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Study of the *Mandrillus sphinx* (Cercopithecoidea) diet behaviour from the Lekedi Park (South-East, Gabon) as a valuable approach for drugs discovery

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ABSTRACT
The last decades, various research approaches have been undertaken worldwide for drug discoveries. Our study aimed to investigate medicinal plants of the Lékédi Park through a zoopharmacological and ethnopharmacological surveys on mandrills and on human population respectively from the Department of Lékoko.

Data on feeding behaviour were collected on 57 mandrills, from Lékédi Park, using a 5-min focal sampling method for 17 months. The ethnopharmacological uses were carried out on the human population using semi-structured questionnaires and scientific databases. Data were evaluated statistically by using the index of Use value (UV) and informant consensus factor (Fic).

The results showed that studied mandrills used about 147 plant species belonging to 48 botanical families. The Rubiaceae and Euphorbiaceae families were the most representative in the mandrill diet. Among plant organs eaten, some organs of plants such as bark or roots rich in non-nutritional compounds were occasionally used by mandrills, suggesting the involvement of a self-medication behavior in mandrill. Also, it appears that the plant selection would be mainly due to the availability, protein and sugar contents. Ethnopharmacological surveys show that among the 147 consumed by mandrills, 33% were used for medicinal purposes only, 41% as food and 11% were used as food and as medicine. The informant consensus factor values indicate that the medicinal plants are effective in treating certain diseases.

Thus, the study of mandrill diets behaviour would be a potential approach for the drugs discovery against bacterial and parasitic affections.
Keywords: Mandrill diet, Zoopharmacognosy, Drug discovery, Infectious diseases.

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1. INTRODUCTION

The discovery of new effective drugs, nowadays, represents a challenge to fight against the emergence and re-emergence of many diseases and the resistance of pathogens.

Since, infectious diseases emergence and re-emergence are a major concern for medical, veterinary, and conservation-related disciplines [1, 2].

Indeed, in human populations, diseases such as malaria threaten approximately 40% of the world population with an estimate death of over 800000 per year [3]. In the same way, others pathologies as HIV⁄AIDS, tuberculosis, Lassa fever, Lyme disease, and cholera would represent a cause of the morbidity and the mortality in millions of people every year [4]. In addition, many neglected diseases such as ascariasis, amoebiasis and filariasis would continue to cause extensive damages to human health in Africa [5].

In order to bring out efficient therapeutic molecules in the drug market, several approaches are undertaken for the drug discovery: the chemical synthesis of bioactive molecules, the production of drugs from natural products including plants resources.

About that way, during the last decades, researchers have used different approaches in bioactive compounds research including the bio-prospection, ethnobotanical or ethnopharmacological investigations and closer, the zoopharmacological studies which involve the interactions between the wildlife and flora.

Since, the self-medication in the animal kingdom was well evidenced [6-10]. Indeed, studies on animal behavior have demonstrated that several vegetal species are ingested for health needs [11-14]. In the same way, various plants are used in the realization of nests by certain species of birds. For example, *Hieraaetus fasciatus* would select the fragrant branches of *Pinus pinaster* [15-17] or for rub on their fur [18-20].

Recent studies showed that different species of wild primates such as chimpanzees (Pan troglodytes schweinfurthii, *Pan troglodytes troglodytes*, Pan troglodytes verus and more lately Pan troglodytes vellerosus), bonobos (Pan paniscus), and gorillas (*Gorilla gorilla gorilla*) occasionally use various bioactive organs of plants for prophylactic or for therapeutic purposes mainly for gastro-intestinal [21-24].

Thus, it appears that the zoopharmacognosy may constitute a very promising strategy for the human health care due to the phylogenetic proximity of humans and non-human primates (NHP). In order to study medicinal plants of Lékédi Park and to evaluate their therapeutic potential, in a public health concern, zoopharmacological and ethnopharmacological investigations were, respectively, carried out on mandrills from the la Lékédi Park and the human population from Lékoko Department.

2. Material and methods

2.1. Study area

This study realized on human and non-human primates, was conducted in the Lékédi Park located 7 km northeast of the village of Bakoumba (1°47.595 S and 12°59.226 E) and in the Lékoko Department in the province of Haut-Ogooué, Southern part of Gabon. The Department of Lékoko is divided into two districts, Miagassa (North) and Lébombi (South). The vegetation is mainly made of savannas and an alternation of rainforest-savannah [25].

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The Lékédi is a private park, which is made of 14000 hectares of forests and divided into three fenced modules (650 ha, 1750 ha and 11600 ha, respectively). It is composed of a mosaic of savannas, grassland, and evergreen forests. Forested blocks are mainly composed of primary and secondary Marantaceae forests with patches of humid open savannas. The study area covers about 1400 ha (modules 1 and 2). It is the area of the park usually frequented by the mandrill population of survey. The module 1 is dominated by savannas, grasslands, and block of forests, which are mainly composed of secondary Marantaceae forests. The module 2 on the other hand is largely dominated by blocks of primary forests. Gabonese habitats are characterized by four different seasons: a long rainy season (February-May; during the study period: mean±SD temperatures: 23.8°C±3.2°C; total amount of rainfalls: 1256.8mm), a long dry season (June-September; 22.1°C±2.6°C; 142.2mm), a short rainy season (October-November; 23.3°C±3.0°C; 535.2mm) and a short dry season (December-January; 23.4°C±2.9°C; 312mm).

Figure 1. The localization of the study area (Lékoko Department) in Haut-Ogooué province (Gabon).

2.2. Zoopharmacological data collection

2.2.1. Animal survey

The study population of mandrills is the only habituated population of ~130 free-ranging individuals living in the Lékédi Park and its vicinity. The population originated from 65 captive individuals initially housed at the CIRMF (Centre International de Recherche Médicale de Franceville, Gabon) and released in the park on two occasions (2002 and 2006; see details [26]). Daily monitoring combined with genetic analyses of the population indicates that 85% of the mandrills studied are wild-born individuals [27].

When released, mandrills can forage freely in the park and its vicinity but their diet is also supplemented with bananas and cakes about five times a week for the first few years after their release.

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However, to boost their foraging behavior, supplements of food were gradually reduced over time so that they could provide for themselves in the long run [27]. During the study period (May 2013-October 2014), the supplementation was stopped except during the capture. The group was composed of 100-120 individuals of which almost all adult individuals and all sub-adult males (6-9 years old) are individually known.

2.2.2. Data collection

Data on feeding behavior were collected on 57 individuals. We considered three classes of age. Juveniles were animals aged 1.5 years (the youngest animal in the data set) to 4 years (N=17, 12 males and 5 females). Because of a strong sexual dimorphism in this species, the pace of sexual maturity is different between sexes.We therefore considered as adolescent, females aged 4-5 years (N=3) and males aged 4-9 years (N=4). Finally, adult females were those older than 5 years (N=27) and males older than 9 years (N=5).

The study was done over a period of 17 months (May 2013-October 2014) using a 5-min focal sampling methods [28]. During focal periods, we recorded all food items (including mainly vegetal items) consumed by focal individuals and, whenever possible, the number of bites performed on each consumed food item. During the entire study period, we collected 6350 focal observations representing approximately 529 hours of data collection.

Personal observation allowed recording the different types of plants consumed by one individual. The plant samples were pressed in the field and prepared for identification. A first identification was achieved by using relevant standard literature including various region tropical floras [29-34]. Final identification of plant specimens were realized from the herbaria National Herbarium of Institute of Traditional Medicine and Pharmacopoeia (IPHAMETRA) in Libreville, Gabon. These herbaceous samples were deposited in the herbarium of the Biology Department at the University of Sciences and Technique of Masuku.

2.3. Ethnopharmacological survey

2.3.1. Population survey and data collection

The local population was composed mainly of three ethnic groups (Awandji, Tsengui, and Nzébi). These three ethnic groups are originally from the North-East part of the Popular Republic of Congo in the Sangha region [35]. The Department has 12 villages and the total population is 3412 people (see: www.GeoHive - Gabon extended population statistics.htm). The majority of the population is Christian but other traditional beliefs such as Dzobi, Moughala, and Ngoyi also prevail. The different customs countered in the locality are Moanda, Chéyi, Makanda, Bavoda and Ipena [35].

Ethnobotanical information on plants consumed by the *Mandrillus sphinx* was collected close to 229 adult informants (98 males and 131 females) living in different villages of the Department from February to March 2015. Random interviews with groups 46 of 5 individuals were conducted. Semi-structured questionnaires were used for to collect the needed information. The questionnaire focused on the different uses of plants consumed by the mandrills, local name of the plants, foods or drugs, and the organs of the plant used. If is the plant was utilized for medicinal purposes, other information such as the pathology, preparation, methods of administration were required. Fresh plant specimens collected from the Hill were shown to

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different informants to get relevant ethnobotanical information. Interviews were carried out during busy hours and in public places such as field, yard, drawing-room, etc.

2.3.2. Data collection from reviews

Literature reviews on the types of plants consumed by mandrills and used in traditional medicine by local population (Table 3) were conducted. It was primarily done through the collection of abstracts and articles from: Medline (www.pubmed.gov), http://bibliovie.inist.fr, BioInfoBank (http://lib.bioinfo.pl), Elsevier (www.sciencedirect.com). We also went through books [33, 36], journals, abstracts, articles, patents, and bibliographies from Google (www.google.com).

2.4. Data analysis

Ethnopharmacological data were entered in to Excel spreadsheet and summarized using descriptive statistics [37]. The Spearman rank correlation test was realized using Instat3 software to determine whether frequency of consumption of vegetables was a significant correlation with the availability of plant species in area was used.

The use value is a quantitative method [38]. That demonstrates the relative importance of species known locally. This use value was also calculated according to the following formula:

$$UV=U/n$$

UV refers to the use value of a species; U to the number of citations of use per species; and n to the total number of informants.

On the other hand, informant consensus factor (Fic) was employed to deduce the homogeneity of the information about a specific plant used as foods or to treat a particular category ofailments.

A high value (close to 1) indicates that the taxa (usually species) are relatively, used by a large proportion of the informants indicating a more consistent use of the medical resources. While a low value indicates that informants disagree on the taxa to be used in treatment within a category of illness. This informant consensus factor (Fic) was calculated as in the following formula [39]:

$$Fic = \frac{(nur - nt)}{(nur - 1)}$$

Where n_{ur}: number of use reports per each category and n_t: number of taxa used.

3. RESULTS

3.1. Investigation on plants species consumed by mandrillus

Our study has shown that a total of 147 plants species belonging to 48 families distributed in 106 genera were eaten by 52 mandrills living in the Lékédi Park (Table 1). Based on the number of plants species consumed, the family of plants mostly consumed were Rubiaceae (9.52 %), Euphorbiaceae (8.84 %) followed by Apocynaceae (6.12 %), zingiberaceae (5.44 %). The families least consumed were Piperaceae, Pandaceae, Nymphaeaceae, Smilaceae, and Aspleniaceae with one plant species each one.

However, based on the mandrillus plant-intake (figure 2), the most consumed of plants species during the study period were *Xylopia aethiopica* (Annonaceae) with 13.62 % followed by *Croton sylvaticus* (Euphorbiaceae) with 3.93 %, *Psychotria gilletii* (Rubiaceae) with 3.85 %, *Pentaclethra macrophylla* (Mimosaceae) with 2.47 % and *Megaphrynium macrostachum* (Marantaceae) with 2.12 %. The least consumed plants were *Plagiostyles africana*

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(Euphorbiaceae) with 1.89%, *Nymphaea maculata* (Nymphaeaceae) with 1.44 % followed by *Landolphia glabra* (Apocynaceae), *Parinari excelsa* (Chrysobalanaceae), *Agelaea rubiginosa* (Connaraceae), *Aframomum alboviolaceum* (Zingiberaceae) with less than 1 %.

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Table1: Plants list consumed by the mandrill's population in Lékédi Park with different class (age and sex)

Family	Scientific name and [voucher specimen no.]	Parties	Ri (%)	Intake	F (%)	Sex	Age
Anacardiaceae	*Antrocaryon klaineanum* Pierre [Breteler 8352]	Fruits	99.3	0189	0.48	All	All
	Lannea welwitschii (Hiern) Engl. [Bourobou 508 A]	Fruits	97.3	0082	0.21	All	All
	Manguifera indica L. [Bourobou 513]	Fruits	97.3	0213	0.54	All	All
	Pseudospondias longifolia (Engl.) Keay [Bourobou 229]	Fruits/ Seeds	100	0083	0.21	All	All
Annonaceae	*Neostenanthera myristicifolia* (Oliv.) Exell [Dorr 4283]	Fruits	98.0	0041	0.10	All	All
	Uvaria klaineana Engl. & Diels [Azizet Issembé 267]	Fruits	60.0	0093	0.24	Fe	Ad
	Uvaria scrabida Oliv [Bos 10671]	Seeds	58.0	5381	13.62	All	All
	Xylopia aethiopica(Dunal) A.Rich [Azizet Issembé 226]	Seeds	52.0	0118	0.30	All	All
	Xylopia staudtii Engl. & Diels [Bois SRFG 823]	Seeds	57.3	0009	0.02	Fe	Ad
Apocynaceae	*Landolphia breviloba* J.G.M.Pers. [Breteler 6953]	Fruits	86.7	0340	0.86	All	All
	Landolphia dewevrei Stapf [Breteler 8718]	Fruits	84.0	0010	0.03	All	All
	Landolphia glabra (Pierre ex Stapf) Pichon [Breteler 8030]	Fruits	94.7	0390	0.99	All	All
	Landolphia hirsuta (Hua) Pichon [Arends 587]	Fruits/ Leaves	92.0	0036	0.09	All	All
	Landolphia incerta (K.Schum.) J.G.M. Pers. [Arends 319]	Fruits	98.0	0375	0.95	All	All
	Landolphia mannii Dyer [Breteler 10731]	Fruits	100	0824	2.09	All	All
	Landolphia owariensis P. Beauv. [Bourobou 404]	Fruits	90.0	0040	0.10	All	All
	Landolphia sp. P.Beauv. [van Bergen 102]	Stems	85.3	0012	0.03	All	Ad/ Juv
	Rauvolfia vomitoria Afzel. [Bernard SRFG 1628]	Stems/ Fruits	87.3	0193	0.49	All	All
Aracaceae	*Elaeis guineensis* Jacq. [Simons 376]	Fruits	94.0	0203	0.51	All	All
	Laccosperma laeve (G.Mann & H.Wendl.) Wendl. [LJT White 1434]	Fruits/ Stems	46.7	1005	2.54	All	All
	Laccosperma secundiflorum (P.Beauv.) Kuntze [Le Testu 1658]	Fruits	84.7	0531	1.34	All	All
	Raphia vinifera P.Beauv. [van Valkenburg 2511]	Fruits	97.3	0011	0.03	All	All
	Sclerosperma mannii H.Wendl. [van Valkenburg 2682]	Fruits	96.0	0016	0.04	Ma	Juvenile

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Aspleniaceae	*Asplenium africanum* Desv. [Sosef 1119]	Leaves	100	0014	0.04	Ma	Ado
Balanophoraceae	*Thonningia sanguinea* Vahl. [Bos 10642]	Fruits	33.3	0081	0.21	All	Ad/ Juv
Burseraceae	*Aucoumea klaineana* Pierre [Alers 137]	Seeds/ Resins	98.0	0040	0.10	All	All
Caesalpiniaceae	*Dacryodes edulis* (G.Don) H.J.Lam. [Bourobou 652]	Fruits/ Seeds	72.0	0964	2.44	All	All
Chrysobalanaceae	*Hylodendron gabunense* Taub. [Bernard SRFG 291]	Seeds	94.0	0323	0.82	All	All
	Parinari excelsa Sabine [Breteler 14765]	Fruits/ Leaves/ Flowers and Stems	46.0	0175	0.44	All	All
Commelinaceae	*Palisota ambigua* (P.Beauv.) C.B.Clarke [Dibata 100]	Leaves/ Stems	57.3	0031	0.08	All	All
	Palisota hirsuta (Thumb.) K.Schum. [Wilks 830]	Fruits/ Leaves	36.7	0060	0.15	All	All
Connaraceae	*Agelaea pentagyna* (Lam.) Baill. [Bourobou 361]	Fruits/ Roots	52.0	0284	0.72	All	All
	Agelaea rubiginosa Gilg [Wieringa 4133]	Roots	75.3	0564	1.43	All	All
	Cnestis corniculata Lam. [Bourobou 234]	Leaves/ Fruits	71.3	0308	0.78	All	All
	Cnestis ferruginea Vahl ex DC. [Bourobou 402]	Fruits/ Leaves	46.0	0028	0.07	All	Ad/ Juv
	Cnestis sp. Sol. Ex Planch. [A.M. Louis 3309]	Roots	100	0045	0.013	Fe	Ad
Cucurbitaceae	*Cogniauxia podolaena* Baill. [Walters 1248]	Fruits	100	0079	0.20	Fe	Ad
Cyatheaceae	*Cyathea cameroonian*a Hook. [Bourobou 371]	Morrows	100	0068	0.16	All	All
Cyperaceae	*Rhynchospora corymbosa* (L.) Britt. [Wilks 2630]	Stems/ Fruits	54.7	0217	0.55	All	All
	Scleria boivinii Steud. [van der Maesen 5625]	Leaves	66.0	0057	0.14	All	All
Dichapetalaceae	*Dichapetalum cf umbellatum* Chodat [Breteler 15261]	Fruits	40.7	0935	2.37	All	All
Dilleniaceae	*Tetracera alnifolia* Willd. [Bourobou 277]	Fruits	59.3	0416	1.05	All	All
Euphorbiaceae	*Alchornea floribunda* Müll.Arg [Azizet Issembé 311]	Fruits/ Leaves/ Stems	98.7	0106	0.26	All	All
	Bridelia ferruginea Benth. [Bourobou 252]	Fruits	98.7	0534	1.35	All	All
	Croton mayumbensis J.Léonard [van valkenburg 2668]	Fruits	94.7	1554	3.93	All	All
	Croton sylvaticus Hochst. ex Krauss [Breteler 14856]	Fruits	78.7	0236	0.61	All	All
	Macaranga schweinfurthii Pax [Breteler 14984]	Fruits/ Petioles	94.7	0038	0.09	All	All
	Macaranga spinosa Müll.Arg. [Doumenge 148]	Fruits	69.3	0840	2.13	All	All
	Maesobotrya klaineana (Pierre) J.Léonard [Jongkind 5723]	Fruits	95.3	0191	0.48	All	All
	Maesobotrya staudtii (Pax) Hutch. [van der Maesen 5768]	Fruits	95.3	0108	0.27	All	All
	Manniophyton fulvum Müll.Arg. [A.M. Louis 3185]	Leaves/ Stems	99.3	0106	0.27	All	Ad/ Juv

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	Plagiostyles africana (Müll.Arg.) Prain [Azizet Issembé 223]	Fruits/ stems bark	72.7	0747	1.89	All	All
	Ricinodendron heudelotii (Baill.) Heckel [A.M. Louis 2056]	Seeds	94	0102	026	All	All
	Uapaca guineensis Müll.Arg. [Alers 84]	Fruits	44.1	1096	2.78	All	All
	Uapaca mole Pax [Nguema Ekomo 565]	Fruits	44.0	0009	0.02	Fe	Ad
Flacourtiaceae	*Oncoba welwitschii* Oliv. [Wieringa 341]	Pulp	84.7	0028	0.07	All	Ad/ Juv
Gramineae	*Hyparrhenia diplandra* (Hack.) Stapf [Alers 72]	Leaves	95.3	0204	0.01	All	All
	Jardinea gabonensis [Alers 68]	Leaves	99.3	0084	0.21	All	All
	Olyra latifolia L. [Bourobou 230]	Leaves	90.0	0122	0.31	All	All
	Paspalum scrobiculatum L. [Alers 112]	Seeds	98.0	0299	0.76	All	All
	Setaria megaphylla (Steud.) Dur. & Schinz [Sosef 1293]	Leaves	100	0042	0.11	Fe	Ad
	Setaria sp. [Sosef 1301]	Leaves	99.3	0008	0.02	Fe	Ad
	Urelytrum fasciculatum [Sosef 549]	Fruits	98.7	0029	0.07	All	All
Sapotaceae	*Chrysophyllum africanum* A.DC. [Bourobou 451]	Fruits	99.3	0968	2.45	All	All
	Chrysophyllum lacourtianum De Wild. [Wilks 1105]	Fruits	99.3	0207	0.52	All	All
Irvingiaceae	*Irvingia grandifolia* (Engl.) Engl. [Breteler 15429]	Fruits	98.7	0438	1.11	All	All
	Klainedoxa gabonensis Pierre [Breteler 14381]	Fruits	99.3	0111	0.28	All	All
Lauraceae	*Persea americana* Mill.	Pulp/ Seeds	100	0060	0.15	All	Ad/ Juv
Lecythidaceae	*Petersianthus macrocarpus* (Beauv.) Liben [Breteler 14803]	Seeds/ Flowers	96.0	0079	0.20	All	All
Leguminosae-Caesalpinoideae	*Berlinia bracteosa* Benth. [Azizet Issembé 433]	Seeds/ Flowers	99.3	0009	0.02	All	All
	Berlinia confusa Hoyle [van Bergen 172]	Seeds	84.0	0005	0.13	All	All
	Dialium corbisieri Staner [Ngok Banak 1092]	Leaves	62.7	0428	1.08	All	All
	Dialium dinklagei Harms [Breteler 11066]	Leaves	88.0	0052	0.13	All	All
	Dialium tessmannii Harms [Bois SRFG 848]	Leaves	94.7	0018	0.05	All	Ado/ Ad
Leguminosae-Mimosoideae	*Distemonanthus benthamianus* Baill. [Bernard SRFG 320]	Stems/ Leaves	99.3	0554	1.04	All	All
	Parkia bicolor A.Chev. [Bourobou 369]	Seeds	100	0234	0.59	All	All
	Parkia filicoidea Welw. ex Oliv. [van der Maesen 5445]	Seeds	100	0001	0.002	Ma	Ado
	Tetrapleura tetraptera (Schumach. & Thonn.) Taub. [Bourobou 479]	Seeds	100	0002	0.01	Fe	Ad
	Angylocalyx sp. Taub. [Azizet Issembé 246]	Stems bark	82.0	0027	0.07	All	Ad/ Juv

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	Dalhousiea africana S.Moore [Breteler 14903]	Roots	99.3	0099	0.25	All	All
	Eriosema glomerata (Guill. & Pierr.) Hook.f.[Bourobou 254]	Fruits	95.3	0062	0.16	All	Ad/ Juv
Marantaceae	*Halopegia azurea* (K.Schum.) K.Schum. [Ley 24]	Morrows	62.0	0218	0.55	All	All
	Haumania danckelmaniana (J.Braun & K.Schum.) [Simons 60]	Seeds/ Stems/ Roots	68.7	0575	1.46	All	All
	Haumania liebrechtsiana (De Wild. & T.Durand) [Ley 101]	Seeds/ Stems	78.7	0004	0.01	All	All
	Megaphrynium macrostachum (Benth.) Milne-Redh. [Bourobou 603]	Fruits/ Stems/ Flowers/ Leaves	52	0837	2.12	All	All
	Sarcophrynium brachystachyum (Benth.) K.Schum. [Wieringa 787]	Fruits/ Marrows	72.0	0098	0.25	All	All
	Trachyphrynium braunianum (K.Schum.) K.Schum. [Breteler 15759]	Stems/ Seeds	62.7	0195	0.49	All	All
Melastomataceae	*Dichaetanthera africana* (Hook.f.) Jacq.-Fél. [Breteler 14727]	Leaves	96.7	0102	0.26	All	All
	Dissotis multiflora (Sm.) Triana [Bourobou 354]	Leaves	74.7	0105	0.27	All	All
	Medinilla mirabilis (Gilg) Jacq.-Fél. [A.M. Louis 3189]	Fruits	96.7	0066	0.17	All	Ad/ Juv
	Ochthocharis dicellandroides (Gilg) C.Hansen & Wicken [Wilks 2250]	Leaves	90.0	0028	0.07	All	All
	Tristemma mauritianum J.F.Gmel. [Tabak 185]	Leaves/ Fruits	86.7	0002	0.01	Fe	Ad
Meliaceae	*Carapa procera* DC. [Durand SRFG 1615]	Seeds	93.3	0065	0.16	All	Ad/ Juv
Mimosaceae	*Albizia gummifera* J.F.Gmel.) C.A.Sm. [van der Maesen 5852]	Roots	47.3	0131	0.33	All	All
	Pentaclethra eetveldeana De Wild. & T.Durand [A.M. Louis 1587]	Seeds/ Gums	69.3	0975	2.47	All	All
	Pentaclethra macrophylla Benth. [Bourobou 595]	Seeds	64.7	0025	0.06	All	All
	Piptadeniastrum africanum (Hook.f.) Brenan [Azizet Issembé 230]	Leaves	80.0	0067	0.17	All	All
Moraceae	*Pseudoprosopis gilletii* (De Wild.) Villiers [Breteler 14835]	Young leaves	98.7	0263	0.67	All	All
	Ficus mucuso Ficalho [Breteler 15338]	Fruits	98.7	0526	1.33	All	All
	Musanga cecropioides R.Br. ex Tedlie [Breteler 14944]	Fruits/ Leaves/ Flowers	92.7	0141	0.36	All	All
	Myrianthus arboreus P.Beauv. [Jongkind 5792]	Fruits/ Leaves	100	0020	0.06	All	All

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Musaceae	*Musa paradisiaca* Cv.	Fruits	84.0	0389	0.23	All	All
Myristicaceae	*Pycnanthus angolensis* (Welw.) Warb. [Bois SRFG 827]	Fruits	99.3	0018	0.05	All	All
	Scyphocephalium ochocoa (Warb. [SRFG 1770]	Fruits	99.3	0570	1.44	All	All
Nymphaeaceae	*Nymphaea maculata* Schumach. & Thonn. [Simons 450]	Stems/ Leaves	80.7	0004	0.01	Fe	Ad
Ohnaceae	*Ochna afzelii* R.Br. ex Oliv. [Sosef 647]	Fruits	99.3	0015	0.04	Fe	Ad
Orchidaceae	*Stanhopea hernandezii* (Kunth) Schltr. [Nguema Miyono 1320]	Stems/ Leaves	41.3	0116	0.29	All	All
Pandaceae	*Microdesmis haumaniana* J.Léonard [A.M. Louis 1550]	Fruits	98.0	0401	1.02	All	All
Papillonaceae	*Colopogonium mucunoides* Desv [Wieringa 1268]	Flowers/ Fruits	31.5	0002	0.01	Ma	Ad
	Popowia sp. Endl. [Azizet Issembé 278]	Roots	69.3	0060	0.15	All	All
Passifloraceae	*Barteria fistulosa* Mast. [Breteler 14663]	Fruits/ Leaves	100	0130	0.33	All	All
Pentadiplandraceae	*Pentadiplandra brazzeana* Baill. [A.M. Louis 1962]	Fruits	80.7	0035	0.09	Fe	Ad
Piperaceae	*Piper guineensis* Schumach. & Thonn. [Jongkind 5833]	Fruits/ Leaves	84.0	0234	0.59	All	All
Rubiaceae	*Craterispermum cerinanthum* Hiern [Ngok Banak 267]	Leaves/ Fruits	53.3	0911	2.31	All	All
	Geophila afzelii Hiern [Mboma 23]	Fruits	59.3	0554	1.40	All	All
	Lasianthus batangensis K.Schum. [Bourobou 543]	Fruits/ Leaves	90.7	0029	0.07	All	Ado/ Ad
	Lasianthus sp. Jack [Ngok Banak 1734]	Fruits	52.0	0071	0.18	All	Ad/ Juv
	Morinda morindoides (Baker) Milne-Redh. [Bourobou 237]	Fruits	95.3	0024	0.06	All	Ad/ Juv
	Mussaenda debeauxii Wernham [Doumenge 194]	Fruits	98.0	0089	0.23	Fe	Ad
	Mussaenda soyauxii Büttner [Simons 12]	Fruits	100	0006	0.02	All	All
	Nauclea latifolia Smith. [Sosef 1806]	Fruits	77.3	0010	0.003	Ma	Ad
	Pausinystalia johimbe (K.Schum.) Pierre ex Dup. & Beille [Azizet Issembé 255]	Young leaves	92.7	0722	1.83	All	All
	Pseudosabicea milbraedii (Wernham) N.Hallé [Azizet Issembé 259]	Fruits	76.0	1519	3.85	All	All
	Psychotria gilletii De Wild. [Breteler 14556]	Fruits/ Flowers	90.7	0389	0.98	All	All
	Psychotria stenostegia [Azizet Issembé 220]	Leaves/ Stems/ Fruits	98.7	0277	0.70	All	All
	Spermacoce latifolia Aubl. [Sosef 1290]	Leaves	58.7	0453	1.15	All	All
	Tricalysia cf. breteleri Robbr. [A.M. Louis 9420]	Fruits/ Young leaves	99.3	0242	0.61	All	All

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Sapindaceae	*Ganophyllum giganteum* (A.Chev.) Hauman [Duran SRFG 1442]	Fruits	66.0	0345	0.87	All	All
Selaginellaceae	*Selaginella myosurus* (Sw.) Alst. [Wieringa 4361]	Leaves	43.3	0955	2.42	All	All
Smilaceae	*Smilax anceps* Wild. [Doumenge 150]	Fruits/ Flowers/ Young leaves/ Stems	100	0009	0.02	All	Ad/ Juv
Sterculiaceae	*Leptonychia echinocarpa* K.Schum. [Azizet Issembé 281]	Fruits	85.3	0140	0.35	All	All
Violaceae	*Rinorea cerasifolia* M.Brandt [Ngok Banak 1827]	Fruits	90.7	0035	0.09	All	All
Zingiberaceae	*Aframomum alboviolaceum* (Ridl.) K.Schum. [D.W. Thomas 6508]	Fruits	71.3	0573	1.45	All	All
	Aframomum cf. polyanthum (K.Schum.) K.Schum. [Wieringa 3665]	Fruits/ Flowers	90	0052	0.13	All	All
	Aframomum daniellii (Hook.f.) K.Schum [N. Hallé 3891]	Marrows/ Fruits/ Flowers/ Stems	97	0078	0.20	All	All
	Aframomum sp. K.Schum. [Nguema Miyono 1296]	Fruits	96.7	0016	0.04	Fe	Ad
	Costus afer Ker Gawl. [Ngok Banak 1383]	Morrows/ Flowers	97	0025	0.06	All	All
	Costus sp. L. [A.M. Louis 2016]	Morrows	84	1000	2.53	All	All
	Renealmia cincinnata (K.Schum.) Baker [Sosef 1216]	Fruits	100	0058	0.1	Ma	Ad
	Renealmia macrocolea K.Schum. [Sosef 968]	Fruits	90.7	0009	0.02	Ma	Ado/ Juv
	Indet1	Fruits	99.3	0009	0.02	Fe	Ad
	Indet2	Seeds	96.7	0025	0.06	All	Ad/ Juv
	Indet3	Fruits	100.0	0014	0.03	Fe	Ad
	Indet4	Fruits	92.7	0001	0.003	Fe	Ad
	Indet5	Fruits	100	0.010	0.02	Fe	Ad
	Indet6	Fruits	100	0002	0.007	All	Ado/ Ad
	Indet7	Leaves	99.3	0003	0.07	Ma	Juv
	Indet 10	Leaves	96.4	0056	0.01	All	All

Ado: Adolescent individual, **Juv:** Juvenile individual, **All:** all class or all sex, **Fe:** Female, **Ma:** Male; **Ad:** Adult individual

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Regarding the organs of plants consumed (Figure 2a) and used in traditional medicine, fruits were the most consumed by mandrills (42 %), followed by stem (24 %), seeds (16 %), leaves (12 %), the least consumed were roots (3.36 %), followed by flowers (1.64 %), bark (0.25 %), gum and resin (0.75 %).

However, leaves (38%) on the other hand are mostly used for medicinal purposes, followed by barks (36%), stems (12%), fruits (7 %), roots (5%), gum and resin (2%) (Figure 2b).

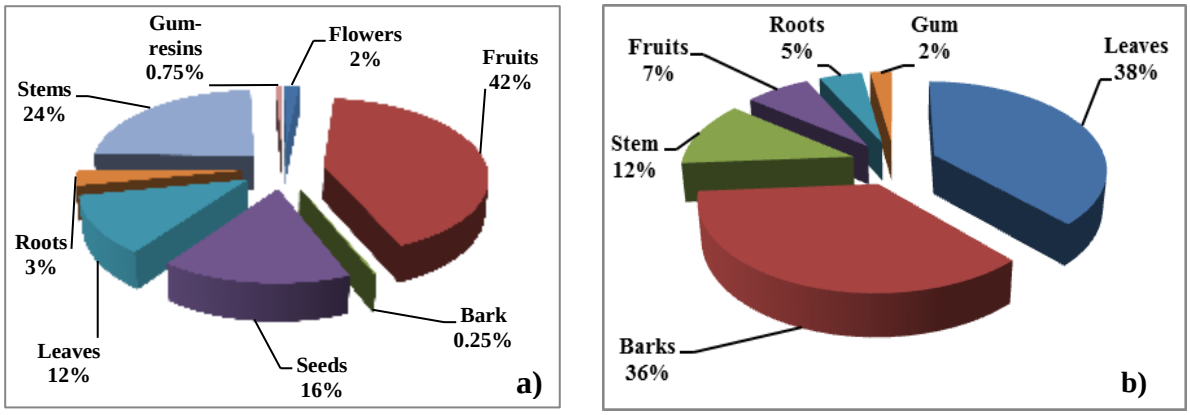

Figure 2: Contribution of plant parts in the mandrill diet (**a**) and in traditional medicine (**b**)

The figure 3 presents the correlation (r = - 0.339) between the frequency consumption of plant species and their availability (R_i). The result shows that the mandrills spend more time consuming vegetable species which were abundant ($0 < R_i < 80$) in their area and that the selection of plant species by the mandrills would be made according to their availability in area.

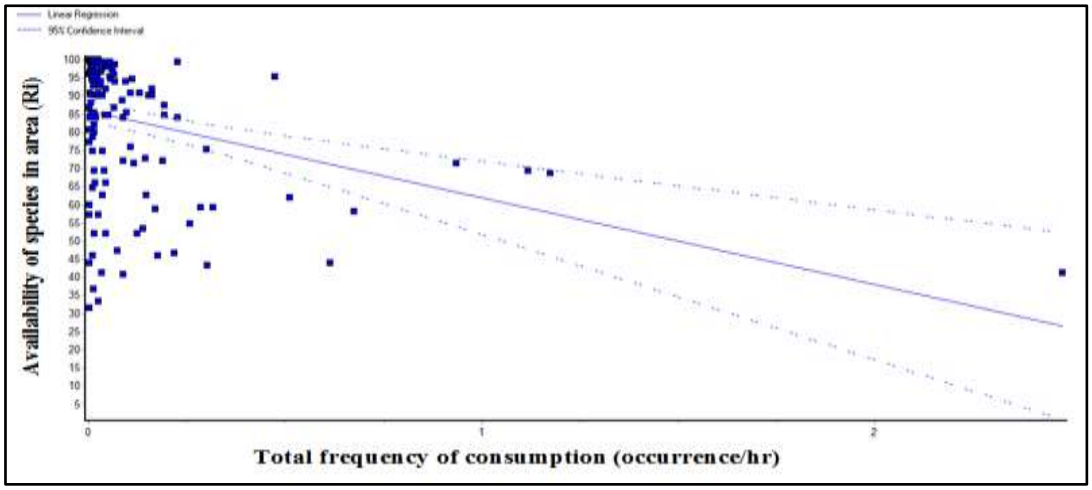

Figure 3: The correlation (r = -0.339) between consumption plants and their availability

The table 2 presents various plant species consumed according to the sex of the studied mandrill's population. The results show that among all plants species used by studied mandrills during study period, 11.56 % vegetal species were consumed by female individuals only and 2.72 % by male individuals.

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Table 2: Various plant species consumed according sex of studied mandrill's population

Individual class	Plant species
Females only	*Neostenanthera myristicifolia, Pausinystalia johimbe, Piptadeniastrum africanum Carapa procera, Urelytrum fasciculatum, Costus sp, Ochna afzelii, Uvaria scrabida, Setaria sp, Mussaenda soyauxii, Stanhopea hernandezii, Macaranga schweinfurthii, Piper guineensis, Angylocalyx sp, Cogniauxia podolaena, Cyathea camerooniana, Setaria megaphylla.*
Males only	*Popowia sp, Trachyphrynium braunianum, Bridelia ferruginea, Maesobotrya staudtii*

3.2 Ethnopharmacological investigation on plants species consumed by the mandrillus

The Table 2 shows ethnopharmacological data on plants consumed by the mandrillus from both the field. Among the 147 plants species, 86 plants species belonging to 31 families and 83 genera were well known by the population of the Lékoko Department. The most abundant botanical family used were Euphorbiaceae and Rubiaceae (8.61 %) followed by Leguminosae (5.96 %), Apocynaceae (5.29 %) and Zingiberaceae (4.64 %). The least consumed family were Marantaceae (3.97 %), Arecaceae (3.31 %), Moraceae and Commelinaceae (1.98 %), Irvingiaceae, Burseraceae, and Cyperaceae (1.32 %) followed by the Smilaceae, Meliaceae, Aspleniaceae, Pandaceae, Lauraceae with 1%.

3.3. Relative importance of medicinal plants consumed by the mandrills.

According to the use values (Table 2), the highest use value reported in this study was 1 and the lowest value was 0.01. The most commonly used vegetable species were food plants (UV=1). On the other hand, the most commonly used medicinal plants were *Thonningia sanguine*a (UV=0.99), *Scleria boivinii* (UV = 0.99), *Dichaetanthera africana*(UV= 0.98), *Haumania liebrechtsiana* (UV= 0.98), *Haumania danckelmaniana* (UV= 0.95), *Parinari excels*a (UV= 0.95), *Costus afer* (UV= 0.93), *Nauclea latifolia* (UV= 0.92), *Geophila afzelii* (UV= 0.86) and *Palisota ambigua* (UV= 0.76) which indicates their extensive use in local medicine.

The literature reviews data (Table 2) shows that some of their species have pharmacological properties. It was the case of *Alchornea floribunda* (antiprotozoal, antibacterial and antifungal activities), *Manniophyton fulvum* (antiprotozoal activities), *Thonningia sanguinea* (antibacterial activity against Extended-Spectrum-β-Lactamases strains), *Distemonanthus benthamianus* (antibacterial activity) and of *Musanga cecropioides* (antiprotozoal and antidiarrheal activities) were used by the mandrill population.

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Table 3: Phytochemical and ethnopharmacological of plants consumed by the mandrills and their traditional utilizations by native populations.

Species	Local names	Traditional use	Phytochemical and pharmacology	UV
Aframomum alboviolaceum	Toudoutsèrè	Food: fruits are eaten raw.	Vitamin, calcium and Tr. Antimicrobial and anti-tumor activities [40-42].	**1**
Aframomum cf stipulatum	Toudoumaboutou	Food: fruits are eaten raw.		**1**
Aframomum daniellii	Toudoumissoutou	Food: fruits are eaten raw.	Alk, Fla and Poly. Antifungal, anthelmintic, antioxydantes and antibacterial activities [43-45].	**1**
Albizia gummifera	Tsèlè	Wood of heating.	Alk, Sap, Fla, and St/Tr. Antimicrobial, antiplasmodial, anti- trypanosomal and antitumor properties [46-50].	**0.34**
Alchornea floribunda	Melonlogo'o	Food: leaves are consumed. Medicinal: leaves decoction is utilized in treatment of fever.	St/Tr, Fla, Tan and Sap. Antiprotozoal, cytotoxic, antibacterial and antifungal activities [51-53].	**0.50**
Antrocaryon klaineanum	Megongtsèrè	Food: Fresh fruits are consumed.	Alk, Tan, Sap St and Re-S. Antiplasmodial properties [54-57].	**1**
Asplenium africanum	Leninmi	Medicinal: leaves are used for bath of children	Alk, Tan, Co, Poly and Gly. Radical scavenging properties [58].	**0.01**
Aucoumea klaineana	Ngoumi	Medicinal: powder of bark is consumed for treatment of diarrhea.	Antimicrobial activity [59].	**0.54**
Barteria fistulosa	Megomena	Medicinal: bark is utilized as protection.	Gly, Alk, Fla, Tan and Tr [60, 61].	**0.23**
Berlinia bracteosa	Mouposse	Medicinal: gum applied for treatment of abscess.		**0.01**
Bridelia ferruginea	Dzandatsèrè	Medicinal: bark decoction treat the cough.	Poly, St/ Tr, Fla, Alk, Tan, Re-S and Quinone. Anti-inflammatory, antimicrobial and antioxidant properties [62, 63].	**0.34**
Carapa procera	Moudindindji	Food: seeds are consumed raw.		**0.40**
Chrysophyllum lacourtianum	Moubamba	Food: fresh fruits are consumed raw.	Antimicrobial activity [64].	**1**
Chrysophyllum africanum	Moubamba	Food: fresh fruits are consumed raw		**1**
Cnestis ferruginea	Unknown	Medicinal: leaves are applied on the snake bite.	Anth, Tan, Alk, Fla and Sap. Anti-stress, analgesic, antibacterial, anti-inflammatory and antioxidant proprieties [65-67].	**0.01**
Costus afer	Mouwoussou	Medicinal: fresh stem is eaten for treatment of cough.	Tan, Sap, Fla, St/Tr, Gly and Alk. Radical scavenging [68-70].	**0.89**

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Costus sp	Mouwoussou	Medicinal: fresh stem is eaten raw for treatment of cough.		**0.93**
Craterispermum cerinanthum	Itchouyi	Wood of heating. Medicinal: decoction leaf treats the fever.		**0.37**
Croton mayumbensis	Moubamba foukou	Medicinal: bark and fruit decoction treat tooth decay.	Tan, Fla, St/Tr, alk and Sap. Anti-malarial activity [71].	
Croton sylvaticus	Lebimbi	Medicinal: fresh bark is eaten in Ndjobi (Gabonese rite).		**0.54**
Dacryodes edulis	Moutsèra	Food: Fruits boil are eaten. Medicinal: powder fresh bark is used against the diarrhea.	Poly, Fla, Sap, Alk, Tan and Gly [72-74].	**1**
Dialium corbisieri	Mebodi	Food: Fresh fruits are eaten.		**0.88**
Dichaetanthera africana	Moutsèngueni	Food: fresh leaves are eaten. Medicinal: leaves decoctions treat the cough.	Tan, Sap, Poly, Fla, Co, Alk, St/Tr and Re-S. Radical scavenging properties [75].	**0.98**
Distemonanthus benthamianus	Mouvenguè	Medicinal: bark is used for bath of children.	Poly, Fla, Pro, Alk, Sap and St/Tr. Antioxidant and antibacterial properties [76-78].	**0.06**
Elaeis guineensis	Lebèdi	Food: fruits and stem are consumed cooked.	Tan, Sap, Anth, Poly, Alk, and Gly. Antimicrobial activities [79-80].	**1**
Ficus mucuso	Iwouyi	Wood of heating.	Poly and Fla. Antioxidant properties. [40-42]	**0.16**
Geophila afzelii	Mabate	Food: fruits are consumed cooked Medicinal: decoction leaves are consumed raw for treatment of stomach and painful rules.		**0.86**
Halopegia azure	Makaya madroubi	Food: leaves are used for packing's of foods.		**0.73**
Haumania danckelmaniana	Moussèssètè	Medicinal: sap is used as eye lotion.		**0.95**
Haumania liebrechtsiana	Moukapa	Medicinal: sap is used as eye lotion and as alcohol.		**0.98**
Trachyphrynium braunianum	Moukapa	Medicinal: sap is used as eye lotion and as alcohol.		**0.24**
Hylodendron gabunense	Pèdè	Wood of heating.		**0.06**
Klainedoxa gabonensis	Mougnagna	Food: seeds are eaten cooked.	Quinones, Tan and Alk. Antibacterial and anti-	**0.88**

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			tumor properties [81].	
Laccosperma leave	Leboulou	Food: stem is eaten cooked.		**0.34**
Laccosperma secundiflorum	Mokanda	Food: stem is eaten cooked.		**1**
Landolphia incerta	Mouke malimba	Food: fruits are eaten fresh.		**1**
Landolphia mannii	Mouke malimba	Food: fruits are eaten fresh.		**0.41**
Landolphia owariensis	Mouke malimba	Food: fruits are eaten fresh.	Tan, Poly, Fla, Alk, Sap and Gly [82-83].	**1**
Macaranga schweinfurthii	Moupoupourhou	Leaves are used for to transport of manioc.		**0.56**
		Wood of heating.		**0.12**
Macaranga spinosa	Moutsètsèdè	Medicinal: Fresh bark is consumed against the diarrhea.		
Maesobotrya klaineana	Bekomassèssè	Food: stem is eaten cooked.		**0.09**
Manguifera indica	Mangue	Food: fruits are eaten fresh and decoction of leaves treat the fever.	Alk, St/ Tr, Poly, Fla, Anth, Tan, and Quinones. Anti-malarial, anti-amoebic and antimicrobial properties [84, 87].	**1**
Manniophyton fulvum	Ngnamatsarre	Food: Leaves are used as condiment for cooking of manioc leaves.	Alk, Fla, Sap, St/ Tr, Tan and Re-S. Antiprotozoal and cytotoxic activities [88, 89].	**0.90**
Medinilla mirabilis	Bekobekongadzèli	Food: leaves are eaten cooked.		**0.07**
Megaphrynium macrostachyum	Makaya	Food: leaves are used for packing's of foods.	Alk, St/ Tr, Poly, Fla, Pro, Sa and Re-S. Antifungal and radical scavenging activities [90, 91].	**1**
Microdesmis haumaniana	Koutou	Medicinal: Fresh roots are eaten for the treatment of sexual weakness.		**1**
Morinda morindoides	Ibouéla	Medicinal: Powder of fruit treats scabies.	Sa, Tan, Anth, St/ Tr, Pro and Gly. Antifungal activities [60].	**0.04**
Musa paradisiaca		Food: fruits are eaten	Fla, Catecholamine, and Gly. Antimicrobial and anti-diabetes, activities [92-95].	**1**
Musanga cecropioides	Moussènguè	Medicinal: root sap is consumed for treatment of cough and bark decoction treat tooth decay.	Sa, Tan, Anth, St/Tr, Pro and Gly. Antiprotozoal, antihypertensive, anti-diabetes anti-diarrhea and cytotoxic activities [96-98].	**0.56**
Myrianthus arboreus	Mouboba	Food: Seeds are eaten fresh.	Alk, Tan, Fla, St/ Tr and Sap. Antibacterial activities [99-101].	**1**
Nauclea latifolia	Lebouboudji	Medicinal: decoction of bark or root is used for	Antiplasmodial, anthelmintic, antimicrobial, anti-	**0.92**

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		treatment of fever.	pyretic activities [102-106].	
Nymphaea maculate	Itoumou chamamba	Food: dried leaves are used as salt.		**1**
Olyra latifolia	Viètè	Stem is used for consumed wine of palm tree.		**0.44**
Oncoba welwitschii	Irramba	Fruits are used as bait of fish. The bark is utilized as insecticide to collect of honey.		**0.14**
Palisota ambigua	Lebomboude	Medicinal: decoction of leaves is used for treatment rheumatism and stem is used for to make walk children.		**0.76**
Palisota hirsuta	Lebomboude	Medicinal: decoction of leaves is used for treatment rheumatism.	Antimicrobial and antiviral properties [107].	**0.55**
*Parinari excels*a	Mouguèk	Medicinal: powder of bark treat the constipation of children.	Fla and myricetin. Antidiabetic and hypoglycemic properties [108].	**0.95**
Parkia bicolor	Dindè	Fruits are used as bait of fish.	Tan, Alk, Gly and St. Antibacterial activity [109].	**0.39**
Parkia filicoidea	Tchèlè	Medicinal: decoction of bark is consumed in treatment of sexual weakness.	Co and St/Tr. Analgesic, anti-inflammatory and anti-hypertensive properties [110, 111].	**0.07**
Paspalum scrobiculatum	Tsèrè	Medicinal: fresh leaves applied on the body for treat of dermatitis.		**0.24**
Pentaclethra eetveldeana	Moussame	Medicinal: Bark put in fire is applied externally to the body for treat the rheumatism.		**0.12**
Pentaclethra macrophylla	Moubala	Food: Seeds are consumed cooked. Medicinal: bark put in fire is applied externally to the body for treat the rheumatism.	Poly, Tan, Sap, Alk, Anth and Gly. Antimicrobial activities [112-114].	**0.81**
Persea Americana	Ivoka	Food: fresh fruits are consumed. Medicinal: Leaves decoction treat hypertension.	Poly, Fla, carotenoids, and vitamin (E, C). Antimicrobial, analgesic anti-inflammatory, hypotensive, antioxidant, anti-viral and hypoglycemic properties [115-119].	**1**
Piper guineensis	Drougou à kète	Food: Fruit and leaves cooked are consumed. Medicinal: stem maceration treat sexual weakness.	Antiprotozoal and cytotoxic activities [120, 121].	**1**
Piptadeniastrum africanum	Mechinga	Medicinal: Bark put in fire is applied externally to	Alk, Fla, Gly, Sap, St/ T and, Tan. Abortive,	**0.81**

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		the body for treat the rheumatism and kidney ill.	antitumor, antimicrobial and anti-parasitic activities [53, 122].	
Plagiostyles africana	Lemvoulou	Medicinal: fresh leaves are used as cicatrizing of wound.	Co, Fla and St/ tr. Antibacterial and antifungal properties [102].	**0.07**
Pseudospondias longifolia	Mbokili	Food: Food: fruits are eaten fresh.	Alk, Fla, Tan, Re-S and Sap [56-58].	**0.52**
Psychotria gilletii	Itchouyi	Wood of heating.		**0.25**
Pycnanthus angolensis	Lelomba	Fruits are used as bait of fish.	Anthelmintic properties [106].	**0.18**
Raphia vinifera	Lépika	Food: Stem is used for produce to wine palm tree.		**1**
Renealmia macrocolea	Dzobo'o mikoui	Medicinal: Fresh leaves are applied on the body for treatment odor corporal.		**0.01**
Ricinodendron heudelotii	Mouguèmbè	Wood is used for fabrication of musical instruments.	Dinorditerpenoids, E-ferulic Acid lupeol and Octacosylate. Antimicrobial activity [115-118].	**0.09**
Sarcophrynium brachystachyum	Makaya maldzoubou	Food: leaves are used for packing's of foods.		**0.82**
Scleria boivinii	Kièmè	Medicinal: Leaves and root decoction treat sexual weakness and cough.		**0.99**
Sclerosperma mannii	Mangua	Leaves are used for the construction of hut.		**0.36**
Scyphocephalium ochocoa	Moutsoukou	Food: Seeds cooked are consumed. Medicinal: Bark decoction is used for treatment of cough.		**0.29**
Selaginella myosurus	Melanguela	Medicinal: leaves decoction is consumed for treatment of gonorrhea and sexual weakness.		**0.72**
Setaria megaphylla	Tsèèrè	Medicinal: leaves decoction treats the constipation.	Tan, Fla, Sap, Anth, Re-S and St/Tr. Anti-diabetes and antimalarial activities [120].	**0.31**
Smilax anceps	Mouguila	Food: Stem and leaves cooked are consumed. Medicinal: fresh leaves are eaten treat abundance menses.	Tan, St/Tr, Anth, Sap, Re-S, Gly, Fla and Alk. Antibacterial and antifungal activity [121-125].	**1**
Tetracera alnifolia	Moughaguela	Food: fresh water stem is consumed.	Tan, Alk, Fla, Sap, and St/Tr [78].	**1**
*Thonningia sanguine*a	Go'obe	Medicinal: powder dried fruit is used for treatment scabies.	Antimicrobial activity [59].	**0.99**

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Tristemma mauritianum	Bekobemassèssè	Food: fresh fruits are eaten and leaves cooked are eaten.		**0.10**
Uapaca guineensis	Mousèmbi	Food: Fresh fruits are eaten. Medicinal: bark decoction treat fever	Alk, Fla, Co and St/Tr. Analgesic, antiulcer and anti-inflammatory properties [54, 97, 104].	**1**
Uapaca mole	Mousèmbi	Food: Fresh fruit are eaten.		
Xylopia aethiopica	Mouyaguela foukou	Bark is used for construction of house.	Alk, Tan, Sap and St/Tr [97, 104].	**0.58**
Xylopia staudtii	Mouyaguela bènguè	Wood of heating.		**0.29**

Poly: Polyphenols, **Sap:** Saponins, **Tan:** Tannins, **St/Tr:** Sterols and Triterpenes, **Alk:** Alkaloids, **Fla:** Flavonoids, **Re-S:** Reducing Sugar, **Gly:** Glycosides, **Anth:** Anthraquinones, **Co:** Coumarins, **Pro:** Proanthocyanidins.

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The Figure 3 shows the uses of vegetal species by native population. Among 86 plant species known, 33 % were used for medicinal purposes, 41% enter in their diets and 11% of the plant species were used for food and 15% for buildings and others.
Figures 4 and 5 show various use of medicinal plants used by native people. Regarding the parts of plants used, leaves were the most used (38%) followed by stem barks (36%), stem (12 %) and roots (5%).
Concerning the mode of preparation, the results (figure 7) on the medicinal use of the plants show that preparation methods most utilized by local population include the decoction (36%), Raw (35%) followed by powdering of the plants (12%).

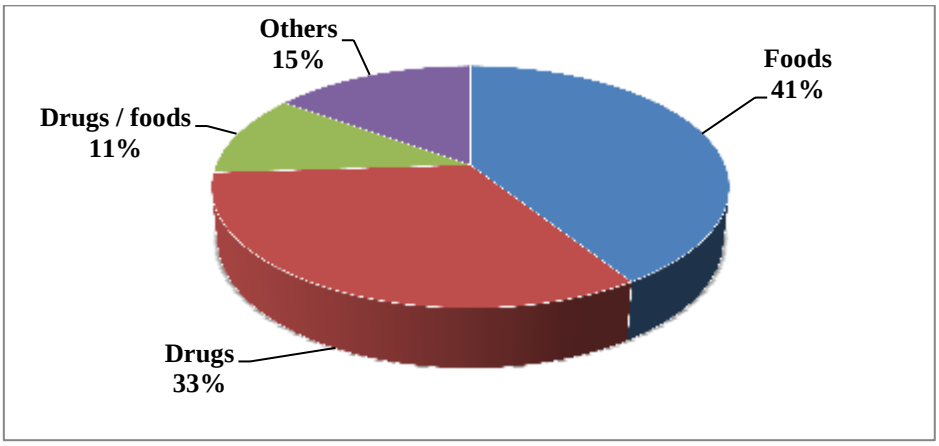

Figure 4: Traditional use of mandrill plant foods by native population.

The informant consensus factor (Fic) used to identify the ethnopharmacological importance of the collected plant species is shown in the Table 4. The results show that categories with the highest degree of consensus from informants were abscess (1), hypertension (1) and Stomach (1) followed foods, fever/malaria, diarrhea, wounds, constipation and sexual weakness with 0.99 each one. Only the pains (0.50) and thoothake (0.69) categories have shown small informant consensus factor.

Tableau 4: Category of ailments and their informant consensus factor (Fic).

Traditional uses	Taxons	Use reports	Fic
Foods	35	3546	0,99
Fever/malaria	4	435	0,99
Diarrhea	2	315	0,99
Pain	7	13	0,50
Wounds	4	417	0,99
Toothake	5	14	0,69
Constipation	2	230	0,99
Abscess	1	15	1
Hypertension	1	66	1

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Cough	7	512	0,98
Sexual weakness	4	327	0,99
Stomach	1	44	1

The figure 5 shows the various consumption modes mandill foods by department population. The results show that mandrill food plants were mainly consumed cooked and raw. Others consumption forms such as decoction, powder (figure 6) were also used. Among these modes of consumption of mandrill food plants by the native people, the cooking (43%) and raw consumption (27%) was the most used by the Department population.

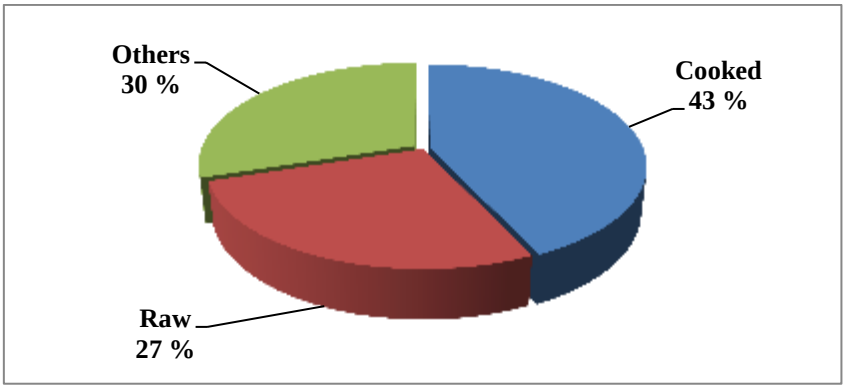

Figure 5: Various traditional methods of preparation of plant foods.

3.4. Mode of preparation of drugs and their utilizations in traditional medicine.

The native people of Lékoko Department were recorded to make medicinal preparations using wild plants for curative purposes via simple methods such as decoction, powder, raw, fumigation, friction, and bath. The plant species used by mandrills are used by native population in the treatment of various affections (Tbleau 2). Among plant parts used in the treatement of pathologies in traditional medecin, some also consumed by the mandrills. It is the cas of leaves of *Alchornea floribunda* and *Craterispermum cerinanthum* which are used for treat the malaria or ferver, the marrow of *Costus afer* and leaves of *Scleria boivinii* and of *Dichaetanthera africana* are used in the treatement of cough and the stems of *Scleria boivinii* are used in the treatment genital tract diseases (Table 2).

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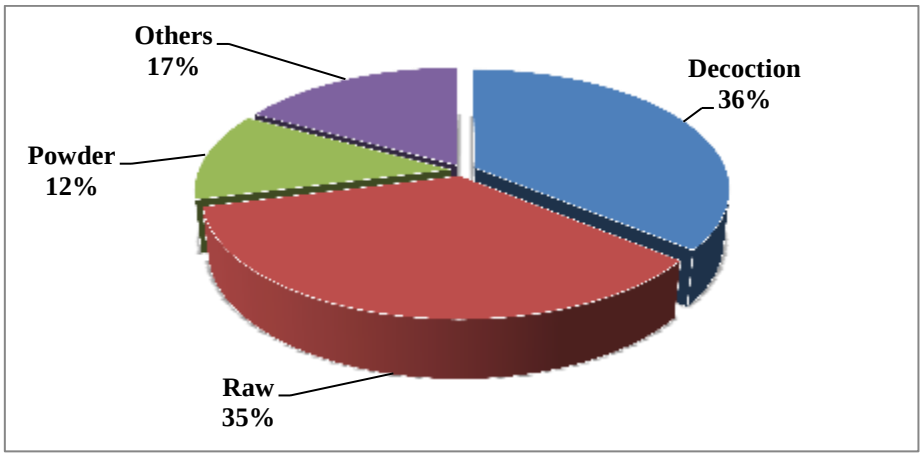

Figure 7: Various methods of preparation of remedies in traditional medicine

4. DISCUSSION

The present work performed on the mandrill diet at the Lékédi Park, allowed us to record 147 plants species belonging to 47 families.

Based on the number of plant species consumed per family, the results revealed that Rubiaceae and Euphorbiaceae were the most represented families, with 14 species followed by Apocynaceae and Zingiberaceae with 8 species. Among the 48 botanical families, 17 were less represented in diet *Mandrillus sphinx* as the case of Dilleniaceae, Sapindaceae, Flacourtiaceae, Cesalpiniaceae, Piperaceae, Nymphaeaceae, Passifloraceae, Smilaceae, with one plant species for each family (Table 1).

However, based on the food intake, the botanical family of Annonaceae (intake = 6738) was the most consumed followed by Euphorbiaceae (intake = 6083), Rubiaceae (intake = 5279), Marantaceae (intake = 1794) and Mimosaceae (intake = 1526).

Despite the small representativeness in mandrill diet and their rarity in area, some families count also among the most consumed plants. It was the case of Cesalpiniaceae (intake = 964) and Nymphaeaceae (intake = 570). Examination of plant parts selected by mandrills, show that fruits, leaves, and stems were consumed (Table 1).

The strong representativeness of botanical families in the mandrill diet was somehow expected, since the mandrills are among the dominant fruit-eating primates [123-125] and that vegetables belonging to these different botanical families would be the most representatives in the area with the largest number of fruit plants. Indeed, more than 50 % of these plants species are fruit plants.

These observations on the predominance of fruits in mandrills' diet are in accordance to those reported by Petroni (2016) on Brachyteles which would have fruits as a main food source explained by the existence of higher number of fruits plants in the area (Strier, 1986).

Regarding specifically the eating-plants selection by non-human primates, several studies showed that, for diet purposes, the plants selection by these animals is determined by many factors: availability, nutrient content, non-nutritional factors such as self-medication [13, 126-128].

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In this study, the great consumption of the most representative plant species may be firstly related to their availability in the study area, since a correlation was shown between availability (R_i) and the total frequency of consumption (occurrence/hr).

When we observed specifically organs of some plant species used like *Chrysophyllum africanum*, *Myrianthus arboreus*, *Landolphia hirsuta* and *Pentaclethra macrophylla*, the fruits, the leaves, and the seeds were abundantly consumed suggesting that, in addition to availability, the nutrients content may determine also the choice of plant in mandrill diet.

Since, the fruits, the leaves and the seeds are known to be a good source of carbohydrates and protein [129-132] and that the leaves of *Myrianthus arboreus* and *Landolphia hirsuta* and the seeds of *Pentaclethra macrophylla* consumed by *Mandrillus sphinx* would represent an abundant source of food proteins and are considered as a good diet protein supplements [133-135].

Our results are in phase with the works of some authors, which have shown that carbohydrates and proteins would determine the choice of food plants in animals [136-138].

Though our study did not establish a direct correlation between mineral content and the plant selection by mandrills as reported by some authors [139, 140] but, some mandrill diet behaviours observed may suggest that mineral content would be involved in the selection of some vegetables by mandrills.

Indeed, observations have shown that the petioles of *Musanga cecropioides* and the stems of *Rhynchospora corymbosa* are consumed by chimpanzees and lowland gorillas for their minerals content [127, 138, 141] and these two vegetal species were also consumed by mandrills.

It is reported that minerals such as phosphorous (P), calcium (Ca), magnesium (Mg), iodine (I), manganese (Mn), copper (Cu), selenium (Se), and zinc (Zn) are involved in successful reproductive processes and that the calcium is involved in the growth, animal reproduction and the sperm capacitation [142, 143].

The selection of some plant species such as *Setaria megaphylla*, *Urelytrum fasciculatum*, and *Uvaria scrabida* by female mandrills only, *Asplenium africanum* and *Thonningia sanguinea* by juvenile and adolescent mandrills might be explained by their mineral content, which helps fulfill their physiological needs of growth and reproduction.

Indeed, ethnobotanical studies on pygmy populations from Gabon have reported that *Asplenium africanum* species were used to stimulate the growth of children [33]

The evidence of self-medication is well known in the animal kingdom through some animal diet behaviors [14, 144, 145]: the use by animals of particular plants that are not commonly consumed by the healthy individuals of the group [146], the consumption of plant parts with low nutritional value but rich in anti-nutritional compounds such as barks and roots [146] and the use of biologically active plants (*Vernonia amygdalina* and *Trichilia rubescens*). The later can be seen with some monarch butterfly females, which lay their eggs in toxic plants to preserve the infestation of larvae [147] or with some birds, which would plants to build their nests to prevent parasite affections [148, 149].

During our study period, plant parts (barks, marrow, and roots) were occasionally consumed by the mandrills. These plant parts, known as synthesis sites and reservoirs of non-nutritional compounds such as alkaloids, saponins, and tannin protect the plants against herbivorous [150-153]. So, barks of *Albizia gummifera*, marrow of *Costus afer* and roots of *Cnestis sp* were occasionally consumed by mandrills.

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Phytochemical and pharmacological analyses of the barks of *Albizia gummifera* and marrows of *Costus afer* highlighted the richness in non-nutritional metabolites like alkaloids such as spermine, the most abundant one in *Albizia gummifera*, tannins, and saponins [48, 69], were revealed antimicrobial and antiprotozoal properties [150], suggesting that mandrills would use the plants for therapeutic or prophylactic purposes as reported by several works [13, 154-156].
This hypothesis was reinforced by the behavior of some wounded mandrills observed during our investigations.
Some male mandrills, suffering injuries as a result of fights among themselves, were observed, several times, rubbing themselves against the stem barks of *Alchornea floribunda* (Euphorbiaceae) only (Nsi Akoué, personal observations). These kind of fur-rubbing behaviors assimilated to the self-medication described on other species of primates such as capucins (*Cebus capicinus*) and orangs-outans [18, 157]. This could suggest that the stems of *Alchornea floribunda* could be used for curative purposes by the mandrills. Indeed, pharmacological studies on *Alchornea floribunda* revealed antibacterial activities against the Gram-negative (*Bacillus cereus*, *Enterococcus faecalis*, *Staphylococcus aureus* and *Staphylococcus saprophyticus*), Gram-positive (*Escherichia coli*, *Klebsiella pneumoniae*, *Moraxella catarrhalis* and *Proteus mirabilis*) [158], antiprotozoal activity on *Trypanosoma brucei brucei*, *Trypanosoma cruzi*, on *Leishmania infantum* and on the *Plasmodium falciparum* strain resistant to the chloroquine and to the pyrimenthamine [51].
The consumption of some plants with antiparasitic activity by the mandrills Lékédi Park could translate or explain a behavior of self-medication for the management of parasitic diseases as had already highlighted the Poirotte studies et al. [159]
Our ethnopharmacological surveys have revealed that 86 out of the 147 plant species eaten by mandrills were well-known by native populations. Several of these plants have a high use value (Table 3), especially food plants and some medicinal plants such as *Thonningia sanguinea* and *Scleria boivinii*, used in the whole Department to treat wounds and cough respectively.
The Fic values indicate the degree of shared knowledge for the treatment of the ailment by medicinal herbs [39]. Our results show the higher informant concensus factor (Fic) values of the majority categories indicating that the medicinal plants are effective in treating a certain diseases.
Among the mandrill food plants used by the native people, 41% were used as foods (e.g. *Uapaca guineensis*, *Aframomum cf polyanthum and Aframomum daniellii*), 33% for medicinal purposes and mainly for the treatment of various affections such as gastrointestinal infections (e.g. *Setaria megaphylla*, *Smilax anceps*, *Piptadeniastrum africanum*, *Cnestis ferruginea and Alchornea floribunda*), and 11% were used both as food and as medicines (e.g. *Microdesmis haumaniana*, *Smilax anceps*). In that way, the use of several plants species included in non human primate diet by human primates as food or medicinal purposes are well documented (Cousins and Huffman, 2002; Krief et al., 2005; Petroni et al., 2016).
In that way, it was shown that some plant parts consumed by the mandrills are used in traditional medicine in the treatment of certain affections. The leaves of *Alchornea floribunda* and *Craterispermum cerinanthum* which are used for treat the malaria or fever, the marrow of *Costus afer* and leaves of *Scleria boivinii* and of *Dichaetanthera africana* are used in the treatement of cough and the stems of *Scleria boivinii* are used in the treatment genital tract diseases.

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Such similarities in plants used by both human and non-human primates for medicinal purposes have been reported [43, 144, 146], arguing that the *Mandrillus sphinx'* diet could be one of the pathways to the discovery of drugs to treat infectious diseases as suggested by other various works on animal self-medications [24, 144, 146]. This fact was attested by the worldwide ethnomedicinal uses of some plants species and their pharmacological properties reported in various ethnopharmacological studies. *Alchornea floribunda,* for example, is commonly used for the treatment of trypanosomiasis and microbial infections [36, 51, 160], chronic diarrhea, respiratory tract infections, abscess ovarian problems, ringworm and eczema [51, 161, 162]. *Alchornea floribunda* is reported also to exhibit anti-inflammatory and analgesic properties when applied topically and is commonly used for the treatment of arthritis, muscle pain, and other inflammatory disorders [183].

Pharmacological studies revealed activities against gram^{+} and Gram^{-} bacteria responsible for gastro-intestinal, skin, respiratory and urinary infections of *Alchornea floribunda* [164].

The decoction of the leaves *Cnestis ferruginea* is used by the Yoruba of South West Nigeria as a laxative, enema for dysentery and gonorrhea. The fruits are used locally for the treatment of tooth-ache, mouth and skin infections, it is also used for nasopharyngeal affections, pulmonary troubles and as analgesic, anti-inflammatory, antibacterial, and antifungal properties [64, 120, 121]. *Setaria megaphylla* would exert antiplasmodial activities [117]. *Piptadeniastrum africanum* would have antitumor, antimicrobial and anti-parasitic properties [51, 81] and *Klainedoxa gabonensis*, *Landolphia hirsute*, and *Manniophyton fulvum* commonly eaten by studied mandrill and also by chimpanzee populations from Salonga National Park, DR Congo for self-medication [21, 23] would have antibacterial, anti-parasitic properties and antidiarrheal activity on gastrointestinal motility [21, 165].

Fruits of *Megaphrynium macrostachyum* also consumed by the mandrills would exhibit antimicrobial activities against *Escherichia coli*, *Shigella dysenteriae*, *Staphylococcus aureus*, *Enterococcus faecalis*, *Pseudomonas aeruginosa*, and *Candida albicans* [166].

Palisota hirsuta would have antimicrobial and antiviral properties [99] and *Myrianthus arboreus* is reported to have antibacterial activities [93, 94].

Several species from the genus *Aframomum,* which are major food plants for the great apes throughout the lowland rainforest and many mountain areas [167-169], would exhibit a wide range of antibacterial and antifungal activities [153, 170]. It is the case of *Aframomum daniellii* for example, which is reported to have antimicrobial activities against *Salmonella enteriditis*, *Pseudomonas fragi*, *P. fluoresecens*, *Proteus vulgaris*, *Streptococcus pyogens*, *Staphylococcus aureus*, *Aspergillus flavus A. parasiticus*, *A. ochraceus*, and *A. niger* [171].

The resin of *Aucoumea klaineana* consumed occasionally by the mandrill is reported to have antifungal and antibacterial properties and is used by native people to purify water [58].

Concerning the plant parts used, some plant organs were used by the mandrills as well as by native people.

Indeed, the morrows of *Costus afer,* leaves of *Setaria megaphylla* and stems of *Scleria boivinii* were used by mandrills and humans.

However, for the large number of plants there were not similirities in the parts of plants used by both human and non-human primates since humans, for medicinal puporses, rely mostly on leaves and barks [172-177]. Similar observations were eported by Petroni (2016) for who an

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explanation in the dissimilarities would be the fact of plants preparation forms in folk medicine in which leaves and barks are predominant and fruits being rarely used.
Among the forms of preparation, decoction was the method most used in preparing remedies. Our results are similar to those of other studies which have shown that decoction was the method most used in the consumption of drugs and that water was the good solvent for the preparation of the drugs in traditional medicine [178, 179].

5. CONCLUSION

Overall, our study which involved both zoopharmacological and ethnopharmacological approaches allowed us to highlight the floristic richness in nutritional and/or medicinal plants of La Lékédi Park (Bakoumba, South-Est Gabon). Some of the medicinal plants recorded may be useful for the management of various affections including infectious diseases and or neglected ones. Thus, the mandrill diet behaviour study may be a potential approach for the discovery drugs.

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