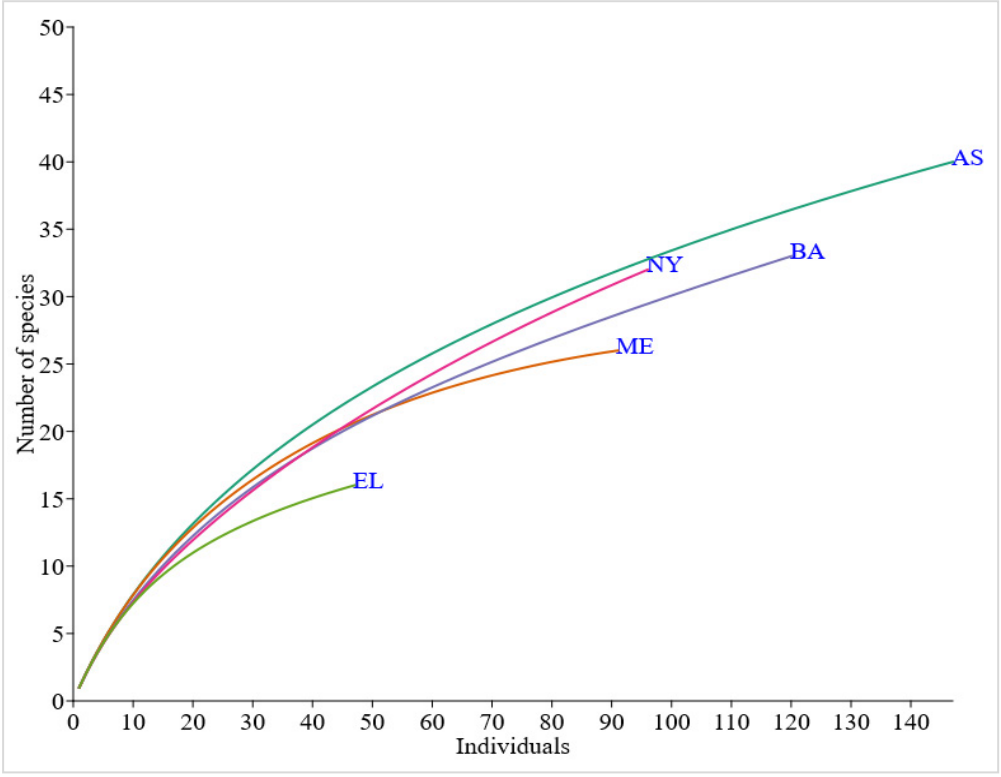

Fig 3. Incidence based species accumulation curves of ant community on Island of the Park. AS: Assoko Island; ME: Méha Island; BA: Baloubaté Island; NY: Nyamouan Island; EL: Elouamin Island.

Table 2. List of ant species recorded in National Park of Ehotilés Islands. AS: Assoko Island; ME: Méha Island; BA: Baloubaté Island. NY: Nyamouan Island; EL: Elouamin Island.

Species	AS	ME	BA	NY	EL	Total
DOLICHODERINAE						
***Tapinoma luteum* (Emery, 1895)**	0	1	0	0	0	1
Tapinoma melanocephalum* (Fabricius, 1793)	6	7	5	8	0	26
Tapinoma sp.1	0	0	0	1	0	1
***Technomyrmex andrei* Emery, 1899**	0	2	0	0	0	2
Technomyrmex sp.1	0	0	0	2	0	2
FORMICINAE						
***Camponotus acvapimensis* Mayr, 1862**	0	0	0	0	8	8
***Camponotus maculatus* (Fabricius, 1782)**	1	0	4	0	0	5
***Camponotus puberulus* Emery, 1897**	0	0	0	0	1	1
Camponotus sp1	2	0	3	0	0	5
***Camponotus vividus* (Smith, 1858)**	1	0	0	0	0	1
Lepisiota sp.3	0	0	0	0	5	5
***Nylanderia boltoni* LaPolla & Fisher, 2011**	2	6	1	1	3	13
***Nylanderia impolita* LaPolla & Fisher, 2011**	1	0	0	0	0	1
***Nylanderia lepida* LaPolla & Fisher, 2011**	15	12	10	14	4	55
***Nylanderia scintilla* LaPolla & Fisher, 2011**	0	3	2	1	2	8
***Oecophylla longinoda* (Latreille, 1802)**	26	0	29	3	1	59
MYRMICINAE						
***Carebara distincta* (Bolton & Belshaw, 1993)**	0	3	0	0	0	3
Carebara sp.1	1	0	1	0	0	2
Carebara sp.3	0	2	0	0	0	2
***Crematogaster africana* Mayr, 1895**	1	0	0	0	0	1
Crematogaster sp.1	4	2	5	0	0	11
Crematogaster sp.10	1	0	1	0	0	2
Crematogaster sp.2	3	1	2	1	2	9
Crematogaster sp.3	1	0	1	0	0	2
Crematogaster sp.4	6	0	3	2	0	11
Crematogaster sp.8	5	0	1	0	0	6
***Crematogaster striatula* Emery, 1892**	1	0	0	0	0	1
Crematogaster sp.7	1	0	1	1	0	3
Mellissotarsus sp.1	0	0	0	1	0	1
***Monomorium invidium* Bolton, 1987**	5	4	0	9	2	20
Monomorium sp.1	2	2	1	0	0	5
Monomorium sp.2	0	2	0	0	0	2
Monomorium sp.3	0	0	0	1	0	1
Monomorium sp.9	0	0	0	1	0	1
Pheidole megacephala* (Fabricius, 1793)	0	0	5	1	5	11
Pheidole sp.1	2	5	0	0	1	8
Pheidole sp.2	8	5	7	5	1	26
Pheidole sp.3	1	4	1	1	0	7
Pheidole sp.4	0	0	0	0	1	1

Table 2. List of ant species recorded in National Park of Ehotilés Islands. AS: Assoko Island; ME: Méha Island; BA: Baloubaté Island. NY: Nyamouan Island; EL: Elouamin Island. (Continuation)

Species	AS	ME	BA	NY	EL	Total
MYRMICINAE						
Pheidole megacephala* (Fabricius, 1793)	0	1	0	0	0	1
Pheidole sp.5	5	0	2	0	3	10
Pheidole sp.6	3	2	8	2	0	15
Pheidole sp.7	2	2	0	0	0	4
Pheidole sp.8	0	0	0	1	0	1
Pheidole sp.9	0	0	0	1	0	1
Pheidole sp.10	0	0	1	0	0	1
Pheidole sp.11	5	0	0	0	0	5
***Pheidole termitophila* Forel, 1904**	0	3	0	0	0	3
***Strumigenys bernardi* Brown, 1960**	2	0	0	0	0	2
***Strumigenys minima* (Bolton, 1972)**	0	0	0	3	0	3
***Strumigenys nimbrata* Bolton, 1983**	1	0	1	1	0	3
***Strumigenys rufobrunea* Santschi, 1914**	1	0	0	0	0	1
***Strumigenys rogeri* Emery, 1890**	3	3	5	0	0	11
Strumigenys sp.1	0	0	1	2	0	3
Strumigenys sp.2	0	0	1	0	0	1
Strumigenys sp.3	1	0	0	0	0	1
Strumigenys sp.4	0	0	0	3	0	3
***Tetramorium anxium* Santschi, 1914**	0	0	0	1	0	1
***Tetramorium minimum* (Bolton, 1976)**	1	1	1	1	0	4
***Tetramorium minusculum* (Weber, 1943)**	0	0	0	1	0	1
Tetramorium sp.1	1	0	1	1	0	3
Tetramorium sp.3	0	1	0	0	0	1
Tetramorium sp.4	1	0	0	0	0	1
***Tetramorium versiculum* Bolton, 1980**	0	0	0	1	0	1
***Tetramorium zapyrum* Bolton, 1980**	7	0	0	0	0	7
PONERINAE						
***Anochetus siphneus* Brown, 1978**	0	0	1	0	0	1
***Brachyponera sennaarensis* (Mayr, 1862)**	1	0	0	0	0	1
***Hypoponera dulcis* (Forel, 1907)**	2	0	0	0	0	2
***Hypoponera punctatissima* (Roger, 1859)**	0	0	4	0	0	4
Hypoponera sp.2	1	0	0	0	0	1
***Leptogenys conradti* Forel, 1913**	0	1	0	0	1	2
***Leptogenys occidentalis* Bernard, 1953**	0	0	1	2	0	3
Leptogenys sp.1	0	2	0	0	0	2
Leptogenys sp.2	0	0	1	0	0	1
***Odontomachus troglodytes* Santschi, 1914**	14	14	9	21	7	65
Plectrotena sp.1	0	1	0	0	0	1
PROCERATIINAE						
Probolomyrmex sp.1	0	0	0	2	0	2

(*) Tramp and Potential invasive ant species.

Our results showed that the ant community of the islands is dominated by six species whose abundance represents 50% of all (i.e., 251 occurrences out of 501 occurrences). These species are *Odontomachus troglodytes* (12.9% of total occurrences), *Oecophylla longinoda* (11.7%), *Nylanderia lepida* (11%), *Pheidole* sp.2 (5.2%), *Monomorium invidium* (4%) and the invasive ghost ant *Tapinoma melanocephalum* (5.2%). In addition, the potentially invasive species detected seem to occur on most islands (Figure 3). Indeed, *Tapinoma melanocephalum* (5.2% of total occurrences) is missing only on Elouamin Island but occurs on Assoko, Méha, Balouaté, and Nyamouan. These observations may suggest that *T. melanocephalum* and *P. megacephala* are already established and may cause severe damage and threats to the islands' local ant fauna and other invertebrates. *T. melanocephalum* is known to be highly aggressive and can coexist with other invasive ants like *Solenopsis Invicta* (Yue Lu et al., 2012). This ant is able to invade natural and disturbed habitats. It is also a serious pest indoors as a vector of pathogens (Moreira et al., 2005) and in cultivated fields where it tends phloem feed Hemiptera (Wetterer, 2009). The big-headed ant *Pheidole megacephala* (≈ 3% of total occurrences) was recorded on Elouamin, Balouaté, and Nyamouan Islands. Although this ant might be native to Côte d'Ivoire (Wetterer, 2012), it is common in urban areas (Kouakou et al., 2018b), disturbed habitats, and open natural habitats with grassy vegetation like savannah (Yeo et al., 2017). Its introduction in isolated habitats like islands can have harmful consequences. It is known to eliminate native ant species, invertebrates like snails, spiders, and centipedes (Dejean et al., 2007; Burwell et al., 2012) and disturb the carbon storage process in the soil by some plant species (Milligan et al., 2022).

Our data also revealed that the subfamily Ponerinae (≈ 17% of the total occurrence) was relatively abundant on all islands. We noticed a high abundance of *Odontomachus troglodytes*. Surprisingly, the giant African stink ant *Paltothyreus tarsatus*, abundant in nearby ecosystems on the mainland, was missing. Maybe high abundances of *Odontomachus* could explain the absence of *P. tarsatus*. Hence, *O. troglodytes* could become the bigger and more efficient predator ant and be able to develop large populations among the Ponerinae found on the islands. In addition, this ant seems to tolerate and adapt to high humidity in wetland ecosystems like Ehotilés National Park. However, further investigation is needed to explain the absence of *P. tarsatus* because this later ant species is widely occurring elsewhere in tropical Africa (Wheeler, 1922; Fisher & Bolton, 2016; http//: antmaps.org).

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Author's Contribution

L. M. M. K.: Conceptualization; Resources; Writing, Review & Editing.
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N. F. K.: Sampling, identification.
D. O.: Sampling, identification.
F-U. E.: Sampling, identification.
M. F. D.: Review & Editing.
K. Y.: Review & Editing.
W. D.: Review & Editing.

References

Agosti, D., Majer, J.D., Alonso, L.E. & Schultz, T.R. (2000). Standard methods for measuring and monitoring biodiversity. Smithsonian Institution, Washington DC, 9: 204-6.

Anderson, L.G., Rocliffe, S., Haddaway, N.R. & Dunn, A.M. (2015). The role of tourism and recreation in the spread of nonnative species: a systematic review and meta-analysis. PloS One, 10: e0140833. https://doi.org/10.1371/journal.pone.0140833

Bango, K.N. (2005). Diagnostic et mise en place d'une base de données pour une gestion durable du Parc National des îles Ehotilé. Mémoire de DEA, UFR SGE Univ. Abobo-Adjamé. 62 p. + Annexes.

Bolton, B. (1976). The ant tribe Tetramoriini (Hymenoptera: Formicidae). Constituent genera, review of smaller genera, and review of *Triglyphothrix* Forel. Bulletin of the British Museum (Natural History) Entomology, 34: 283-379.

Bolton, B. (1980). The ant tribe Tetramoriini (Hymenoptera: Formicidae). The genus *Tetramorium* Mayr in the Ethiopian zoogeographical region. Bulletin of the British Museum (Natural History) Entomology, 40: 193-384

Bolton, B. (1982). Afrotopical species of the myrmicine *Cardiocondyla*, *Leptothorax*, *Melissotarsus*, *Messor* and *Cataulacus* (Formicidae) in the Ethiopian region. Bulletin of the British Museum (Natural History) Entomology, 45: 307-370

Bolton, B. (1987). A review of the *Solenopsis* genus-group and revision of Afrotropical *Monomorium* Mayr (Hymenoptera: Formicidae). Bulletin of the British Museum (Natural History) Entomology, 54: 263-452.

Burwell, C.J., Nakamura, A., McDougall, A. & John Neldner, V. (2012). Invasive African big-headed ants, *Pheidole megacephala*, on coral cays of the southern Great Barrier Reef: distribution and impacts on other ants. Journal of Insect Conservation, 16: 777-789. https://doi.org/10.1007/s10841-012-9463-6

Dejean, A., Moreau, C.S., Uzac, P., Le Breton, J., & Kenne, M. (2007). The predatory behavior of *Pheidole megacephala*. Comptes Rendus Biologies, 330: 701-709. https://doi.org/10.1016/j.crvi.2007.06.005

Hölldobler, B. & Wilson, E.O. (1990). The ants. Harvard University Press, Cambridge MA, 732 p. https://doi.org/10.1007/978-3-662-10306-7

Hulme, P.E. (2009). Trade, transport and trouble: managing invasive species pathways in an era of globalization. Journal of Applied Ecology, 46: 10-18. https://doi.org/10.1111/j.1365-2664.2008.01600.x

Kouakou, L. M. M., Yeo, K., Kone, M., Ouattara, K., Kouakou, A.K., Delsinne, T. & Dekoninck, W. (2018). Espaces verts comme une alternative de conservation de la biodiversité en villes: le cas des fourmis (Hyménoptère: Formicidae) dans le district d'Abidjan (Côte d'Ivoire). Journal of Applied Biosciences, 131: 13358-13381. https://doi.org/10.4314/jab.v131i1.10

Kouakou, L.M.M., Yeo, K., Ouattara, K., Dekoninck, W., Delsinne, T. & Konate, S. (2018a). Investigating urban ant community (Hymenoptera: Formicidae) in port cities and in major towns along the border in Côte d'Ivoire: a rapid assessment to detect potential introduced invasive ant species. Journal of Animal and Plant Sciences, 36: 5793-5811.

Kouakou, L.M.M. (2018). Distribution et Biodiversité des fourmis anthropophiles, exotiques et potentielles invasice en Côte d›Ivoire, Thèse unique de Doctorat de l'Université NANGUI ABROGOUA, Abidjan, 1-256 p.

Kwassi, A.E. (2002). Apport de la télédétection satellitaire dans la gestion intégrée du littoral: cartographie des mangroves et de l'occupation du sol des îles Ehotilé (Lagune Aby - Côte d'Ivoire), mémoire de D.E.A. CURAT, Université de Cocody, Abidjan, 71 p.

Lach, L. & Hooper-Bui, L.M. (2010). Consequences of ant invasions. In Ant ecology. Lach, L., Parr, C. & Abbott, K. (eds). Oxford University Press, Oxford, 261-286. https://doi.org/10.1093/acprof:oso/9780199544639.003.0015

Malan, D.F. (2008). Utilisations traditionnelles des plantes et perspective de cogestion des aires protégées de Côte d'Ivoire: cas du Parc National des Iles Ehotilé (littoral est de la Côte d'Ivoire) (Doctoral dissertation, PhD Thesis. Abidjan: University of Abobo-Adjamé, Nature Science Department). 238 p.

Milligan, P.D., Martin, T.A., Pringle, E.G., Riginos, C., Mizell, G.M. & Palmer, T. M. (2022). A soil-nesting invasive ant disrupts carbon dynamics in saplings of a foundational ant-plant. Journal of Ecology, 110: 359-373. https://doi.org/10.1111/1365-2745.13803

Moreira, D., Morais, V.D., Vieira-da-Motta, O., Campos-Farinha, A.E.D.C. & Tonhasca Jr, A. (2005). Ants as carriers of antibiotic-resistant bacteria in hospitals. Neotropical Entomology, 34: 999-1006. https://doi.org/10.1590/S1519-566X2005000600017

Polet, J. (1988). Archéologie des Iles du Pays Eotilé (lagune Aby, Côte d'Ivoire), Thèse de Doctorat d'Etat ès Lettres, Paris Panthéon-Sorbonne, 3 vol., 624 p. + 300p. annexes.

RGPH (Recensement general de la population et de l'habitat) (2014). https://www.ins.ci/documents/rgph/ivoirien18plus.pdf

RGPH (Recensement general de la population et de l'habitat) (2021). https://data.gouv.ci/applications/recensement-generalde-la-population-et-de-lhabitat-rgph-de-2021-simple-table

Vonshak, M. & Gordon, D.M. (2015). Intermediate disturbance promotes invasive ant abundance. Biological Conservation, 186: 359-367. https://doi.org/10.1016/j.biocon.2015.03.024

Wang, C.Y. & Luo, Y.P. (2011). Laboratory evaluation of ant baits on colonies of ghost ants, *Tapinoma melanocephalum* (Hymenoptera: Formicidae). Formosan Entomology, 31: 169-177.

Ward, D.F., Beggs, J.R., Clout, M.N., Harris, R.J. & O'Connor, S. (2006). The diversity and origin of exotic ants arriving in New Zealand via human-mediated dispersal. Diversity and Distributions, 12: 601-609. https://doi.org/10.1111/j.1366-9516.2006.00270.x

Wetterer, J.K. (2009). Worldwide spread of the ghost ant, *Tapinoma melanocephalum* (Hymenoptera: Formicidae). Myrmecological News, 12: 23-33.

Wetterer, J.K. (2009). Worldwide spread of the ghost ant, *Tapinoma melanocephalum* (Hymenoptera: Formicidae). Myrmecological News, 12: 23-33.

Yeo, K. (2006). Dynamique spatiale et diversité des fourmis de la litière et du sol dans une mosaïque foret-savane em Côte d›Ivoire. PhD Thesis, University Pierre Marie Curie and University of Abobo Adjamé.

Yode, C.V.D., Dosso, K., Kouakou, L.M.M., Kolo, Y., Dekoninck, W., Konate, S. & Kouassi, K. P. (2020). Evaluating Efficiency of Different Sampling Methods for Arboreal Ants (Hymenoptera: Formicidae) in A West African Forest-Savanna Mosaic. Sociobiology, 67: 492-500. https://doi.org/10.13102/sociobiology.v67i4.5558

Lu, Y.Y. (2012). Comparison of foraging ability between *Solenopsis invicta* and *Tapinoma melanocephalum* (Hymenoptera: Formicidae). Sociobiology, 59: 1015-1024. https://doi.org/10.13102/sociobiology.v59i3.563