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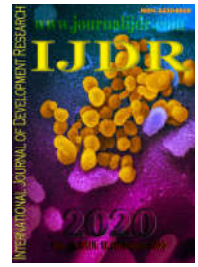
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RESEARCH ARTICLE

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## MELLIFEROUS PLANT DIVERSITY IN THE FOREST-SAVANNA TRANSITION ZONE IN CÔTE D'IVOIRE: CASE OF TOUMODI DEPARTMENT

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### ABSTRACT

The melliferous flora around three apiaries of 6 to 10 hives in the Department of Toumodi (Côte d'Ivoire) was studied with the help of floristic inventories in the plant formations of the study area. Observations were made within a radius of 1 km around each apiary in 3 villages of Toumodi Department (Akakro-Nzikpli, Bédressou and N'Guessankro). The melliferous flora is composed of 157 species in 127 genera and 42 families. The Fabaceae, with 38 species (24.20%) is the best represented. Lianas with 40 species (25.48%) and Microphanerophytes (52.23%) are the most predominant melliferous plants in the study area. They contain plants that flower during the rainy season (87 species, i.e. 55.41%), the dry season (51 species, i.e. 32.48%) and the dry and wet months (19 species, 12.10%). Nectariferous plants are the most represented (90 species, 57.32%), followed by nectaro-polliniferous species (47 species, 29.94%) and polliniferous species (20 species, 12.74%).

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### INTRODUCTION

The forest cover of the Ivory Coast, which in the 1900s was 16 million hectares, was reduced to 1.385 million hectares in 2000 (Koné et al., 2014). Further according to Smith et al. (1997) the reduction in plant cover relating to human activities, namely agriculture, hunting and vegetation fires, weakens the forest-savanna transition zone. In Côte d'Ivoire, the Toumodi region is located in the forest-savanna transition zone of the "V baoulé" which is made up of savannahs included in the forest, forming with the Togo-Benin savanna corridor one of the major accidents in the route of the forest-savannah contact in West Africa (Blanc-Pamard & Peltre, 1975). The V Baoulé region is a very sensitive area to fires according to Dahan (2019). Its results show that in Toumodi, on a total area of 80868.56 ha, in 19 years the average area burned is 12863.02 ha or 15.90%. The passage of fire, negatively impacts, among other things, the regeneration and growth of woody plants in this area (FAO, 2001) and the production of honey. Apiaries are often burned, which is synonymous with the loss of bees

responsible for pollinisation. However, for several decades, there have been hunters and collectors of natural beehive honey in Côte d'Ivoire. Faced with this degradation, it appeared necessary and urgent to develop improved beekeeping in a farming environment. In Toumodi, this was made possible by a project of a non-governmental organisation. Thus, more and more farmers are turning to traditional beekeeping, a fairly recent activity. However, the potential danger of melliferous plants is seen in areas where bush fires are used. Rudimentary materials for making hives, processing techniques, are some of the factors that explain the negative impact on the quantity and quality of honey production. In addition, the use of herbicides and pesticides is nowadays a real threat to bee colonies. Inappropriate honey harvesting methods are also factors that threaten the sustainability of the apiculture fauna. That is why this beekeeping development project in Toumodi has experienced difficulties and has ended in recent years in failure. The lack of information on the potential for honey production has partly

contributed to this failure. Beekeeping did not remain a real source of income for the farmers. In order to better control the factors influencing honey production, a scientific study of the honey flora is necessary. It is in this context that we have conducted this study oriented towards melliferous plants and towards the people who practise beekeeping, in forest-savanna transition zone of Toumodi.

## MATERIAL AND METHODS

**Presentation of the study area:** The study took place in the Department of Toumodi, Côte d'Ivoire. The study site concerns an apiary of 3 villages (Figure 1). The vegetation of the V baoulé area is made up as a whole of pre-forest savannah or Guinean savannah. The vegetation around the apiaries is composed of a discontinuous forest, highly anthropized with a shrubby savannah (Figure 2). This zone is a region of climatic transition which bathes between the sub-tropical climate and the humid tropical climate.

**Plant material:** It is represented by all the plants listed, having been the subject of this study as well as the related herbarium for plants not identified in the field.

**Technical equipment:** In the course of our botanical investigations, we used standard equipment that made it possible to gain access to the plants and to take samples for their setting in a herbarium. In this respect, a machete was necessary to open the tracks and draw lines. A SONY-type digital camera was used to take pictures. Technical sheets of botanical surveys were necessary during the ethnobotanical surveys. We also used a hand-held magnifying glass, for a meticulous observation of the plant organs, a pair of binoculars, to observe the tops of tall trees, a pruning shears, for collecting samples of specimens, a delimeter, for collecting samples of tall specimens that were difficult to access.

### Data collection

**Itinerant method:** For the collection of botanical data, we used the itinerant method (Aké-Assi E. and Ipou, 2006). It consisted in following, in the visited plant formations, the layons that we traced ourselves and sometimes the pre-existing tracks.

**Inventory and identification of plants:** Three apiaries of 6 to 10 hives were visited in 3 villages in the Department of Toumodi, Côte d'Ivoire. In the first village, Akakro-Nzikpli, the apiary is located at the edge of a wooded savannah. In the second village named Bédressou, the apiary is installed in an area of open forest. In N'Guessankro, the third village, the apiary is placed in a fallow area near a mixed plantation. All the apiaries have been colonised with natural swarms. Observations were made within a radius of 1 km around each apiary. According to Yedomonhan (2004), Dongock *et al* (2004), Tossou *et al* (2005), Yedomonhan and *et al.* (2009); and Coulibaly *et al.* (2019), this distance corresponds to the foraging area of the honey bee "*Apis mellifera adansonii*". The observations mainly concerned the flora surrounding these apiaries. It was the direct observation of foraging that made it possible to identify the plant species visited by bees. Observations were made with the naked eye for herbaceous and shrub species and with binoculars for trees. A melliferous plant is a plant visited by bees for its nectar, pollen or fruits.

**Nomenclature:** In this study, species nomenclature does not follow the classic nomenclature (Cronquist, 1981). We have adopted the phylogenetic classification, according to the work of < the most abundant in species. The percentage of Paleodicotyledons, Monocotyledons and Eudicotyledons among Angiosperms and the presence of species with special status (endemic, rare, threatened or vulnerable) were also provided.

**Description of the typology:** The information relating to the typology made it possible to learn about the distribution of morphological types, biological spectrum and phytochory. The morphological types were determined, based on criteria related to the size as well as the consistency of the individuals identified. Biological forms allow a better appreciation of their ecological conditions. The classification of plants into biological types was defined by Raunkiaer (1905). The information on typology provided on the distribution of morphological types, biological spectrum and phytochory. The morphological types were determined on the basis of criteria related to the size and consistency of the individuals surveyed. The biological forms allow a better appreciation of their ecological conditions. The classification of plants into biological types was defined by (Raunkiaer, 1905). The biological types were adapted to the forest conditions. In the tropical zone, the critical period is the dry season, according to Lebrun (1966). This classification takes into account the position of the vegetative points (buds) in relation to the ground level. The model of classification of biological types adopted is that of Aké-Assi (1984; 2001; 2002), itself adapted from the model of Raunkiaer (1905). Each species is assigned the biological type to which it belongs. Species belonging to the same biological type are grouped together.

**Flowering periods and type of nutrients collected:** Melliferous species that flower during the rainy season bear the positive sign (+), those that flower during the dry season bear the negative sign (-) and "x" indicates those that flower during both seasons. Polliniferous species are represented by the sign "\*", nectar-bearing species are marked by the sign "°", and nectaropolliniferous species are indicated by a dot (•).

## RESULTS

**Taxonomic groups listed:** The palynological investigations that we carried out in Toumodi in Côte d'Ivoire allowed us to identify 157 species of the melliferous flora. These species (table 1) belong to 127 genera and 42 families of the Plantae reign. The Fabaceae family, with 38 species (24.74%) is the best represented. There are 23 orders grouped in 3 clades: Paleodicotyledons (03 species), Monocotyledons (07 species) and Eudicotyledons (147 species), a subphylum (Tracheophytina) and a phylum (Embryophyta). The Dicotyledons (Paleodicotyledons and Eudicotyledons) numbering 150 plants represent 95.54% and constitute the majority of the plant species identified. Paleodicotyledons are all Magnoliidae. All Monocotyledons belong to the clade of the Commelinidae. Seven (07) species are directly related to the Eudicotyledons, which are subdivided into 2 clades: the Asteridae clade (44 species), with Campanulidae (04 species) and Lamiidae (40 species) and the Rosidae clade. Three (03) species are directly related to the Rosidae, which also includes

Table 1. Taxonomic groups and typology of the melliferous flora of Toumodi (Ivory Coast)

Plants species	Family	Orders	Clades	Clades	Clades	Morphology	Biology	Phytochory
<i>Abutilon mauritianum</i> <sup>x</sup>	Malvaceae	Malvales	Malvidae	Rosidae	Eudicotyledons	Grass	np	Mc GC-SZ
<i>Acacia pennata</i> - °	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Liana	mP	A GC
<i>Adansonia digitata</i> <sup>o</sup>	Malvaceae	Malvales	Malvidae	Rosidae	Eudicotyledons	Tree	mP	A SZ
<i>Adenia cissampeloides</i> <sup>+o</sup>	Passifloraceae	Malpighiales	Fabidae	Rosidae	Eudicotyledons	Liana	mp	A GC
<i>Adenia lobata</i> <sup>+o</sup>	Passifloraceae	Malpighiales	Fabidae	Rosidae	Eudicotyledons	Liana	mp	A GC
<i>Adenia rumicifolia</i> + °	Passifloraceae	Malpighiales	Fabidae	Rosidae	Eudicotyledons	Liana	mp	A GC-SZ
<i>Azelia africana</i> - °	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Tree	mP	A GC-SZ
<i>Ageratum conyzoides</i> <sup>+*</sup>	Asteraceae	Asterales	Campanulidae	Asteridae	Eudicotyledons	Grass	Th	panT GC-SZ
<i>Albizia adianthifolia</i> - °	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Tree	mP	A GC
<i>Albizia ferruginea</i> - °	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Liana	mP	A GC-SZ
<i>Plants species</i>	Family	Orders	Clades	Clades	Clades	Morphology	Biology	Phytochory
<i>Albizia lebeck</i> - °	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Tree	mp	panT GC-SZ
<i>Albizia zygia</i> <sup>+o</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Tree	mP	A GC-SZ
<i>Alchornea cordifolia</i> <sup>+*</sup>	Euphorbiaceae	Malpighiales	Fabidae	Rosidae	Eudicotyledons	Liana	mp	A GC-SZ
<i>Allophylus africanus</i> <sup>+o</sup>	Sapindaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Shurb	mp	A GC-SZ
<i>Alstonia boonei</i> <sup>+*</sup>	Apocynaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Tree	MP	A GC
<i>Anacardium occidentale</i> <sup>+*</sup>	Anacardiaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Shurb	mp	N GC-SZ
<i>Annona senegalensis</i> <sup>+*</sup>	Annonaceae	Magnoliales	Magnoliidae	Paléodicotylédones		Shub	np	A SZ
<i>Anthocleista djalonensis</i> - •	Loganiaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Shurb	mp	A GC-SZ
<i>Argemone maxicana</i> +*	Papaveraceae	Ranunculales	Directly attached to	Eudicotylédones		Suffrutex	Th	COAm GC-SZ
<i>Azadirachta indica</i> <sup>+o</sup>	Meliaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Tree	mp	A GC-SZ
<i>Basella alba</i> x°	Baselaceae	Caryophyllales	Directly attached to	Eudicotyledons		Liana	np	panT GC-SZ
<i>Bauhinia thonningii</i> - •	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Shurb	mp	A GC-SZ
<i>Bidens pilosa</i> <sup>+*</sup>	Asteraceae	Asterales	Campanulidae	Asteridae	Eudicotyledons	Grass	Th	panT GC-SZ
<i>Blighia sapida</i> - °	Sapindaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Tree	mP	panT GC-SZ
<i>Blighia welwitschii</i> - °	Sapindaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Tree	mP	A GC
<i>Bombax buonopozense</i> - °	Malvaceae	Malvales	Malvidae	Rosidae	Eudicotyledons	Tree	MP	A GC
<i>Borassus aethiopum</i> x•	Arecaceae	Arecales	Commelinidae	Monocotyledons		Tree	mP	A SZ
<i>Borreria scabra</i> <sup>+*</sup>	Rubiaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Grass	Th	A GC-SZ
<i>Borreria verticillata</i> <sup>+*</sup>	Rubiaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Grass	Th	A GC-SZ
<i>Caesalpinia bonduc</i> - °	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Liana	mp	panT GC
<i>Caesalpinia pulcherrima</i> x•	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Shurb	np	I GC-SZ
<i>Calotropis procera</i> - °	Apocynaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Shurb	mp	paléoT GC-SZ
<i>Calpogonum mucunoides</i> <sup>+o</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Liana	mp	AN GC
<i>Carapa procera</i> - °	Meliaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Tree	mp	AN GC-SZ
<i>Cardiospermum grandiflorum</i> <sup>+*</sup>	Sapindaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Liana	mp	AN GC
<i>Carica papaya</i> <sup>+o</sup>	Caricaceae	Brassicales	Malvidae	Rosidae	Eudicotyledons	Shurb	mp	I GC-SZ
<i>Cassia alata</i> <sup>+o</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Shurb	np	AN GC
<i>Cassia hirsuta</i> <sup>+o</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Shurb	np	ANGC-SZ
<i>Cassia mimosoides</i> <sup>+o</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Suffrutex	np	paléoT GC-SZ
<i>Cassia occidentalis</i> <sup>+o</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Shurb	np	panT GC-SZ
<i>Cassia siamea</i> <sup>+o</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Shurb	mp	As GC-SZ
<i>Cassia sophera</i> <sup>+o</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Shurb	np	panT GC
<i>Catharantus roseus</i> <sup>+o</sup>	Apocynaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Grass	np	panT GC
<i>Ceiba pentandra</i> - °	Malvaceae	Malvales	Malvidae	Rosidae	Eudicotyledons	Tree	MP	panT GC-SZ
<i>Centrosema pubescens</i> - °	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Liana	mp	AN GC
<i>Cissus petiolata</i> <sup>+*</sup>	Ampelidaceae	Vitales	Directly attached to	Rosidae	Eudicotyledons	Liana	mP	A GC-SZ
<i>Cissus populnea</i> <sup>+*</sup>	Ampelidaceae	Vitales	Directly attached to	Rosidae	Eudicotyledons	Liana	mP	A GC-SZ
<i>Citrus aurantifolia</i> <sup>+*</sup>	Rutaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Shurb	mp	As GC-SZ
<i>Citrus sinensis</i> <sup>+*</sup>	Rutaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Tree	mp	As GC-SZ

.....Continue

<i>Clerodendrum capitatum</i> <sup>+</sup>	Lamiaceae	Lamiales	Lamiidae	Asteridae	Eudicotyledons	Shurb	np	A GC-SZ
<i>Clerodendrum inerme</i> <sup>+</sup>	Lamiaceae	Lamiales	Lamiidae	Asteridae	Eudicotyledons	Liana	mp	I GC-SZ
<i>Coccinia barteri</i> <sup>+</sup>	Cucurbitaceae	Cucurbitales	Fabidae	Rosidae	Eudicotyledons	Liana	np	A GC
<i>Cochlospermum planchonii</i> <sup>→</sup>	Bixaceae	Malvales	Malvidae	Rosidae	Eudicotyledons	Shurb	np	A SZ
<i>Coffea canephora</i> <sup>+</sup>	Rubiaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Shurb	mp	A GC
<i>Cola gigantea</i> <sup>+</sup>	Malvaceae	Malvales	Malvidae	Rosidae	Eudicotyledons	Tree	mP	A GC-SZ
<i>Combretum paniculatum</i> <sup>-</sup>	Combretaceae	Myrtales	Malvidae	Rosidae	Eudicotyledons	Liana	mp	A GC-SZ
<i>Combretum racemosum</i> <sup>-</sup>	Combretaceae	Myrtales	Malvidae	Rosidae	Eudicotyledons	Liana	mP	A GC
<i>Commelina erecta</i> <sup>x*</sup>	Commelinaceae	Commelinales	Commelinidae	Monocotyledons		Grass	np	panT GC-SZ
<i>Crossopteryx febrifuga</i> <sup>-</sup>	Rubiaceae	Gentianales	Lamiidées	Asteridae	Eudicotyledons	Shurb	mp	A GC-SZ
<i>Crotalaria retusa</i> <sup>+</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Shurb	np	panT GC-SZ
<i>Cussonia arborea</i> <sup>+</sup>	Araliaceae	Apiales	Campanulidae	Asteridae	Eudicotyledons	Shurb	mp	A SZ
<i>Cyanothis lanata</i> <sup>-*</sup>	Commelinaceae	Commelinales	Commelinidae	Monocotylédones		Grass	Ch	A GC-SZ
<i>Dalbergia hostilis</i> <sup>+</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Liana	mp	A GC
<i>Datura metel</i> <sup>+</sup>	Solanaceae	Solanales	Lamiidae	Asteridae	Eudicotyledons	Grass	np	paléoT GC-SZ
<i>Delonix regia</i> <sup>-*</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Tree	mp	AM GC-SZ
<i>Dichrostachys glomerata</i> <sup>x*</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Shurb	mp	A GC-SZ
<i>Dovyalis zenkeri</i> <sup>+</sup>	Salicaceae	Malpighiales	Fabidae	Rosidae	Eudicotyledons	Grass	np	A GC
<i>Elaeis guineensis</i> <sup>x*</sup>	Arecaceae	Arecales	Commelinidae	Monocotyledons		Tree	mP	A GC
<i>Entada mammii</i> <sup>+</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Liana	mP	A GC-SZ
<i>Eriosema griseum</i> <sup>+</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Grass	H	A SZ
<i>Erythrina senegalensis</i> <sup>-*</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Shurb	mp	A GC-
<i>Gossypium barbadense</i> <sup>+</sup>	Malvaceae	Malvales	Malvidae	Rosidae	Eudicotyledons	Shurb	mp	I GC-S
<i>Grewia carpinifolia</i> <sup>x*</sup>	Urticaceae	Rosales	Fabidae	Rosidae	Eudicotyledons	Liana	mp	A GC
<i>Griffonia simplicifolia</i> <sup>x*</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Liana	mp	A GC
<i>Harrisonia abyssinica</i> <sup>-</sup>	Rutaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Shurb	mp	A GC-SZ
<i>Hibiscus rosa-sinensis</i> <sup>+</sup>	Malvaceae	Malvales	Malvidae	Rosidae	Eudicotyledons	Shurb	np	I GC-S
<i>Hibiscus rostellatus</i> <sup>+</sup>	Malvaceae	Malvales	Malvidae	Rosidae	Eudicotyledons	Liana	mp	A GC
<i>Holarrhena floribunda</i> <sup>+</sup>	Apocynaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Tree	mP	A GC-SZ
<i>Hoslundia opposita</i> <sup>+</sup>	Lamiaceae	Lamiales	Lamiidae	Asteridae	Eudicotyledons	Shurb	np	AM GC-SZ
<i>Hura crepitans</i> <sup>+</sup>	Euphorbiaceae	Malpighiales	Fabidae	Rosidae	Eudicotyledons	Tree	mP	I GC
<i>Hyptis suaveolens</i> <sup>+</sup>	Lamiaceae	Lamiales	Lamiidae	Asteridae	Eudicotyledons	Grass	np	panT GC-SZ
<i>Imperata cylindrica</i> <sup>+</sup>	Poaceae	Poales	Commelinidae	Monocotyledons		Grass	Cr	paléoT GC-SZ
<i>Ipomoea quamoklit</i> <sup>+</sup>	Convolvulaceae	Solanales	Lamiidae	Asteridae	Eudicotyledons	Liana	mp	I GC
<i>Jatropha gossypifolia</i> <sup>+</sup>	Euphorbiaceae	Malpighiales	Fabidae	Rosidae	Eudicotyledons	Shurb	np	I GC-SZ
<i>Keetia venosa</i> <sup>+</sup>	Rubiaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Liana	mp	A GC-SZ
<i>Landolphia dulcis</i> <sup>-</sup>	Apocynaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Liana	mp	A GC
<i>Landolphia heudelotii</i> <sup>-</sup>	Apocynaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Liana	mp	A GC
<i>Lannea acida</i> <sup>-</sup>	Anacardiaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Shurb	mp	A GC-SZ
<i>Lannea barteri</i> <sup>-</sup>	Anacardiaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Shurb	mp	A GC-SZ
<i>Lannea welwitschii</i> <sup>-</sup>	Anacardiaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Tree	MP	A GC-SZ
<i>Lantana camara</i> <sup>x°</sup>	Verbenaceae	Lamiales	Lamiidae	Asteridae	Eudicotyledons	Liana	mp	I GC-SZ
<i>Laportea aestuans</i> <sup>+</sup>	Urticaceae	Rosales	Fabidae	Rosidae	Eudicotyledons	Grass	Th	panT GC
<i>Lecaniodiscus cupanioides</i> <sup>-</sup>	Sapindaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Tree	mp	A GC
<i>Leea guineensis</i> <sup>x°</sup>	Vitaceae	Vitales	Directly attached to	Rosidae	Eudicotyledons	Shurb	mp	A GC-SZ
<i>Leucaena leucocephala</i> <sup>x*</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Shurb	mp	N GC-SZ
<i>Lonchocarpus cyanescens</i> <sup>+</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Liana	mP	A GC-SZ
<i>Lonchocarpus sericeus</i> <sup>+</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Shurb	mp	AN GC-SZ
<i>Luffa aegyptiaca</i> <sup>+</sup>	Cucurbitaceae	Cucurbitales	Fabidae	Rosidae	Eudicotyledons	Liana	mp	A GC-SZ
<i>Lycopersicon esculentum</i> <sup>x°</sup>	Solanaceae	Solanales	Lamiidae	Asteridae	Eudicotyledons	Grass	Th	I GC-SZ
<i>Mangifera indica</i> <sup>-</sup>	Anacardiaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Tree	mP	I GC-SZ
<i>Manihot esculenta</i> <sup>+</sup>	Euphorbiaceae	Malpighiales	Fabidae	Rosidae	Eudicotyledons	Shurb	mp	I GC-SZ
<i>Margaritaria discordea</i> <sup>+</sup>	Euphorbiaceae	Malpighiales	Fabidae	Rosidae	Eudicotyledons	Shurb	mp	I GC-SZ
<i>Mezoneuron benthamianum</i> <sup>+</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Liana	mp	A GC
<i>Millettia zechiana</i> <sup>x°</sup>	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Shurb	mp	A GC

.....Continue

<i>Mimosa pudica</i> —*	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Liana	np	panT GC
<i>Mitracarpus scaber</i> +•	Rubiaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Grass	Th	A GC-SZ
<i>Montandra guineensis</i> +°	Apocynaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Liana	mp	A GC-SZ
<i>Mucuna pruriens</i> +•	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Grass	Th	panT GC-SZ
<i>Nauclea latifolia</i> +•	Rubiaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Liana	mp	A GC-SZ
<i>Nelsonia canescens</i> +•	Acanthaceae	Lamiales	Lamiidae	Asteridae	Eudicotyledons	Grass	Ch	panT GC-SZ
<i>Newbouldia laevis</i> —°	Bignoniaceae	Lamiales	Lamiidae	Asteridae	Eudicotyledons	Shrub	mp	A GC
<i>Ocimum gratissimum</i> +•	Lamiaceae	Lamiales	Lamiidae	Asteridae	Eudicotyledons	Shrub	np	paléoT GC-SZ
<i>Olax subscorpioidea</i> —•	Olacaceae	Santalales		Eudicotyledons		Tree	mp	A GC-SZ
<i>Oldlandia corymbosa</i> +•	Rubiaceae	Gentianales	Lamiidae Directly attached to	Asteridae	Eudicotyledons	Grass	Ch	panT GC-SZ
<i>Parinari curatellifolia</i> —°	Chrysobalanaceae	Malpighiales	Fabidae	Rosidae	Eudicotyledons	Tree	mp	A SZ
<i>Parkia bicolor</i> —•	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Tree	MP	A GC
<i>Parkia biglobosa</i> —•	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Tree	mp	A SZ
<i>Passiflora eudulis</i> +•	Passifloraceae	Malpighiales	Fabidae	Rosidae	Eudicotyledons	Liana	mp	N GC
<i>Passiflora foetida</i> +°	Passifloraceae	Malpighiales	Fabidae	Rosidae	Eudicotyledons	Liana	mp	AN GC
<i>Paullinia pinnata</i> +•	Sapindaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Liana	mp	AN GC-SZ
<i>Pericopsis laxiflora</i> +°	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Shrub	mp	A SZ
<i>Persea americana</i> +•	Lauraceae	Laurales	Magnoliidae		Paleodicotyledons	Tree	mp	I GC-SZ
<i>Phoenix reclinata</i> —°	Arecaceae	Arecales	Commelinidae		Monocotyledons	Shrub	mp	A GC-SZ
<i>Portulaca grandiflora</i> +•	Portulacaceae	Caryophyllales	Directly attached to	Eudicotyledons	Grass	Ch	panT GC-SZ	
<i>Premna quadrifolia</i> +°	Lamiaceae	Lamiales	Lamiidae	Asteridae	Eudicotyledons	Grass	np	A GCi
<i>Pseudarthria hookeri</i> +°	Arecaceae	Arecales	Commelinidae		Monocotyledons	Shrub	np	A SZ
<i>Psidium guajava</i> —•	Myrthaceae	Myrtales	Malvidae	Rosidae	Eudicotyledons	Shrub	mp	N GC-SZ
<i>Psydrax horizontalis</i> +°	Rubiaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Liana	mp	A GC-SZ
<i>Psydrax subcordata</i> +°	Rubiaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Tree	mp	A GC
<i>Pterocarpus erinaceus</i> —°	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Tree	mp	A SZ
<i>Pterocarpus santalinoides</i> —°	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Tree	mp	AN GC-SZ
<i>Ricinus communis</i> +•	Euphorbiaceae	Malpighiales	Fabidae	Rosidae	Eudicotyledons	Shrub	mp	I GC
<i>Secamone afzelii</i> —°	Apocynaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Liana	mp	A GC
<i>Securinega virosa</i> +°	Phyllanthaceae	Malpighiales	Fabidae	Rosidae	Eudicotyledons	Shrub	np	paléot GC-SZ
<i>Sesamum radiatum</i> +•	Pedaliaceae	Lamiales	Lamiidae	Asteridae	Eudicotyledons	Grass	Th	panT GC
<i>Sida acuta</i> +•	Malvaceae	Malvales	Malvidae	Rosidae	Eudicotyledons	Grass	np	panT GC
<i>Sida alba</i> +•	Malvaceae	Malvales	Malvidae	Rosidae	Eudicotyledons	Grass	np	panT GC-SZ
<i>Solanum eryanthum</i> +•	Solanaceae	Solanales	Lamiidae	Asteridae	Eudicotyledons	Shrub	mp	panT GC
<i>Solanum torvum</i> +•	Solanaceae	Solanales	Lamiidae	Asteridae	Eudicotyledons	Shrub	np	panT GC
<i>Spathodea campanulata</i> +°	Bignoniaceae	Lamiales	Lamiidae	Asteridae	Eudicotyledons	Shrub	mP	A GC
<i>Spondias mombin</i> +°	Anacardiaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Tress	mP	panT GC
<i>Stachytarpheta indica</i> +°	Verbenaceae	Lamiales	Lamiidae	Asteridae	Eudicotyledons	Grass	np	panT GC
<i>Syzygium guineense</i> —•	Myrthaceae	Myrtales	Malvidae	Rosidae	Eudicotyledons	Shrub	mp	A GC-SZ
<i>Talinum triangulare</i> +°	Portulacaceae	Caryophyllales	Directly attached to	Eudicotyledons	Grass	np	AN GC	
<i>Tamarindus indica</i> —•	Fabaceae	Fabales	Fabidae	Rosidae	Eudicotyledons	Tree	mp	panT GC-SZ
<i>Tectona grandis</i> +•	Lamiaceae	Lamiales	Lamiidae	Asteridae	Eudicotyledons	Tree	mP	I GC-SZ
<i>Terminalia glaucescens</i> +°	Combretaceae	Myrtales	Malvidae	Rosidae	Eudicotyledons	Shrub	mp	A SZ
<i>Terminalia mantaly</i> +°	Combretaceae	Myrtales	Malvidae	Rosidae	Eudicotyledons	Tree	mp	Mad GC
<i>Tetracera alnifolia</i> —*	Dilleniaceae	No order	Directly attached to	Eudicotyledons	Liana	mp		A GC-SZ
<i>Thalia welwitschii</i> +°	Marantaceae	Zingiberales	Commelinidae		Monocotyledons	Grass	np	AN GC-SZ
<i>Thevetia peruviana</i> +°	Apocynaceae	Gentianales	Lamiidae	Asteridae	Eudicotyledons	Shrub	mp	N GC-SZ
<i>Urena lobata</i> —°	Malvaceae	Malvales	Malvidae	Rosidae	Eudicotyledons	Grass	np	panT GC-SZ
<i>Uvaria chamae</i> +°	Annonaceae	Magnoliales	Magnoliidae		Paleodicotyledons	Liana	mp	A GC-SZ
<i>Vernonia colorata</i> —°	Asteraceae	Asterales	Campanulidae	Asteridae	Eudicotyledons	Shrub	mp	A GC-SZ
<i>Vitex doniana</i> —°	Lamiaceae	Lamiales	Lamiidae	Asteridae	Eudicotyledons	Shrub	mp	ACo GC-SZ
<i>Ximenia americana</i> —•	Olacaceae	Santalales	Directly attached to	Eudicotyledons	Tree	mp	panT GC-SZ	
<i>Zanthoxylum zanthoxyloides</i> +•	Rutaceae	Sapindales	Malvidae	Rosidae	Eudicotyledons	Tree	mp	A GC-S

Flowering time: rainy season: (+), dry season (—), All year round: (x); Nutrient taken up by the bees: Nectar(°), Pollen(\*), Nectar and Pollen at the same time (•)

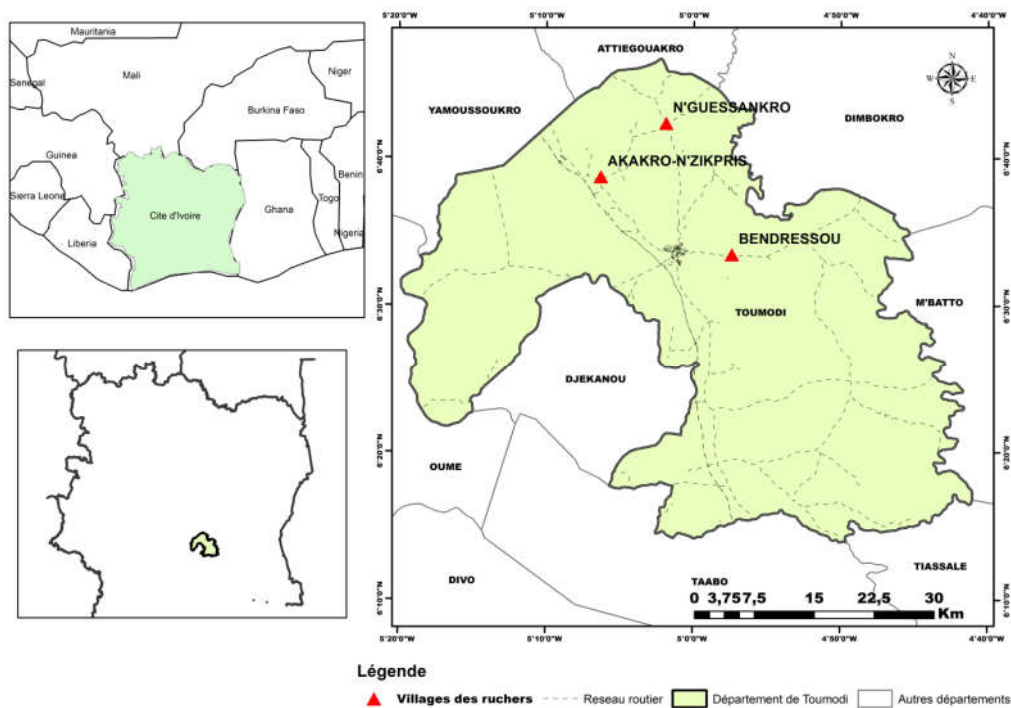


Figure 1. Map of the location of the study area in Ivory Coast

two clades, among which the Fabidae (56 species) and the Malvidae (37 species). Woody species from taxonomic groups such as Pteridophytes and Gymnosperms have not been recorded.

**Morphological types:** Considering the criteria related to the morphology of the species such as size and consistency, the melliferous flora of Toumodi is characterised by 06 Morphological Types (table): trees (37 species or 23.57%), shrubs (34 species or 21.66%), bushes (16 species or 10.19%), suffrutex (02 species or 1.27%), grasses (28 species or 17.83%) and lianas (40 species or 25.48%). The lianas are therefore mostly represented. Then come, in descending order: trees, shrubs, grasses, bushes and suffrutex.

**Biological types:** Toumodi's melliferous flora is characterised by a majority of Phanerophytes (142 or 90.44%) against a minority represented by the other biological types: Cryptophytes (01 or 0.63%), Hemicryptophytes (01 or 0.63%), Chamephytes (04 or 02.57%), Thérophytes (09 or 05.73%). Among the Phanerophytes, we note: Nanophanerophytes (33 or 21.02%), Microphanerophytes (82 or 52.23%) which are the most dominant, Mesophanerophytes (22 or 14.01%) and Megaphanerophytes (05 or 03.18%).

**Phytochory:** The taxa surveyed are mainly African (82) and represent 52.23% of the species surveyed. The others are pluricontinental (75 or 47.77%). The distribution of species, by phytogeographic type, enabled 3 groups of plants to be established. The taxa of the Guinean-Congolese zone are found in forest areas. Forty-eight (48) taxa recorded belong to this zone and represent 30.57%. The taxa of the Sudano-Zambésian zone are found naturally in the northern part of the country. We encountered twelve (12 or 7.65%). The taxa common to the Guineo-Congolese zone and the Sudano-Zambésian zone number 97, or 61.78%, and are mostly represented.

**Flowering period of honey plants:** Three groups of melliferous plants can be distinguished according to their flowering period.

The first concerns plants that flower during the rainy season. This group includes most of the inventoried melliferous species (87 species, or 55.42%); the second group includes melliferous species that flower during the dry season (51 species, or 32.48%) and the third group includes melliferous species that flower during both dry and wet months, this group being the least supplied in melliferous species (19 species, or 12.10%).

**Distribution of honey species according to the type of nutrient taken up by the bees:** Nectariferous plants are the most represented (90 species, or 57.32%), followed by nectaro-polliniferous species (47 species, or 29.94%) and the least numerous polliniferous species (20 species, or 12, 74%).

## DISCUSSION

The inventory of melliferous plants in a given area is essential for the knowledge of its melliferous potential. In Côte d'Ivoire, existing work on the inventory of melliferous plants is recent and limited in number (Coulibaly *et al.*, 2014; 2019; Kouassi *et al.*, 2019; Iritié *et al.*, 2014). The study identified 157 melliferous plants in the Toumodi region in the forest-savanna transition zone of V-Baoulé in Côte d'Ivoire. The number of species inventoried is almost identical to that of Iritié *et al.* (2014) in the agroforestry zone of the Yamoussoukro agricultural college (160 species), also located in the forest-savanna transition zone of Côte d'Ivoire. However, it is significantly higher than that recorded by Kouassi *et al.* (2019). They obtained 128 plant species to the east of the same area. In Cameroon, Dongock *et al.* (2004) and in Benin, Yedomonhan *et al.* (2009) capitalised respectively on 78 and 87 melliferous species on forest-savanna sites. These variations could result from differences in the floristic composition of ecosystems, the openness of vegetation relative to anthropic activities and environmental conditions (humidity, degree of insolation). Concerning the morphological types of the inventoried melliferous species, lianas (25.48%) constitute the majority of the melliferous species.



**Figure 2. Different Landscapes Around Study Sites:**  
**(a, b) Savannah; (d, f) pre-forest savannah; (c, e) Anthropogenic disturbance**

This result is different from those of most authors who note a predominance of trees and shrubs or herbaceous plants (Yédomonhan *et al.*, 2009; Lobreau-Callen and Damblon, 1994; Dongock *et al.*, 2004; Yédomonhan, 2004; Iritié *et al.*, 2014; Coulibaly *et al.*, 2019). The floristic differences between ecosystems reflect this inequality in composition. Furthermore, according to (Mc Telleria, 1993), the interzonal (spatial) diversity of honey plants is due to the preference of honey bees. This selection of melliferous species by bees is influenced by the floral morphology, phenology and floristic composition of the environment (Lobreau-Callen, 1994; Macumu *et al.*, 2015). Bees produce honey for consumption by their colony. The flowers give off various aromas depending on the species.

As the basic element of production is the nectar, its composition plays an important role in the quality of the honey. The nectar can be dissolved or highly concentrated depending on the plant species and the season. A bee will prefer to forage a flower containing a concentrated, good quality nectar than one whose nectar is too diluted. Their selection is therefore relative to the quality of the pollen and the concentration of nectar in the flowers. During periods when there is little flowering, for its survival the bee will work according to the availability of its raw material. In this study, phanerophytes (90.44%) predominate as noted by Vestalys H. & Andrianarivelo-Andriatoavina (2008). The latter reported a dominance of phanerophytes on the island of Idjwi in South Kivu in DR Congo.

This could be due to forest-savanna vegetation types and climate. With regard to the distribution of honey plants according to the nutrients taken up by the bees, nectariferous species are the most represented (57.32%) followed by nectaro-polliniferous species (29.94%) and polliniferous species (12.74%). The high proportion of nectariferous species observed in the study was also observed elsewhere in Côte d'Ivoire and other countries in Africa. Nombro (2003) in the provinces of Garango and Nazinga in Burkina, reported 61.46% and 62.89% nectariferous species among the inventoried melliferous species respectively, and (Coulibaly *et al.*, 2019) reported 76% nectariferous species in Dimbokro in central-eastern Côte d'Ivoire. This result is however different from that of Dongock *et al.* (2004) in Cameroon with a high percentage of polliniferous species inventoried (41%). Yédomonhan *et al.* (2009) inventoried 31% of nectariferous species in Benin and Iritié *et al.* (2014) identified 25% of nectariferous species among the inventoried honey species. This large number of nectariferous plants would be an important asset for the development of beekeeping in the region because in Madagascar according to Vestalys & Andrianarivelo (2008), the development of beekeeping is linked to the presence of vast expanses of plants producing nectar for bees.

The study revealed three groups of melliferous plants according to the flowering seasons, with melliferous plants that flower during the rainy season dominating (87 species, 55.42%), followed by melliferous plants that flower during the dry season (52 species, 32.48%) and melliferous plants that flower during both dry and wet months (19 species, 12.10%). This finding is in agreement with those made by Iritié *et al.* (2014) in the forest zone of the Yamoussoukro Higher School of Agronomy, who count a rate of 60.41% of melliferous plants that flower during the rainy season, and by Dongock *et al.* (2004) who also count more melliferous species that flower during the rainy season (69.2%) in the Sudano-Guinean high altitude zone of western Cameroon. This would be explained by the fact that most plants, whether endemic to arid or humid zones, need a certain quantity of water brought by the rains to normally ensure their various biological functions, notably that of flower formation which precedes sexual reproduction.

## Conclusion

Our palynological investigations, carried out at Toumodi, in the forest-savanna transition zone in V-Baoulé, Côte d'Ivoire, have led to the identification of 157 species grouped within 127 genera and 42 families found in 03 clades (Paleodicotyledons, Monocotyledons and Eudicotyledons), one subphylum (Tracheophytina) and one phylum (Embryophyta). Broadleaf weeds (96.15%) are predominantly represented. The morphological types are dominated by lianas (25.64%). This flora is characterised by a majority of Phanerophytes, with a preponderance of Microphanerophytes (52.23%). The taxa encountered, mostly African (52.23%), are commonly found in the Guinean-Congolese and Sudano-Zambésian zones. In addition, this inventory of melliferous plants in the Toumodi forest-savanna transition zone will allow researchers and decision-makers to set up projects for the domestication of plants with high melliferous potential for the production of quality honey, to preserve plant species and bee colonies in the face of the phenomenon of fires.

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