

The introduced and naturalized flora of Côte d'Ivoire: Diversity, origins and introduction history

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Abstract

Limited research has been conducted on the introduced flora of Côte d'Ivoire. The primary aim of this study is to enhance the understanding of the introduced flora in the country. The methodology used to compile the list of exotic plants in Côte d'Ivoire involved a thorough literature review, consulting published works, articles, and national, regional, and international online databases. A total of 1,003 introduced plant species from 609 genera and 154 families were catalogued. The most dominant genera include *Euphorbia*, *Solanum*, *Heliconia*, *Ipomoea*, *Gossypium*, and *Senna*, while the leading botanical families are Fabaceae, Compositae, and Poaceae. Herbaceous plants make up 55% of the introduced species, with woody plants comprising 45%. Additionally, 139 introduced plants of conservation value were identified from their regions of origin, including 39 species listed on the IUCN Red List (2024). A total of 114 species are endemic, primarily from Australia, Brazil, China, India, Madagascar, Mexico, and Papua New Guinea. The majority of introduced plants in Côte d'Ivoire are from two continents: the Americas and Asia. This study revealed that plant introductions into Côte d'Ivoire began in 1896, with a peak in 1958 when 61 species were introduced. Regarding the locations of introduction, the introduced plants are found throughout Côte d'Ivoire. However, the majority were introduced in the Abidjan district, particularly in the commune of Cocody and at the National Floristic Center.

Keywords: Introduced plants; Floristic diversity; Côte d'Ivoire; History

1. Introduction

Humans, due to their mobility, have long been both voluntary and involuntary agents of species introduction [1]. By selecting plants to transport, they introduce species outside their native ranges [2]. However, the introduction and eventual establishment of exotic plant species beyond their original ranges often lead to significant consequences. These species can have substantial impacts on biodiversity and cause ecological and economic damage [3]; [4]. According to [5], over 13,000 exotic plant species worldwide have managed to naturalize outside their native ranges. As a result, various studies on exotic plant inventories have been conducted in African countries, including Ghana [6], Egypt [7], Algeria [8], Sudan, and South Sudan [9], to better understand the introduced flora. However, there is still a lack of comprehensive data on the plants introduced into most African countries, particularly Côte d'Ivoire. This study seeks to address this gap by focusing on the exotic flora of Côte d'Ivoire. The study aims to answer the following questions: (1) What is the richness and composition of introduced or exotic plants in the flora of Côte d'Ivoire? (2) What are the origins of these plants? (3) What is the history of their introduction into Côte d'Ivoire? The overall goal of this study is to enhance our understanding of the introduced flora in Côte d'Ivoire. More specifically, it aims to (1) determine the

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richness and composition of exotic plants in Côte d'Ivoire, (2) analyze the origins of these plants, and (3) examine the history of their introduction into the country.

2. Material and methods

2.1. Study site

This study was carried out in Côte d'Ivoire (Figure 1). Located in West Africa, Côte d'Ivoire lies between latitudes 4°30' and 10°30' north, and longitudes 2°30' and 8°30' west. The country spans an area of approximately 322,462 km² [10]. The soils of Côte d'Ivoire are classified into four main groups: ferralsols, tropical ferruginous soils, soils on basic rocks with areas of cuirassment, and hydromorphic or coastal soils [11]; [12]. The terrain is generally flat and consists of plains and plateaus, except for the mountainous western region. Côte d'Ivoire experiences four main types of climates: sub-equatorial, humid tropical, tropical, and mountainous [13]; [14]. Vegetation in Côte d'Ivoire transitions from various savannah facies in the north to increasingly dense equatorial forests in the south [15].



Figure 1 Study area

2.2. Data Collection

2.2.1. Inventory of introduced or exotic plants in Côte d'Ivoire

In this study, an exotic taxon is defined as any species introduced, either intentionally or accidentally, into a region or area where it was previously absent [16]. Some of these introduced species successfully establish themselves in their new environment, adapt to the local conditions, reproduce, and form new, viable populations without human intervention [17]. These species are considered to be naturalized. The list of introduced plants was compiled based on a bibliographic review of studies conducted on plant species in Côte d'Ivoire. This process involved consulting the national herbarium database of Côte d'Ivoire, as well as several international online databases. These included the World Invasive Species Database (www.issg.org/database/welcome), the CABI Invasive Species Compendium (www.cabi.org/isc/), GRIIS (<http://www.griis.org>), the GloNAF initiative (<https://glonaf.org>), GBIF (<https://www.gbif.org>), and the list of invasive plants in West Africa, (<http://issg.org/pdf/publications/GISP/Resources/wAfrica-EN.pdf>). Additionally, we consulted master's theses, and Thesis, as well as scientific articles and reports on floristic diversity in Côte d'Ivoire. These include the works of [18]; [19]; [20]; [21]; [22]; [23]; [24]; [25]; [26]; [27]; [28]; [29]; [30]; [31]; [32]; [33]; [34]. Data from these various sources were used to generate a provisional list of introduced plants in Côte d'Ivoire. Next, the websites (<https://powo.science.kew.org/>) and (<http://africanplantdatabase.ch/>) enabled us to verify the origin of each plant, as well as the countries where these plants have been introduced. Finally, this stage allowed us to generate the definitive list of introduced and naturalized plants in Côte d'Ivoire.

The species names were updated based on [35], and the nomenclature for families follows [36].

2.2.2. History of plant introductions in Côte d'Ivoire

To trace the history of plant introductions to Côte d'Ivoire, we consulted the National Herbarium of Côte d'Ivoire and the Global Biodiversity Information Facility (GBIF) website (<https://www.gbif.org>). For each introduced species, we determined the place of introduction and the collection year. Due to the lack of precise data on the exact years of introduction, the collection date has been used in this study as a proxy for the year of plant introduction into Côte d'Ivoire.

2.3. Data analysis

Introduced taxa, families, genera, subspecies or varieties, and author names were identified using the methods of [35]; [22]; [23], and [36]. For each species, key characteristics such as biological type, subphylum, cotyledon type, origin, longevity, habitat, morphological type, and the date and location of introduction were recorded. Botanical references [37]; [22]; [23]; [38] were consulted for classification. The conservation value of introduced plants was assessed, considering species endemic to their regions of origin and those listed on the IUCN Red List of rare and threatened species [39]. The origin of introduced plants was analyzed using a spectrum and histogram based on the continents of origin for each species. The history of plant introductions in Côte d'Ivoire was traced using a curve and histogram which reflect the dates of introduction, the number of species introduced each year, and the various locations where these plants were introduced.

3. Results

3.1. Floristic richness and composition

The flora of Côte d'Ivoire is rich in 1,003 introduced species, which belong to 609 genera and are classified into 154 families. The dominant genera are *Euphorbia* (16 species), *Solanum* (15 species), *Heliconia* (14 species), *Ipomoea* (13 species), *Gossypium*, and *Senna* (12 species each). The most prevalent families (Figure 2) are: Fabaceae (125 species, or 12%), Compositae (46 species, or 5%), Poaceae (44 species, or 4%), Malvaceae (42 species, or 4%), Euphorbiaceae (36 species, or 3%), Solanaceae (32 species, or 3%), and Rubiaceae (31 species, or 3%).

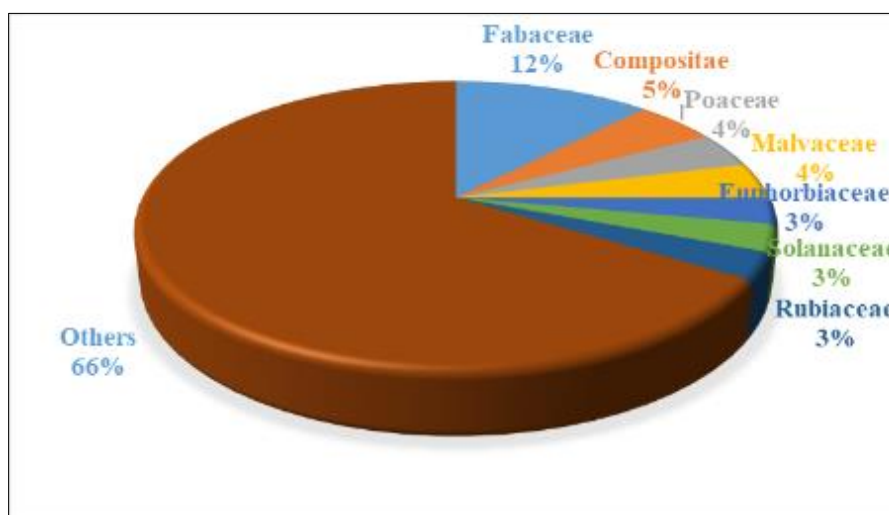


Figure 2 Spectrum of dominant botanical families of plants introduced to Côte d'Ivoire

The biological spectrum (Figure 3) of introduced plants shows a clear predominance of nanophanerophytes and microphanerophytes, with 339 species (33%) and 322 species (32%), respectively. They are followed by mesophanerophytes (97 species, 10%), therophytes (75 species, 7%), champhytes (60 species, 6%), hemicryptophytes (45 species, 4%), and geophytes (30 species, 3%). The remaining biological types account for only 47 species (5%), including hydrophytes (17 species), epiphytes (15 species), megaphanerophytes (12 species), and rheophytes (3 species).

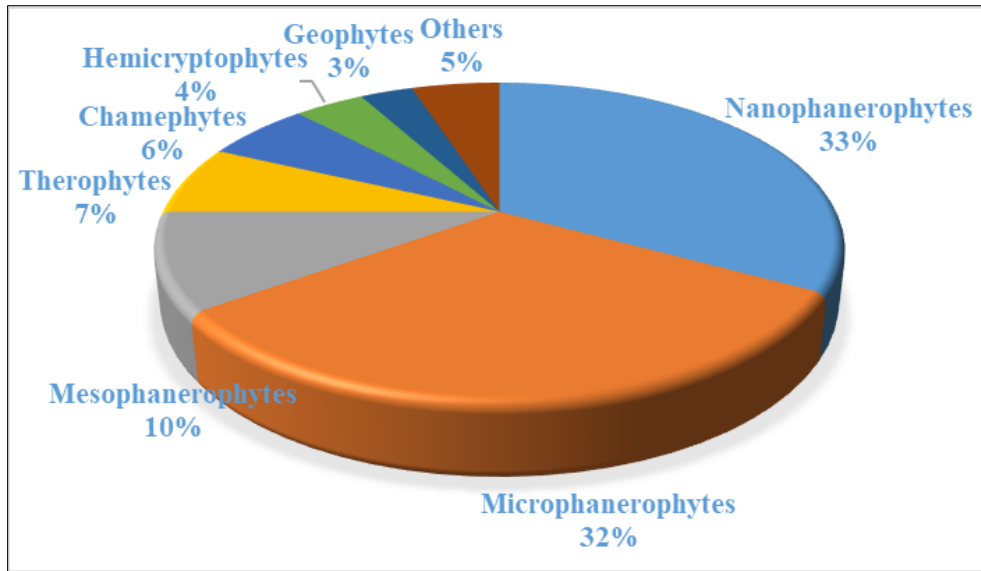


Figure 3 Spectrum of biological types of plants introduced to Côte d'Ivoire

3.2. Subphylum, Cotyledon Type, Living Environment, Longevity, and Morphological Type

Regarding subphyla, 96% of the introduced plants are Angiosperms, while Pteridophytes and Gymnosperms represent 3% and 1%, respectively (Figure 4). In terms of cotyledon type, the majority (76%) of introduced plants are dicotyledons, with 20% being monocotyledons. The remaining 3% and 1% are Pteridophytes (ferns) and Gymnosperms, respectively. Concerning living environment, 96% of the introduced plants are terrestrial, 2% are aquatic, and 1% are semi-aquatic or epiphytic. In terms of longevity, 822 plants (82%) are perennials, 172 (17%) are annuals, and only 9 plants (1%) are classified as annual/perennial. Finally, in terms of morphological type, the introduced flora consists of 550 herbaceous plants (55%) and 453 woody plants (45%).

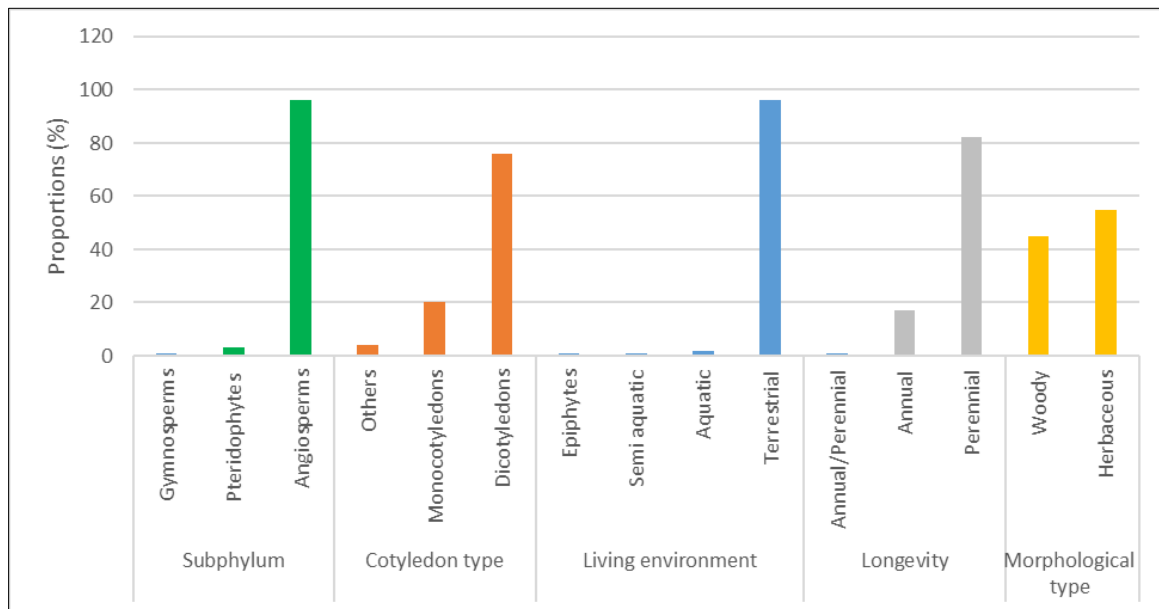


Figure 4 Subphylum, cotyledon type, living environment, longevity and morphological type of plants introduced to Côte d'Ivoire

3.3. Special status

A total of 139 introduced plants, representing 14% of all introduced species, have been identified as having a conservation status in their environment of origin (Table 1). Of these, 114 species (11%) are endemic, primarily to countries such as Australia, Brazil, China, India, Madagascar, Mexico, and Papua New Guinea. Additionally, 39 species (4%) are listed on the IUCN Red List [39]. This includes one species classified as extinct in the wild (EW), *Brugmansia suaveolens* (Humb. & Bonpl. ex Willd.) Bercht. & J.Presl (Solanaceae). There are also six species critically endangered (CR), namely *Euphorbia prostrata* Aiton (Euphorbiaceae), *Gaertnera liberiensis* E. M. A. Petit (Rubiaceae), *Gossypium armourianum* Kearney (Malvaceae), *Hyophorbe lagenicaulis* (L.H. Bailey) H.E. Moore (Arecaceae), *Polyscias paniculata* Baker (Araliaceae), and *Tarenna hutchinsonii* Bremek. (Rubiaceae). In addition, 13 species are classified as endangered (EN), and 19 species as vulnerable (VU).

Table 1 List of introduced plants in Côte d'Ivoire with conservation value in their area of origin

Taxa	Families	IUCN (2024)	Areas of endemism
<i>Acacia dealbata</i> Link	Fabaceae	-	Australia
<i>Acacia fimbriata</i> A.Cunn. ex G.Don	Fabaceae	-	Australia
<i>Acacia polifolia</i> Pedley	Mimosaceae	-	Australia
<i>Acalypha hispida</i> Burm.	Euphorbiaceae	-	Papua New Guinea
<i>Adiantum confine</i> Fée	Pteridaceae	-	Madagascar
<i>Adonidia merrillii</i> (Becc.) Becc.	Arecaceae	VU	-
<i>Afrocarpus mannii</i> (Hook.f.) C.N.Page	Podocarpaceae	EN	-
<i>Agathis robusta</i> (C.Moore ex F.Muell.) F.M.Bailey	Araucariaceae	VU	-
<i>Agave sisalana</i> Perrine	Asparagaceae	-	Mexico
<i>Aglaonema crispum</i> (Pitcher & Manda) Nicolson	Araceae	-	Philippines
<i>Aglaonema robeleynii</i> (Van Geert) Pitcher & Manda	Araceae	-	Philippines
<i>Allamanda violacea</i> Gardn.	Apocynaceae	-	Brazil
<i>Allium fistulosum</i> L.	Amaryllidaceae	-	China
<i>Allium porrum</i> L.	Amaryllidaceae	-	Iran
<i>Aloe vera</i> (L.) Burm.f.	Asphodelaceae	-	Oman
<i>Alstonia mollis</i> Benth.	Apocynaceae	-	Australia
<i>Arachis hypogaea</i> L.	Fabaceae	-	Bolivia
<i>Araucaria bidwillii</i> Hook.	Araucariaceae	-	Australia
<i>Araucaria columnaris</i> (J.R.Forst.) Hook.	Araucariaceae	-	New Caledonia
<i>Artocarpus heterophyllus</i> Lam.	Moraceae	-	India
<i>Asplenium brausei</i> Hieron.	Aspleniaceae	-	-
<i>Aucoumea klaineana</i> Pierre	Burseraceae	VU	-
<i>Aulea amicorum</i> (J. B. Hall) C. Cusset	Podostemaceae	-	Kenya
<i>Averrhoa bilimbi</i> L.	Oxalidaceae	-	Indonesia
<i>Averrhoi carambola</i> L.	Oxalidaceae	-	Indonesia
<i>Barleria lupulina</i> Lindl.	Acanthaceae	-	Madagascar
<i>Bauhinia monandra</i> Kurz	Fabaceae	-	Madagascar

<i>Bertiera sphaerica</i> N.Hallé	Rubiaceae	-	Gabon
<i>Bougainvillea glabra</i> Choisy	Nyctaginaceae	-	Brazil
<i>Bougainvillea spectabilis</i> Willd.	Nyctaginaceae	-	Brazil
<i>Brassica napus</i> L.	Brassicaceae	-	France
<i>Brugmansia suaveolens</i> (Humb. & Bonpl. ex Willd.) Bercht. & J.Presl	Solanaceae	EW	Brazil
<i>Brunfelsia pauciflora</i> (Cham. & Schltld.) Benth.	Solanaceae	-	Brazil
<i>Buchnera capitata</i> Benth.	Orobanchaceae	-	South Africa
<i>Bulbophyllum bifarium</i> Hook.f.	Orchidaceae	VU	-
<i>Bulbophyllum porphyroglossum</i> Kraenzl.	Orchidaceae	-	Borneo
<i>Bulbophyllum tentaculiferum</i> Schltr.	Orchidaceae	-	Papua New Guinea
<i>Callistemon speciosus</i> (Sims) Sweet	Myrtaceae	-	Australia
<i>Catharanthus roseus</i> (L.) G.Don	Apocynaceae	-	Madagascar
<i>Cedrela odorata</i> L.	Meliaceae	VU	-
<i>Chorisia crispiflora</i> Knuth	Malvaceae	EN	Brazil
<i>Chrysalidocarpus madagascariensis</i> (D.T.Fish) Becc.	Palmae	-	Madagascar
<i>Chrysophyllum cainito</i> L.	Sapotaceae	-	Panama
<i>Cinchona officinalis</i> L.	Rubiaceae	-	Ecuador
<i>Cinnamomum verum</i> J.Presl	Lauraceae	VU	Sri Lanka
<i>Citrus japonica</i> Thunb.	Rutaceae	-	China
<i>Citrus reticulata</i> Blanco	Rutaceae	-	China
<i>Clavija longifolia</i> Ruiz & Pav.	Primulaceae	-	Peru
<i>Coffea arabica</i> L.	Rubiaceae	EN	-
<i>Croton dispar</i> N.E. Br.	Euphorbiaceae	EN	-
<i>Cryptostegia grandiflora</i> (Roxb.) R.Br.	Apocynaceae	-	Madagascar
<i>Curcuma longa</i> L.	Zingiberaceae	-	India
<i>Cycas circinalis</i> L.	Cycadaceae	-	India
<i>Delonix regia</i> (Bojer ex Hook.) Raf.	Fabaceae	-	Madagascar
<i>Dendrocalamus macroculmis</i> (Rivière) J.Houz.	Poaceae	-	Vietnam
<i>Diospyros crassiflora</i> Hiern	Ebenaceae	VU	-
<i>Dipterocarpus alatus</i> Roxb	Dipterocarpaceae	VU	-
<i>Dovyalis hebecarpa</i> (Gardner) Warb.	Salicaceae	-	Sri Lanka
<i>Dypsis lutescens</i> (H.Wendl.) Beentje & J.Dransf.	Arecaceae	-	Madagascar
<i>Elaphoglossum angustatum</i> (Schrad.) Hieron.	Dryopteridaceae	-	South Africa
<i>Encephalartos barteri</i> Carruth.	Zamiaceae	VU	-
<i>Epipremnum aureum</i> (Linden & André) G.S.Bunting	Araceae	-	Society Island
<i>Eriobotrya japonica</i> (Thunb.) Lindl.	Rosaceae	-	China
<i>Eriosema macrostipulatum</i> Bak.f.	Fabaceae	-	Brazil

<i>Eucalyptus angustifolia</i> Desf.	Myrtaceae	-	Australia
<i>Euphorbia canariensis</i> L.	Euphorbiaceae	-	Canary Island
<i>Euphorbia milii</i> Des Moul.	Euphorbiaceae	-	Madagascar
<i>Euphorbia prostrata</i> Aiton	Euphorbiaceae	CR	-
<i>Euphorbia splendens</i> Bojer ex Hook.	Euphorbiaceae	-	Madagascar
<i>Euphorbia tirucalli</i> L.	Euphorbiaceae	-	Madagascar
<i>Exacum quinquenervium</i> Griseb.	Gentianaceae	EN	-
<i>Gaertnera liberiensis</i> E. M. A. Petit	Rubiaceae	CR	Liberia
<i>Gossypium armourianum</i> Kearney	Malvaceae	CR	Mexico
<i>Gossypium bickii</i> (F.M.Bailey) Prokh.	Malvaceae	-	Australia
<i>Gossypium incanum</i> (O.Schwartz) Hillc.	Malvaceae	-	Yemen
<i>Gossypium nelsonii</i> Fryxell	Malvaceae	-	Australia
<i>Gossypium raimondii</i> Ulbr.	Malvaceae	EN	Peru
<i>Gossypium thurberi</i> Tod.	Malvaceae	EN	-
<i>Graptophyllum pictum</i> (L.) Griff.	Acanthaceae	-	Papua New Guinea
<i>Grevillea robusta</i> A. Cunn. ex R. Br.	Proteaceae	-	Australia
<i>Heliconia rodriguensis</i> Aristeg.	Heliconiaceae	-	Venezuela
<i>Hibiscus cooperi</i> J.Veitch f.	Malvaceae	-	Vanuatu
<i>Hibiscus rosa-sinensis</i> L.	Malvaceae	-	Vanuatu
<i>Hippobroma longiflora</i> (L.) G.Don	Campanulaceae	-	Jamaica
<i>Hohenbergiopsis guatemalensis</i> (L.B.Sm.) L.B.Sm. & Read	Bromeliaceae	VU	-
<i>Hopea odorata</i> Roxb.	Dipterocarpaceae	VU	-
<i>Hyophorbe lagenicaulis</i> (L.H.Bailey) H.E.Moore	Arecaceae	CR	-
<i>Ixora macrothyrsa</i> (Teijsm. & Binn.) N.E.Br.	Rubiaceae	-	Indonesia
<i>Jacaranda mimosifolia</i> D.Don	Bignoniaceae	VU	-
<i>Jatropha integerrima</i> Jacq.	Euphorbiaceae	-	Cuba
<i>Khaya anthotheca</i> (Welw.) C.DC.	Meliaceae	VU	-
<i>Lactuca sativa</i> L.	Compositae	-	Iraq
<i>Ligustrum myrsinites</i> Decne.	Oleaceae	-	India
<i>Macadamia ternifolia</i> F.Muell.	Proteaceae	EN	Australia
<i>Manihot carthagenensis</i> subsp. <i>glaziovii</i> (Müll.Arg.) Allem	Euphorbiaceae	-	Brazil
<i>Medinilla magnifica</i> Lindl	Melastomataceae	-	Philippines
<i>Mussaenda philippica</i> Rich.	Rubiaceae	-	Philippines
<i>Myristica fragrans</i> Houtt.	Myristicaceae	-	Indonesia
<i>Nicotiana rustica</i> L.	Solanaceae	-	Peru
<i>Nicotiana tabacum</i> L.	Solanaceae	-	Bolivia
<i>Opuntia ficus-indica</i> L.	Cactaceae	-	Mexico

<i>Oryza sativa</i> L.	Poaceae	-	China
<i>Pachira glabra</i> Pasq.	Malvaceae	-	Brazil
<i>Pavetta brachycalyx</i> Hiern	Rubiaceae	EN	-
<i>Pavetta mollissima</i> Hutch. & Dalziel	Rubiaceae	VU	Ghana
<i>Peperomia sandersii</i> C. DC.	Piperaceae	-	Brazil
<i>Pereskia grandiflora</i> Haw.	Cactaceae	-	Brazil
<i>Philodendron erubescens</i> K.Koch & Augustin	Araceae	-	Colombia
<i>Phyllanthus acidus</i> (L.) Skeels	Phyllanthaceae	-	Brazil
<i>Piper nigrum</i> L.	Piperaceae	-	India
<i>Plerandra elegantissima</i> (H.J.Veitch ex Mast.) Lowry,	Araliaceae	EN	New Caledonia
<i>Plerandra grandiflora</i> A.C.Sm.	Araliaceae	-	Fiji
<i>Pleroma semidecandrum</i> (Schrank & Mart. ex DC.) Triana	Melastomataceae	-	Brazil
<i>Polyscias paniculata</i> Baker	Araliaceae	CR	Mauritius
<i>Ptisana fraxinea</i> (Sm.) Murdock	Marattiaceae	-	India
<i>Punica protopunica</i> Balf.fil.	Lythraceae	VU	Yemen
<i>Ravenala madagascariensis</i> Sonn.	Strelitziaceae	-	Madagascar
<i>Rosa chinensis</i> Jacq.	Rosaceae	-	China
<i>Rubus pinnatus</i> Willd.	Rosaceae	-	South Africa
<i>Ruellia congoensis</i> Benoist	Acanthaceae	-	Central African Republic
<i>Russelia equisetiformis</i> Schlecht. & Cham.	Plantaginaceae	-	Mexico
<i>Saccharum officinarum</i> L.	Poaceae	-	Papua New Guinea
<i>Schefflera grandiflora</i> (A.C.Sm.) Frodin	Araliaceae	-	Fiji
<i>Schlumbergera truncata</i> (Haw.) Moran	Cactaceae	VU	Brazil
<i>Sinningia speciosa</i> Benth. & Hook	Gesneriaceae	-	Brazil
<i>Solanum wrightii</i> Benth.	Solanaceae	-	Bolivia
<i>Spilanthes oleracea</i> Jacq.	Compositae	-	Brazil
<i>Stiffia chrysantha</i> Mikan.	Compositae	-	Brazil
<i>Syzygium mauritianum</i> J.Guého & A.J.Scott	Myrtaceae	-	Mauritius
<i>Tarenna hutchinsonii</i> Bremek.	Rubiaceae	CR	-
<i>Tectona grandis</i> L.f.	Lamiaceae	EN	-
<i>Terminalia neotaliala</i> Capuron	Combretaceae	VU	Madagascar
<i>Thunbergia atcorensis</i> Akoègn. & Lisowski	Acanthaceae	-	Benin
<i>Uvaria dinklagei</i> Engl. & Diels	Annonaceae	-	Liberia
<i>Vanilla planifolia</i> Jacks. ex Andrews	Orchidaceae	EN	-
<i>Vepris trifoliolata</i> (Engl.) Mziray	Rutaceae	VU	Cameroon
<i>Vitex domingensis</i> Urb. & Ekman	Lamiaceae	VU	-

<i>Washingtonia robusta</i> H.Wendl.	Areaceae	-	Mexico
<i>Zamia furfuracea</i> L.f.	Zamiaceae	EN	Mexico Gulf

Legend: IUCN Red List categories: VU = Vulnerable; EN = Endangered; CR = Critically Endangered; EW = Extinct in the Wild.

3.4. Origin of introduced plants

The majority (37%) of plants introduced to Côte d'Ivoire originate from the Americas, with South America accounting for 44% and North America for 34%. Plants from Asia make up 27%, primarily from Southeast Asia (38%) and South Asia (36%). African-origin plants represent 21% of the introduced species, with the largest contributions from East Africa (34%) and Central Africa (31%). Additionally, 12% of the introduced plants come from Oceania, while only 3% originate from Europe (Figures 5 and 6).

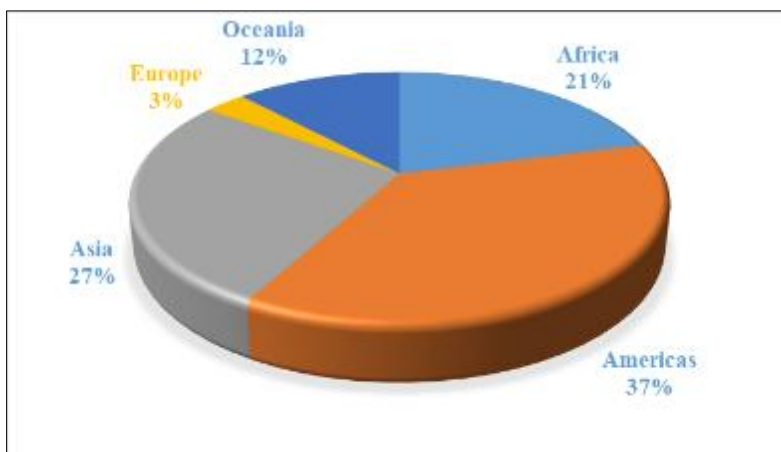


Figure 5 Spectrum of origins of introduced plants in Côte d'Ivoire

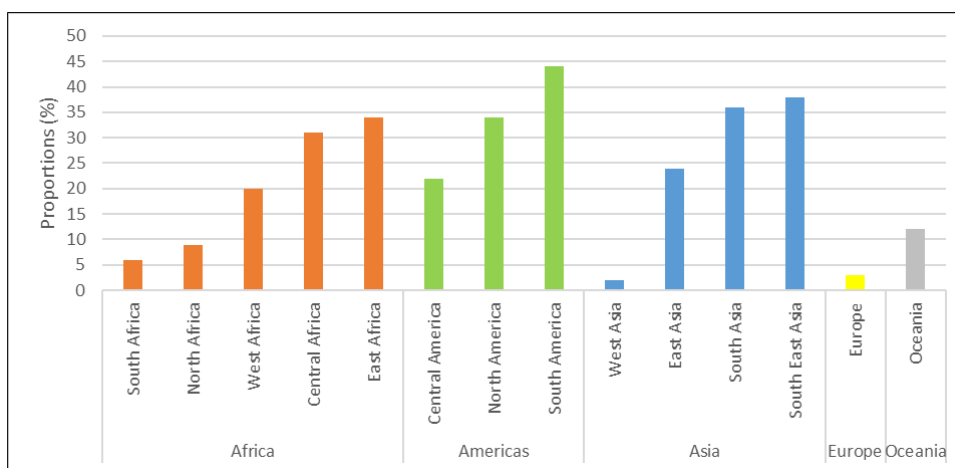


Figure 6 Histogram of the origins of plants introduced to Côte d'Ivoire by continent

3.5. History of plant introductions in Côte d'Ivoire

The introduction of plants to Côte d'Ivoire (Figure 7) began in 1896 with two species: *Jatropha gossypifolia* L. (Euphorbiaceae) and *Persea americana* Mill. (Lauraceae). The pace of introductions accelerated in 1950, with 14 species introduced, and peaked in 1958 when 61 species were introduced. However, there was a decline in plant introductions during the 1980s, with an average of only 3 species introduced annually. A resurgence in plant introductions occurred in 1995, with 24 species introduced, followed by a steady decrease from 1996 to 2024, with an average of just 2 species introduced each year.

Regarding the locations of plant introductions (Figure 8), introduced species can be found throughout Côte d'Ivoire. However, the majority of these plants were introduced in the district of Abidjan, particularly in the commune of Cocody and at the Centre National de Floristique (CNF). Other notable locations for plant introductions include Bondoukou, Bouaké, Man and Aboisso.

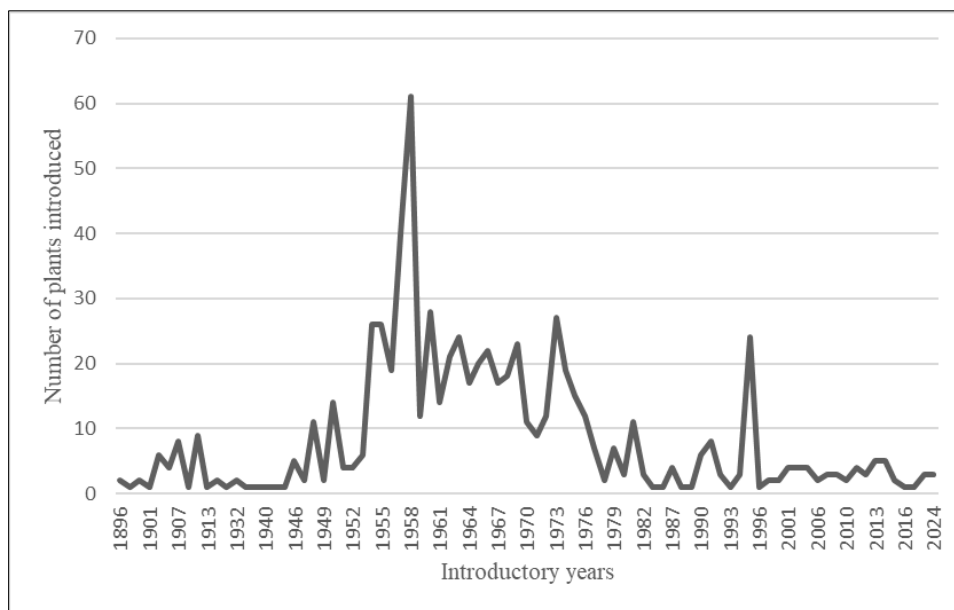


Figure 7 Timeline of plant introductions to Côte d'Ivoire by year

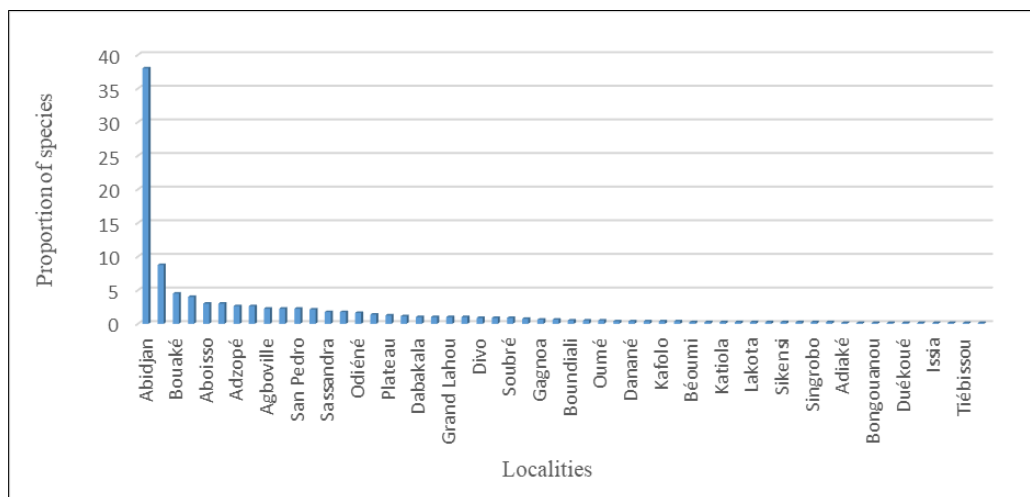


Figure 8 Histogram of plant introduction zones within Côte d'Ivoire

4. Discussion

4.1. Floristic diversity

This inventory and analysis of the exotic flora of Côte d'Ivoire reveals that it consists of 1,003 species, belonging to 609 genera and 154 families. This represents 26% of the country's native flora, which has been estimated at 3,882 species across 1,218 genera and 192 families [22]; [23]. This proportion is lower than that of the introduced species in the New Caledonian archipelago, which is estimated to range between 1,410 and 1,570 taxa [40]. However, it surpasses the introduced flora of Ghana and Algeria, which contain 291 and 211 species, respectively [6]; [8]. The dominant genera within the introduced flora include *Euphorbia*, *Solanum*, *Heliconia*, *Ipomoea*, *Gossypium*, and *Senna*. The most prevalent

botanical families are Fabaceae, Compositae, Poaceae, Malvaceae, Euphorbiaceae, Solanaceae, and Rubiaceae, mirroring the diversity seen in many Ivorian forests. In fact, this introduced flora has become an integral part of the Ivorian vegetation, as several Ivorian forests are now dominated by the same families [41]; [19]. When examining biological types, phanerophytes (77%) form the majority of the floristic composition of introduced plants in Côte d'Ivoire. The vast majority of these introduced species (96%) are terrestrial dicotyledonous angiosperms, with herbaceous plants (55%) outnumbering woody plants (45%). This prevalence of herbaceous species is likely due to their competitive advantage over woody plants. Herbaceous plants are highly productive, producing numerous seeds that enhance their competitive success [42]; [43]. Notably, 139 introduced plants have been identified as having conservation value in their native regions. Among these, 39 species are listed on the IUCN Red List [39], including one species extinct in the wild (EW), *Brugmansia suaveolens* (Humb. & Bonpl. ex Willd.) Bercht. & J.Presl (Solanaceae), 19 vulnerable species (VU), 13 endangered species (EN), and 6 critically endangered species (CR). Additionally, 114 species are endemic, primarily from countries such as Australia, Brazil, China, India, Madagascar, Mexico, and Papua New Guinea. The significant proportion (14%) of these species with conservation value clearly highlights that species introductions are often motivated by global biodiversity conservation efforts. However, several species listed on the IUCN Red List [39] have become invasive in their countries of introduction. For example, *Hopea odorata*, a vulnerable species introduced to Côte d'Ivoire in the 1970s for reforestation in Banco National Park, has since become invasive [44]; [45].

4.2. Origin of introduced plants

This study revealed that the introduced plants in Côte d'Ivoire primarily originated from two continents: the Americas and Asia. Among these, species from South America, North America, Southeast Asia, and South Asia were the most predominant. Our findings align with those of [6], who also observed that most exotic species in Ghana originated from the Americas and Asia. The large number of South American species introduced into Ivorian habitats can be attributed to the shared climate of the intertropical zone. According to [46], Africa and South America were once part of a single continent that split apart during the Mesozoic Era, leading to geological and pedological similarities as well as comparable climatic conditions due to their similar latitudinal positions. As a result of these shared characteristics, the plant landscapes of the Americas and Africa exhibit many common features, including the lush rainforests, the vast savannahs marked by seasonal fires in Sudano-Guinean Africa, and the expansive, open steppes of the Sahara deserts [47].

4.3. History of plant introductions in Côte d'Ivoire

This study indicates that plant introductions into Côte d'Ivoire began as early as 1896. As noted by [48], the first botanical collections in the country date back to 1882, coinciding with the arrival of the first settlers. The specimens housed in the NFC herbarium also date from the late 19th century. Plant introductions peaked in 1958, with 61 species introduced, likely reflecting the pre-independence period when many settlers arrived in the country. Upon their arrival, these settlers brought numerous plant species with them. According to [47], there were two major phases of American species introductions into Africa: one during the era of the transatlantic slave trade and another during the colonial period. The study also highlights a decline in plant introductions from 1996 to 2024, with an average of only two species introduced per year. This decline may be attributed to the fact that, by then, the herbarium had already accumulated nearly 60,000 specimens [49]; [50]. Today, however, the herbarium has significantly diminished, primarily due to reduced funding for collections, the deterioration of many specimens, and losses during events such as the 2011 post-electoral crisis when the herbarium was attacked by vandals. Additionally, some specimens were donated to other herbaria. As for the locations of plant introductions, introduced species can be found throughout Côte d'Ivoire. However, the majority were introduced in the Abidjan district, particularly in the commune of Cocody and at the National Floristic Center (NFC). The NFC, established on 11 July 1973 by government decree, is a research institution focused on the study of flora. It serves as an urban forest providing both in-situ and ex-situ conservation of Ivorian plant species. Several exotic plants have been introduced at the NFC for conservation purposes [49]. The centre currently houses 555 living plant specimens from various countries in the sub-region and around the world [51].

5. Conclusion

This study concludes that the Ivorian flora is rich in 1003 introduced species, distributed across 609 genera and 154 families. The dominant genera include *Euphorbia*, *Solanum*, *Heliconia*, *Ipomoea*, *Gossypium*, and *Senna*, while the most prevalent botanical families are Fabaceae, Compositae, Poaceae, Malvaceae, Euphorbiaceae, Solanaceae, and Rubiaceae. Introduced plants are predominantly nanophanerophytes (33%) and microphanerophytes (32%). The majority of these species originated from two continents, the Americas and Asia. Most introduced plants in Côte d'Ivoire are terrestrial dicotyledonous angiosperms, with herbaceous plants (55%) outnumbering woody plants (45%). A total of 139 introduced species of conservation value have been identified, including 39 species listed on the IUCN Red List [39]. These include one species that is extinct in the wild (EW), 19 species categorized as vulnerable (VU), 13 species as

endangered (EN), and 6 species as critically endangered (CR). One hundred and fourteen (114) species are endemic, primarily to countries such as Australia, Brazil, China, India, Madagascar, Mexico, and Papua New Guinea. This study reveals that plant introductions to Côte d'Ivoire began in 1896, with a peak in 1958, when 61 species were introduced. From 1996 to 2024, however, there was a decline in plant introductions, with an average of only 2 species introduced each year. Regarding the locations of introduction, introduced plants are found throughout Côte d'Ivoire, although the majority were introduced in the district of Abidjan, particularly in the commune of Cocody and at the National Floristic Center.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they do not have any conflict of interest.

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