Agroforest Syst
https://doi.org/10.1007/s10457-019-00423-2

Ethnoapicultural investigation to improve conservation status of threatened melliferous agroforestry species with high medicinal and food values in Benin

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Received: 16 January 2019 / Accepted: 9 July 2019

Abstract In northern Benin, several agroforestry species are nectar-producing, with high medicinal and food values. These species are currently threatened by the destruction of their habitats caused by deforestation and agriculture, mainly cotton production. Considering their importance for humans and beekeeping, this investigation was carried out in one of the most important honey production areas in Benin. Individual interviews and focus group discussions were conducted to identify the medicinal and food plants associated with honey production. Data were collected on food and medicinal uses, beekeepers' preferences in the choice of melliferous species and constraints faced for honey and medicinal species conservation in the areas studied. From these data, 46 species of medicinal and food species were identified as melliferous. Thus, nine new species were added to the list of melliferous species in Benin. Most of the species are also used as sources of human food or medicine in traditional set up. Species preferred by beekeepers were those that provide large amounts of sweet, fragrant hone. It appears that honey from 11 plant species with a high use value was clearly recognized by beekeepers who are involved in various human diseases' treatment. The constraints hampering the management of these melliferous species are extensive farming, animal husbandry, anarchic logging. This study brings us the avenues for modernization of beekeeping and the possibility of producing therapeutic honey.

Keywords Beekeeping · Medicinal and food species · North Benin

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Published online: 17 July 2019

Introduction

Agroforestry constitutes an alternative system of land use allowing farmers to produce annual crops in combination with useful trees and contributing to nature conservation. These land management systems contribute to biodiversity conservation and have only recently attracted wider attention among agroforestry and conservation scientists (Atta-Krah et al. 2004; Ouinsavi et al. 2005; Acharya 2006, McNeely and Schroth 2006, Vodouhe et al. 2010). They have potential to contribute to conservation of tree species on farms and the provision of suitable habitat for a number of plant and animal species on farmlands (McNeely and Schroth 2006). One of the most important reasons that determined household motivation to conserve woody species on farmland was tree products' contribution to food, medicine and household incomes (Vodouhe et al. 2011). Conservation of threatened agroforestry species in honey production areas is an innovation for the honey production and reduction of destruction of plant species population (Decourtye et al. 2010).

Apiculture is not very well developed in Benin. It has evolved from honey hunting to traditional beekeeping with traditional hives to modern beekeeping (Yedomonhan et al. 2009). Hunting honey, which accounts for more than 60% of total honey production in Benin, is a threat to the honeybee because honey is harvested after fire destruction, beehives and wild bee colonies (Paraïso et al. 2011). Population growth, deforestation and the establishment of plantations have contributed to a considerable reduction in available resources per person (Hounkpe et al. 2007). The conservation of endangered agroforestry species in the honey production areas is important for the apicultural, the productivity of bee pollinated species and biodiversity.

Melliferous plant species that produce nectar and pollen collected by honeybees *Apis mellifera mellifera* are an important aspect of beekeeping and biodiversity conservation. These plant species are highly diverse, consisting of woody species such as trees, shrubs and liana; and non-woody plants represented by herbaceous, vines and grasses (Yedomonhan et al. 2009, Iritie et al. 2014). Some of these plants are used by farmers for their nutritional and medicinal properties (Manyi-Loh et al. 2011). Due to this diversity of plants, produced honeys have diverse composition, with unique characteristics including antioxidant and antimicrobial properties. These properties are useful for the treatment of gastrointestinal disorders, managing asthma, wounds, skin ulcers and other therapeutic uses (Nair 2014). To date, there are few studies about the medicinal value of honey extracted form plant and tree species in Benin. Tossou et al. (2011a, b) carried out a pollen analysis of honey produced and commercialized in Benin. Their research shows a close link between honey production and the pollen spectrum, that is when there is a high diversity of bee plants, honey production increases.

Unfortunately, deforestation, changing climatic conditions, overexploitation, agriculture especially cotton production, demographic pressure, grazing and bush fires contribute to the loss of indigenous plants and hence endanger the production of a diverse range of honey and limit their associated medicinal uses (Hounkpe et al. 2007). To cope with this reality, since 1994, the country defined its forestry policy based on the 93-009 law relating to forests, and since 2002, it developed its national strategic plan for biodiversity that focuses on conservation and sustainable use of biological diversity. The current management policy aims at assigning local communities the authority to manage forest resources under their jurisdiction. Many conservation programs have been implemented at local, regional or national level throughout the country in this way. Also, in situ forest tree conservation and traditional agroforestry were promoted (Vodouhe et al. 2011). This kind of agroforestry system involved local species including some endangered melliferous species. Thus, conservation of endangered agroforestry species would be important to help producers to make better choices in the areas in which they will establish their hives (Manyi-Loh et al.2011). These choices are dependent on underlying knowledge of tree diversity, flowering calendar and means of conservation of these species. However, there is a gap of information on the diversity, uses and status of melliferous species in beekeeping in Benin. The overall objective of this study is to investigate the diversity and local food and medicinal uses of melliferous plant species of Benin. More specifically, this study aims at (1) assessing the taxonomic diversity of species visited by honeybees *A. mellifera mellifera* in Northern Benin and to identify their medicinal and food uses; (2) identifying the most widely used melliferous plant species; (3) documenting the

perception of beekeepers on (a) the relationship between principal melliferous species and (b) the therapeutic properties of honey produced, and (c) their preferences in terms of the choice of the principal melliferous medicinal plants; and (4) documenting the constraints of beekeepers related to the conservation of reported melliferous species.

Materials and methods

Study site

The study was carried out in the agroecological zone N° 2 (AZ2) of Benin, also called Cotton Area of Northern Benin. The zone occupies a land mass of about 20.930 km^2 (23% of the national territory) and lies between the latitudes 10°29′34″N and 11°45′25″N and longitudes 01°42′54″E and 3°43′51″E (Fig. 1). It is characterized by a Sudanian climate with a unimodal rainfall regime. The rainy season lasts 7 months between April and October with the peak around August/September. Through the study area, the vegetation is a mosaic of dense dry forests, clear forests, wooded, tree and shrubby savannas (Akoègninou et al. 2006). The natural vegetation is dominated by species such as *Anogeissus leiocarpus, Combretum micranthum, Guiera senegalensis, Boscia senegalensis, Acacia ataxacantha, Acacia gourmaensis, Acacia hockii, Acacia sieberiana*. Species such as *Parkia biglobosa, Adansonia digitata* and *Vitellaria paradoxa* are also encountered in agroforestry systems. Adomou et al. (2011) has recorded nearly 320 plant species of vascular plants. Based on the 2013 National Census, the population of AZ2 was estimated at 731.680 people belonging to five ethnic groups, namely Bariba (38%), Peulh (22%), Dendi (21%), Mokolé (12%) and Gando (7%) (INSAE 2013). The zone is known to be the most important cotton crop zone in the country. This form of land use is one of the principal factors responsible of biodiversity loss.

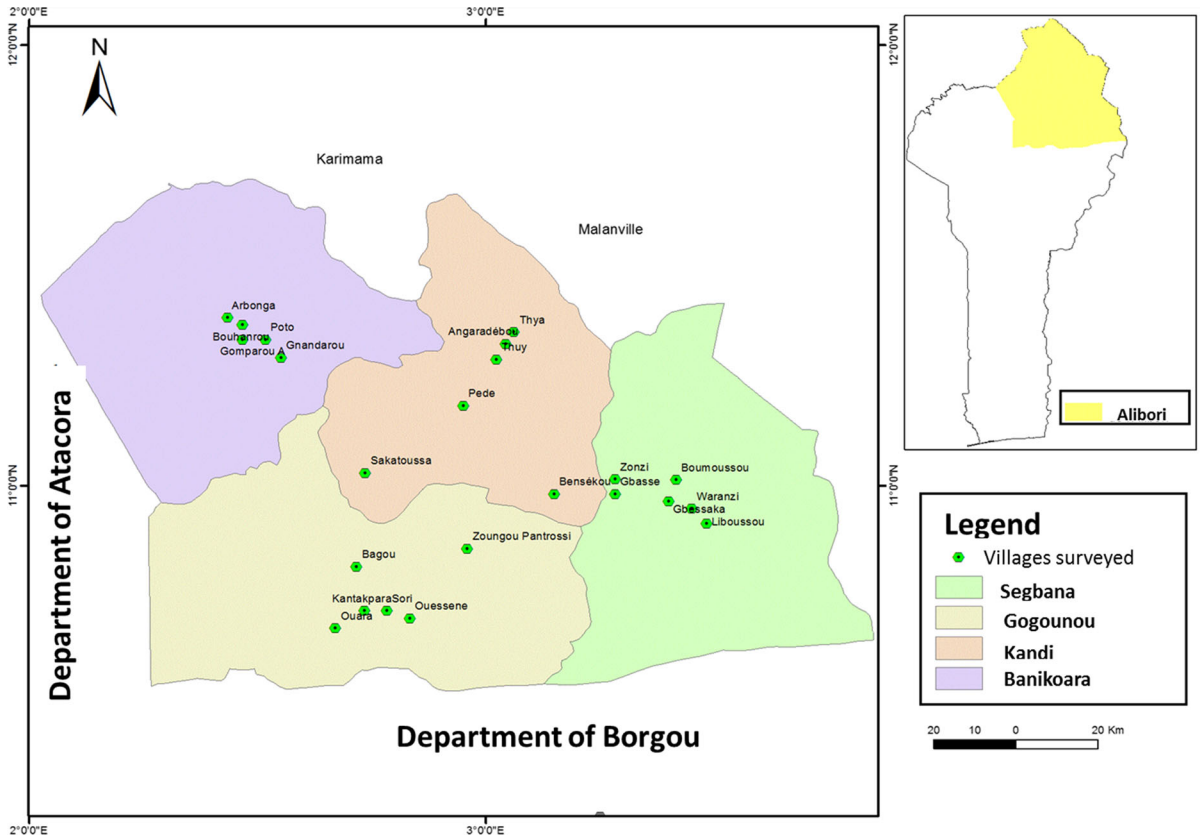

Fig. 1 Map of the villages surveyed in the study area

Other most dominant crops in the zone are sorghum, rice and maize.

Sampling and data collection

AZ2 comprises five municipalities. Four among them, namely Banikoara, Kandi, Segbanna and Gogounou, were selected based on the number of beekeepers. The selection was done with the Responsible of the Regional Action Centre for Rural Development (CARDER). In each municipality, a first village was randomly selected for the survey. During an interview with the head of the village, we asked him to cite all beekeepers of his village. After that, we randomly selected one person in this list and when we met this person we asked him to also list all beekeepers he knows in his locality. We assumed that the sample size was adequate when the saturation was attained. The saturation was defined as the point at which there are no new names of key beekeepers being mentioned by the last interviewee (N'Danikou et al. 2015). We recorded a total of 120 beekeepers selected in 23 villages from the four districts of the study area with which we conducted structured interviews. Beekeeping was a secondary activity for all interviewed people. The sample was dominated by men (98%). They were between 15 and 100 years old, and the dominant age class (51%) years was 15–35 years old (Table 1). All beekeepers surveyed were farmers and 70% of them were not literate. In our sample, 19% of people have attended primary school and about 2% reach high school. Concerning professional experiences, 40% of the beekeepers have benefited from beekeeping training of which Gogounou district held the largest proportion. Although most beekeepers had between 1 and 5 years of experience, at least 34% had 6–10 years of experience. In the district of Banikoara, 54% of beekeepers had more than 10 years of experience in apiculture. We gathered information on the local names of the medicinal and food species visited by honeybees with their medicinal use, the criteria of preference of beekeepers in terms of honey species, the threats to these species, the relationship between species and the qualities of honey. During the interviews, species quoted in the local languages by the respondents were immediately collected and identified at the National Herbarium of Benin using the Analytical Flora of Benin (Akoègninou et al. 2006)

Table 1 Sociodemographic parameters of surveyed beekeepers

Sociodemographic parameters	Banikoara (%)	Kandi (%)	Gogounou (%)	Segbanna (%)
Sex				
Men	96.43	97.43	100	100
Women	3.57	2.56	0	0
Ages				
15–35	32.14	51.28	53.33	70.83
36–50	46.43	41.02	30	25
Over 50	21.43	7.69	16.66	4.17
Education level				
Illiterate	64.29	76.92	70	62.5
Primary	35.71	12.82	13.33	16.66
Secondary	0	5.13	13.33	20.83
university	0	2.56	3.33	0
Professional experience				
Beekeepers trained	7.44	9.09	13.22	10.74
Beekeepers untrained	15.70	15.70	19.01	9.09
Experience years				
1–5	4.96	10.74	16.53	10.74
6–10	5.79	10.74	10.74	7.44
Over 10	12.40	3.31	4.96	2.48

or by comparison with already identified herbarium specimens (Arbonnier 2000).

Data analysis

We successively established the list of recorded melliferous plant species reported by informants, counted the number of species per genus, family, morphological type and calculated their relative frequency. We also generated the comprehensive list of uses, counted their number and calculated their relative frequency. For knowing local relative importance of each species, we determined their use value using formula defined by Phillips and Gentry (1993); Yedomonhan et al. (2009) and Vodouhe et al. (2009). According to previous studies, the use value (UV) index is currently the most widely used technique in quantitative ethnobotany (da Silva et al. 2014).

$$\mathrm{UV} = \frac{\sum U_i}{n} \quad (1)$$

where UV is use value index, U_i the number of use reports cited by each informant for a given species recorded during ethnobotanical investigations was divided by n refers to the total number of informants. Use values were high when there were many use reports for a plant, implying that the plant was important, and approached zero (0) when there were few reports related to its use. Data were also analyzed using principal component analysis (PCA) to categorize the recorded plant species as function of properties. The preferences criteria and honey production constraints were calculated in percentages, and the frequencies were the ratio expressed as a percentage of the number of beekeepers who recognized these parameters by the total number of responses. These percentages allowed us to rank the preferences criteria and honey production constraints in order to determine the most important to consider in the honey production system improvement. Statistical analyses were performed with R version 4.2 (R Development Core Team 2014).

Results

Taxonomic diversity of recorded melliferous species

A total of 46 plant species were collected belonging to 42 genera and 21 families (Appendix 1). The Fabaceae family was the most represented (11 species; 24%) followed by Poaceae (4 species; 9%) and Solanaceae (3 species; 7%) (Fig. 2). Annonaceae, Caricaceae, Flacourtiaceae, Lamiaceae, Moraceae, Moringaceae, Apocynaceae and Sapotaceae were poorly represented (1 species; 2% each) (Fig. 2). *Senna* and *Acacia* (3 species) and *Citrus* (2 species each) were the common genera. The melliferous species mentioned in the study were represented by four categories of type of plants. The higher prevailing type of plants was tree

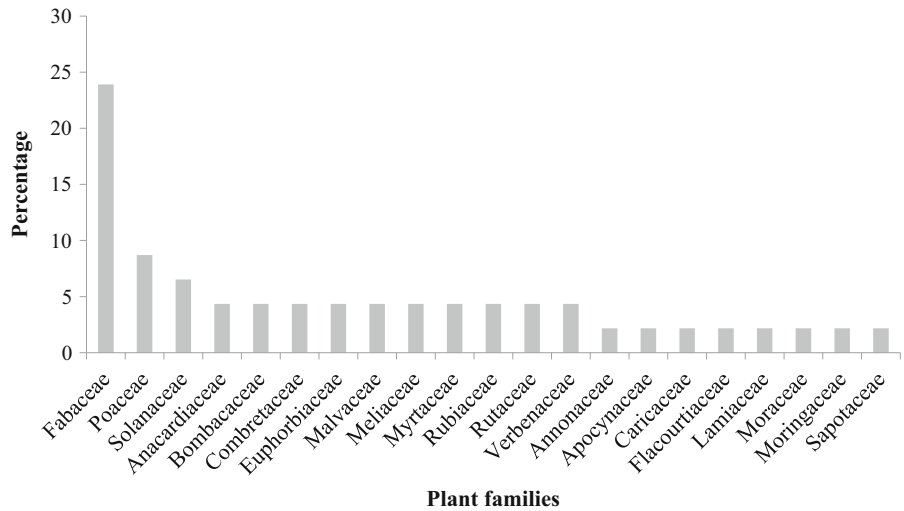

Fig. 2 Different families of melliferous species collected in the study site

(22 species; 48%) followed by herb (13 species; 28%), shrub (10 species; 22%) and suffrutex (1 species; 2%). Most of the reported melliferous plant species were wild (52%) followed by cultivated species (35%) and then by plant species from plantation but that grow in semi natural habitats (13%).

Uses and use value of recorded melliferous species

We recorded twenty-one specific uses distributed in ten uses (gastrointestinal, infections, respiratory, urinary, reproductive, muscular, circular and nervous systems and food) and two use categories (medicinal and food) (Appendix 2). Among use categories, medicinal use was the most important category (83% of total mentions). Analysis of the data revealed abdominal disorders (17% of total), malaria and fever (11% each), were the most important diseases reported as treated by the people. By evaluating the number of plants treating one given disease, we observed that all species were reported as having medicinal properties while only twenty (20 species, 31.25%) were used for their edible value (Appendix 2). Among the diseases treated, malaria and abdominal disorders hold the highest number of species (26 each) followed by fever (16 species), diarrhea (11 species), cold (9 species), ulcer (8 species), dysentery (7 species), painful menstruation (5 species), kidney damage (4 species), wound, hemorrhoid and anemia (3 species each), paralysis, cough, energetic, toothache, headache and icterus (1 species each). About 69% of the species were used for treating at least two diseases whereas 31% were used to treat only one disease.

A diversity of food plants were documented in the study area, mainly edible fruits (13 species; 28% of the total), leafy vegetables (4 species; 9% of the total), fruit vegetables (2 species; 4% of the total) and the cereal (5 species; 11% of the total).

Principal plant parts were solicited for the different uses. The most frequently used plant parts were the leaves (40%) followed by fruits (24%), stem barks (15%), roots (13%) and seeds (9%).

The most commonly used species were *V. paradoxa C. F. Gaertn. ssp. paradoxa* for which the seeds are used to produce shea butter and *Moringa oleifera* Lam. for which the leaves and seeds are used to treat many diseases. Each of these two plants received 12 use reports by 24 informants, giving values of 0.5 for each. They were followed by *Albizia lebbeck* (L.) Benth., *Oryza* sp. L., *Ceiba pentandra* (L.) Gaertn, *Calotropis procera* (Aiton) W.T.Aiton, *Mangifera indica* L. and *Psidium guajava* L., which hold use values ranged between 0.41 and 0.33. The most rarely used species hold use values from 0.13 to 0.04. We can cite *Acacia auriculiformis* A. Cunn. ex Benth., *Citrus limon* (L.) Burm. f., *Terminalia glaucescens* Planch. ex and *Vigna unguiculata* L., etc.

Beekeepers perception on the relation between honey therapeutic properties and species of melliferous species used

Honeys from *V. paradoxa, Tectona grandis* and *Senna occidentalis* were mostly used in the treatment of stomach pains and to help the memory, while that from *P. biglobosa* was mostly used to treat diarrhea. Honeys of *Anacardium occidendale, A. digitata* and *Eucalyptus camaldulensis* were used against coughs, energetics and also as aphrodisiacs. The honeys from *Daniellia oliveri, Azadirachta indica* were reported as excellent for increasing appetite and for curing earache and ulcers (Figs. 3, 4).

According to beekeepers' perception, in the study area, honeybees had a strong preference for *V. paradoxa* (57%) and were less attracted by species such as *S. occidentalis* (16%), *P. biglobosa* (15%), *Anacardium occidentale* (11%) and *Hyptis suaviolens* (7%) (Fig. 5). According to these beekeepers, honeybees have more affinity with *V. paradoxa* because of its abundance in the area and the shiny appearance of flowers.

Criteria of preference of beekeepers in the choice of melliferous food and medicinal species

The two main criteria reported to be useful in the selection of melliferous plants in the study area were (1) medicinal value known by the people and (2) nutritional value known by the people. Regarding the preferences of beekeepers in terms of melliferous species, five melliferous species were highly preferred in study area: *V. paradoxa* followed by *P. biglobosa, Anacardium occidentalis, D. oliveri, M. indica*. The sweet and fragrant honey produced from these species explained beekeepers preference for them. In addition, according to beekeepers, *V. paradoxa* honey was therapeutic and *A. occidentale* allowed them to obtain

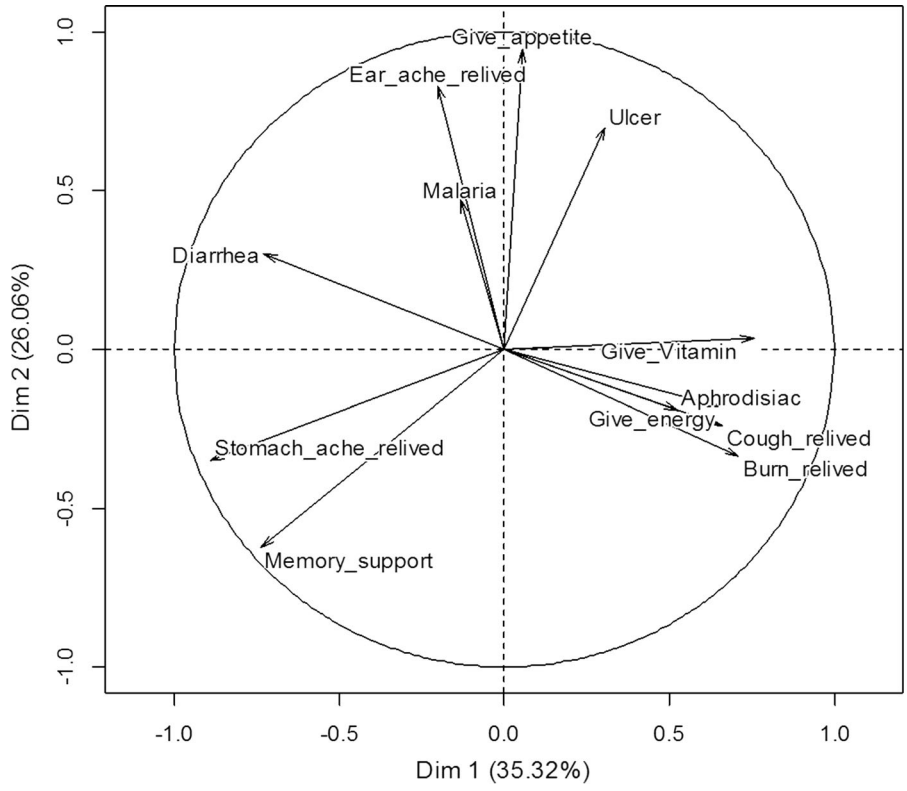

Fig. 3 PCA showing the diseases treated by melliferous plants use

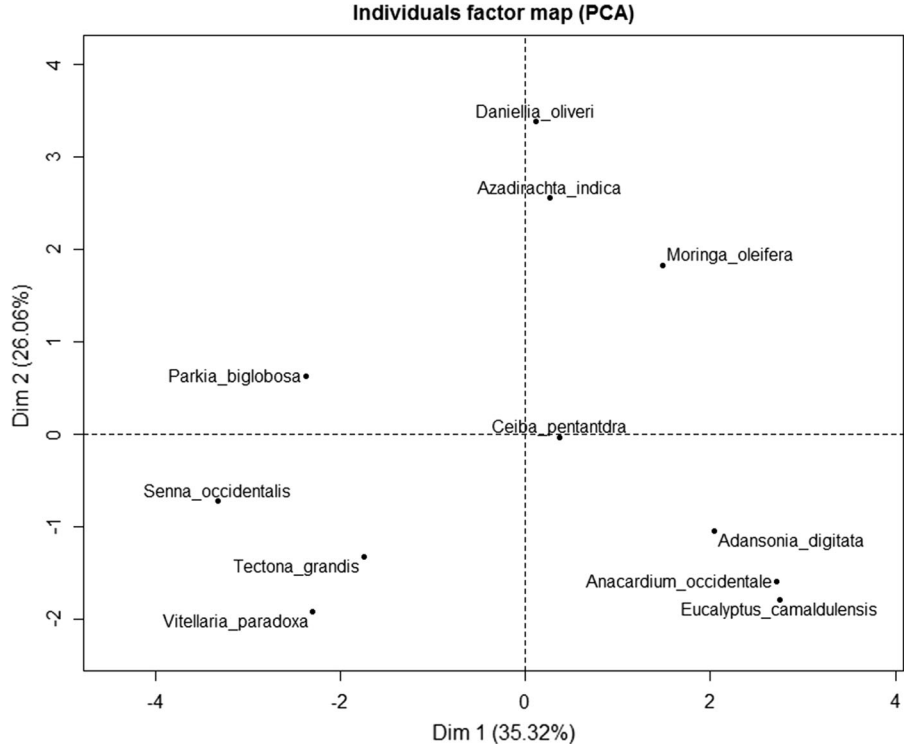

Fig. 4 PCA showing medicinal melliferous plants

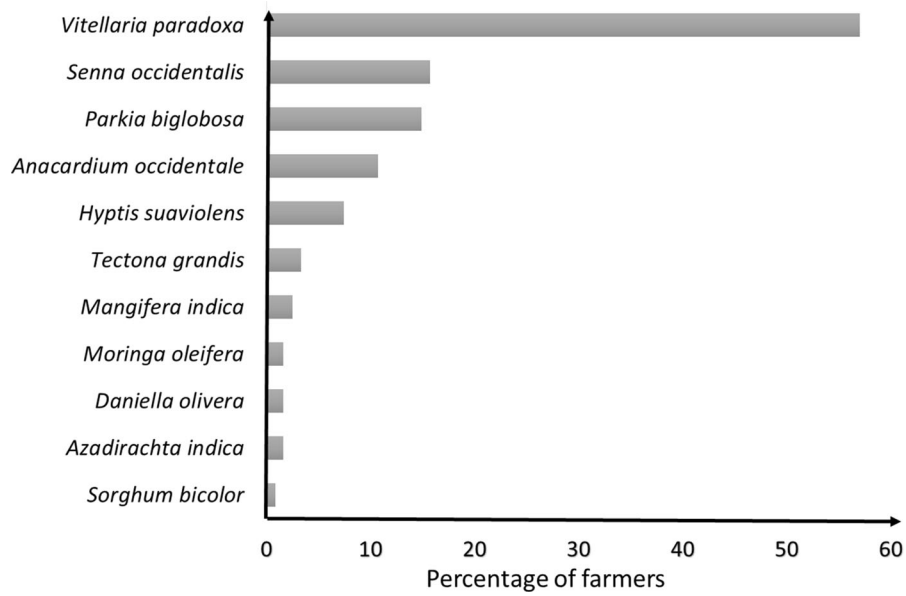

Fig. 5 Bee preferences in terms of food and medicinal melliferous plants

a lot of honey. *Tectona grandis* was mainly preferred by beekeepers for its brilliant flowers (Fig. 6).

Constraints associated with honey production and melliferous species conservation

Almost all respondents stated that the main constraints associated with the honey production and sustainable management of melliferous plant species were agriculture (Fig. 7), plant parts collection for the preparation of traditional drugs, grazing, urbanization and climate change (Table 2). All threats reported by local people are responsible of current conservation status of the reported plant species. Among these species, *Khaya senegalensis* (IUCN: Vulnerable; Benin: Endangered) and *V. paradoxa* (IUCN: Vulnerable; Benin: Vulnerable) are locally threatened and recorded in the International Union for the Conservation of Nature (IUCN) red-listed species.

Discussion

Diversity of melliferous, food and medicinal forest species

In this study, we sampled 46 medicinal and/or food melliferous species. This specific richness is lower than those of previous inventory work. Fohounfo (2002) have identified 120 melliferous plant species, Dèmènou (2006) have identified 56 species, Yedomonhan 2004, Yedomonhan et al. (2009, 2012) have, respectively, identified 92, 87 and 72 melliferous species, Ahouandjinou et al. (2017) have collected 109 melliferous species, and Balagueman et al. (2018) have identified 166 melliferous species. This small number could be justified by the fact that in present study, we are interested only in the medicinal or food melliferous species.

Beekeepers link with honey, melliferous, food and medicinal species

According to the producers, all species hold medicinal properties. Phytochemical and pharmacological data found for some species are evidences of traditional uses of plants by people. For instance, chemical compounds like tannins were found in several plants species, namely *E. camaldulensis*, *A. occidentale*, *M. indica*, and *M. oleifera*. According to Murakami et al. (1991), tannins help treat gastrointestinal disorders like ulcer, while Pengelly (2004) reported their usage for treating diarrhea and dysentery. Producers reported that other diseases such as stomach pain, diarrhea, cough, earache, peptic ulcers, the lack of appetite and aid memory are controlled by the specific honeys of certain species. These results corroborate closely with results of Yedomonhan et al. (2009) who reported that

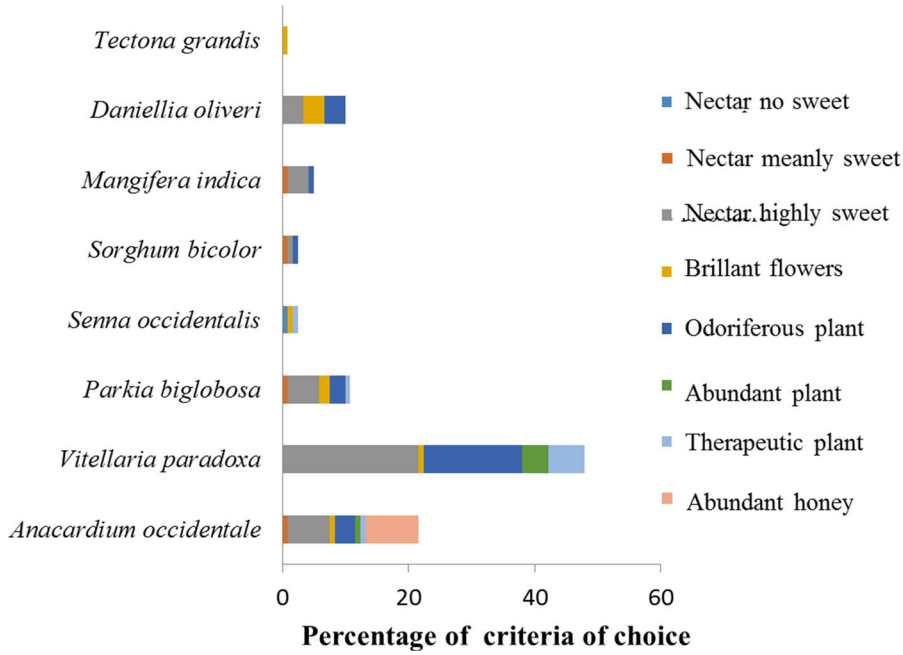

Fig. 6 Criteria of preference of food and medicinal honey plants according to the opinions of beekeepers

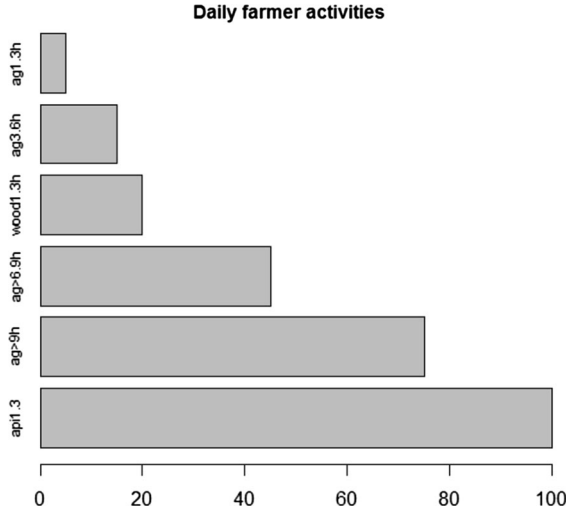

Fig. 7 Daily activities of farmers in the studied areas, wood = collect of woods; api = beekeeping; ag = agriculture; 1.3 h = 1–3 h; 3.6 h = 3–6 h; 6.9 h = 6–9 h; > 9 h = > 9 h

these diseases may be managed by consuming honey. Indeed, based on previous work, honey composition and quality vary greatly with the botanical sources of nectar (Manyi-Loh et al. 2011). This is explained by the richness of honey in many antibiotics, grouped under the generic name of inhibin, which are in fact powerful bacteriostatic (Hakim 1989; Cortopassi-Laurino and Gelli 1991). The parts of these plants used by the population in the control of infections are often roots, bark and leaves. This can be understood because it is within these part plants active substances are concentrated. However, it would important to analyze the flowers of the commonly species used in order to assess the effective presence of the active ingredients that can inhibit the diseases mentioned. These results would provide the opportunity to produce therapeutic honeys through the planting of these plants around hives or organize beekeepers to make regional plantations to promote their involvement in honey production by *A. mellifera mellifera* especially as they make use of the species preferred by *A. mellifera mellifera* to solve certain health problems through our diet. This offers the opportunity to have honey with several medicinal properties since bees cover many flowers.

Table 2 Constraints related to the conservation of food and medicinal melliferous plants

Constraints	Frequency of responses (%)
Agriculture	30.74
Grazing	26.66
Deforestation for use of wood	21.7
Fires of vegetation	20.90

Beekeepers preference for species that were highly preferred by bees could be an asset for a production orientation program for obtaining therapeutic honeys through the planting of some favorite plants around hives. Species are preferred by beekeepers either for the sweet quality of their honey, or for the flavor they provide to honey, or to increase the amount of production. In the further studies, we must study the floral calendars of different species and honeybee activity around them to validate the observations of preferences suggested by beekeepers. It is also important to verify tasting and quality (color and texture) of the honey produced in the study site.

Implication

Agriculture, settlement, domestic energy acquisition and animal husbandry pose a great threat to food and medicinal melliferous species; as reported by Sounon Kon'de et al. (2008) in the departments of Borgou and Alibori in Benin. The departments of Borgou and Alibori are suppliers of the country in plant and animal resources through their 14 forest occupying some 824 133 ha (Sounon Kon'de et al. 2008). The development of agroforestry systems could be a better solution to conserve honey plants. Agriculture will have to be installed in association with the trees. Agricultural development and research programs should be oriented toward agroforestry.

Conclusion

This study carried out in northern part of Benin allowed us to know the implication of 46 medicinal or food plant species in honey production. Nine of these species were not known as honey species and have recently been added to the list of melliferous species in Benin. The involvement of these species in the production of honey and the knowledge of honeys derived from specific species as well as the involvement of these honeys in the treatment of human diseases offer the opportunity to produce therapeutic honeys and to improve the conservation of these species.

Acknowledgements This work was financially supported by the Rufford Small Grant for the Conservation (United Kingdom) through a Grant provided to Anicet G. DASSOU in 2017. We are grateful to local communities who participated in this research. The authors thank Dr Bonaventure Aman Omondi, Bioversity International—Benin, for language editing.

Appendix 1

Family	Scientific name	Common name	Life form	Status	Using parts	Usages	UV = SU_i/N
Moringaceae	*Moringa oleifera* Lam.	Drumstick tree, ben oil tree, horseradish tree	Shrub	Cultivated	Leaves, fruits, roots, bark	Fruits, remedy for malaria, belly ache, diarrhea, fever, kidney damage, painful menstruation, head ache, ulcer, hemorrhoids, dysentery, colds	0.50
Sapotaceae	*Vitellaria paradoxa* C. F. Gaertn. ssp. Paradoxa	Shea butter tree	Tree	Wild	Leaves, roots, bark	Remedy for malaria, abdominal pains, diarrhea, fever, painful rules, ulcer, wound, hemorrhoid, paralysis, cough, cold, dysentery	0.50
Fabaceae	*Albizia lebbeck* (L.) Benth.	East Indian walnut, lebbeck, siris tree	Tree	Wild	Fruits, seeds, leaves and bark	Edible fruit, remedy for malaria, abdominal pains, diarrhea, fever, ulcer, wound, hemorrhoid and dysentery	0.42

Family	Scientific name	Common name	Life form	Status	Using parts	Usages	UV = SU_i/N
Poaceae	*Oryza* sp. L.	Rice tree	Herb	Cultivated	Fruits, seeds, leaves, roots, bark	Edible fruits, remedy for malaria, abdominal pains, diarrhea, fever, painful menstruation, ulcer, wound healing, colds, dysentery	0.42
Bombacaceae	*Ceiba pentandra* (L.) Gaertn.	Kapok tree, silk-cotton tree	Tree	Wild	Fruits, leaves, bark	Remedy for malaria, abdominal pains, diarrhea, kidney damage, painful rulers, hemorrhoids, anemia, dysentery	0.38
Apocynaceae	*Calotropis procera* (Aiton) W.T.Aiton	Apple of Sodom	Suffrutex	Wild	Leaves, seeds, fruits	Edible fruit, remedy for malaria, abdominal pains, diarrhea, fever, ulcer, hemorrhoid, icterus	0.33
Anacardiaceae	*Mangifera indica* L.	Mango tree	Tree	Cultivated	Fruits, leaves, bark	Edible fruits, remedy for malaria, painful menstruation, ulcer, healing of wounds, hemorrhoids, anemia	0.33
Myrtaceae	*Psidium guajava* L.	Guava tree	Shrub	Cultivated	Leaves, bark, fruits, roots	Edible fruit, remedy for malaria, abdominal pains, diarrhea, fever, kidney damage, painful menstruation, colds	0.33
Annonaceae	*Annona senegalensis* Pers.	Wild custard apple	Shrub	Wild	Leaves, roots, bark	Remedy for malaria, abdominal pains, ulcer, fever, dysentery	0.25
Rubiaceae	*Sarcocephalus latifolius* (Sm.) E.A. Bruce	English African peach, Guinea peach, Negro peach	Shrub	Wild	Leaves, roots, bark	Remedy for malaria, abdominal pains, diarrhea, fever, cold, fever	0.25
Fabaceae	*Senna obtusifolia* (L.) H.S. Irwin & Barneby	Foetid Sassia (or "cassia"), Sickle Senna, coffeeweed	Herb	Wild	Leaves	Remedy for malaria, abdominal pains, diarrhea, fever, eteins	0.21
Combretaceae	*Anogeissus leiocarpa* (DC.) Guill. & Perr.	African birch	Tree	Wild	Leaves, bark	Remedy for malaria, abdominal pains, diarrhea, cold	0.17
Fabaceae	*Acacia auriculiformis* A.Cunn. ex Benth.	*Acacia*-tree, Earleaf *Acacia*, black wattle, wattle	Tree	Plantation and naturalized situation	Leaves, bark	Remedy for fever, colds, cold	0.13

Family	Scientific name	Common name	Life form	Status	Using parts	Usages	UV = SU_i/N
Rutaceae	*Citrus limon* (L.) Burm. f.	Lemon	Shrub	Cultivated	Leaves, fruits	Edible fruit, remedy for malaria, abdominal pains	0.13
Fabaceae	*Daniellia oliveri* (Rolfe)Hutch. & Dalziel	African copaiba balsam tree	Tree	Wild	Leaves, bark	Remedy for fever, kidney damage, malaria	0.13
Myrtaceae	*Eucalyptus camaldulensis* Dehnh.	Red river gum, Murray red gum, River red eucalyptus	Tree	plantation and naturalized situation	Fruits, roots, bark	Edible fruit, remedy for painful menstruation, ulcer	0.13
Moraceae	*Ficus glumosa* Delile	Hairy rock fig, mountain rock fig	Tree	Wild	Leaves	Remedy for malaria, fever, colds	0.13
Euphorbiaceae	*Jatropha curcas* L.	Physic nut, Barbados nut, poison nut	Shrub	Cultivated	Leaves, bark, roots	Remedy for malaria, abdominal pains, dysentery	0.13
Fabaceae	*Acacia sieberiana* DC.	Paperbark Acacia	Tree	Wild	Fruits, leaves, bark	Remedy for healing of wounds	0.08
Bombacaceae	*Adansonia digitata* L.	Baobab, dead-rat tree	Tree	Wild	Leaves	Remedy for malaria	0.08
Anacardiaceae	*Anacardium occidentale* L.	Cashew, Caju.	Tree	Plantation and naturalized situation	Fruits, leaves	Edible fruit, remedy for fever	0.08
Caricaceae	*Carica papaya* L.	Papaya tree	Tree	Cultivated	Leaves, roots	Remedy for abdominal pains, head ache	0.08
Fabaceae	*Detarium microcarpum* Guill. & Perr.	Sweet dattock	Tree	Wild	Leaves, bark	Remedy for abdominal pains, fever	0.08
Rubiaceae	*Gardenia ternifolia* Schumach. & Thonn	Large-leaved common gardenia, large-leaved Transvaal gardenia	Shrub	Wild	Leaves, roots	Remedy for malaria, fever	0.08
Meliaceae	*Khaya senegalensis* (Desr.) A.Juss.	African mahogany, dry zone mahogany	Tree	Wild	Leaves, bark	Remedy for malaria, toothache	0.08
Fabaceae	*Parkia biglobosa* (Jacq.) R.Br. ex Benth	African locust bean, locust bean	Tree	Wild	Fruits, seeds, leaves	Food, remedy for malaria	0.08
Solanaceae	*Physalis minima* L.	Wild cape gooseberry and pygmy groundcherry	Herb	Wild	Fruits, leaves	Edible fruit, remedy for colds	0.08
Poaceae	*Sorghum bicolor* (L.) Moench	Sorghum, sorgo	Herb	Cultivated	Fruits, seeds, leaves	Food, remedy for malaria	0.08

Family	Scientific name	Common name	Life form	Status	Using parts	Usages	UV = SU_i/N
Verbenaceae	*Tectona grandis* L.f.	Teak	Tree	Plantation and naturalized situation	Leaves, bark	Remedy for malaria, anemia	0.08
Poaceae	*Zea mays* L.	Maize	Herb	Cultivated	Fruits, seeds, leaves	Food, remedy for malaria	0.08
Malvaceae	*Abelmoschus esculentus* (L.) Moench	Okra, okro, lady's fingers	Herb	Cultivated	Leaves and fruits	Food	0.04
Fabaceae	*Acacia nilotica* (L.) Delile	Babul, babool, prickly *acacia*, black piquant	Shrub	Wild	Leaves, roots, bark	Remedy for fever	0.04
Meliaceae	*Azadirachta indica* A.Juss.	Neem, nimtree	Tree	Plantation and naturalized situation	Leaves	Abdominal pains	0.04
Rutaceae	*Citrus sinensis* (L.) Osbeck, 1765	Sweet orange	Tree	Cultivated	Fruits	Food	0.04
Euphorbiaceae	*Flueggea virosa* (Roxb. ex Willd.) Voigt	White berry-bush	Shrub	Wild	Leaves	Remedy for abdominal pains	0.04
Verbenaceae	*Gmelina arborea* Roxb.	Gmelina	Tree	Plantation and naturalized situation	Fruits, seeds	Remedy for healing of wounds	0.04
Malvaceae	*Gossypium* sp. L.	Cotton tree	Herb	Cultivated	Leaves, roots	Remedy for malaria	0.04
Lamiaceae	*Hyptis suaveolens* (L.) Poit.	American mint, bush mint, chan, horehound, pignut	Herb	Wild	Leaves	Remedy for malaria	0.04
Solanaceae	*Lycopersicon esculentum* Mill.	Tomato	Herb	Cultivated	Leaves, bark	Remedy for abdominal pains	0.04
Flacourtiaceae	*Oncoba spinosa* Forssk.	Snuffbox tree	Shrub	Wild	Fruits, seeds	Food	0.04
Poaceae	*Pennisetum glaucum* (L.) R.Br.	Pearl millet	Herb	Cultivated	Leaves, bark	Remedy for malaria	0.04
Fabaceae	*Senna occidentalis* (L.) Link	Antbush, coffee *Senna*, Negro coffee	Herb	Wild	Leaves, roots	Remedy for healing of wounds	0.04
Fabaceae	*Senna siamea* (Lam.) H.S.Irwin & Barneby	Kassod tree, cassod tree and cassia tree	Tree	Wild	Fruits	Food	0.04
Solanaceae	*Solanum macrocarpon* L.	African eggplant	Herb	Cultivated	Leaves	Food	0.04
Combretaceae	*Terminalia glaucescens* Planch. ex Benth.	–	Tree	Wild	Bark	Energetic	0.04
Fabaceae	*Vigna unguiculata* L.	Black-eyed pea, cowpea	Herb	Cultivated	Leaves, fruits, seeds	Food	0.04

Appendix 2: Categorization, frequency distribution and number of plants involving in each reuse

Use category	Use	Specific use	Frequency	Number of plants reported
Medicinal	Gastrointestinal	Abdominal disorders	17	26
		Ulcer	6	8
		Hemorrhoids	4	3
		Dysentery	5	7
		Wounds	4	3
		Diarrhea	7	11
	Infectious	Malaria	11	26
		Fever	11	16
		Icterus	1	1
	Respiratory system	Cold	6	9
		Cough	1	1
	Urinary system	Kidney damage	2	4
	Reproductive system	Painful menstruation	3	5
	Muscular	Energetic	1	1
	Circular system	Anemia	2	3
	Nervous system	Paralysis	1	1
	Buccal	toothache	1	1
Food	Food	Vegetable leaves	3	4
		Vegetable fruits	1	2
		Fruits	12	13
		Cereal	1	5

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