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Technical Characteristics and Socio-Economic Importance of Beekeeping in the Far North Region, Cameroon

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Beekeeping is a booming industry in Cameroon, thanks to the interests shown by the population in certain regions, notably Adamawa, West, North-West, and East, yet its productivity remains low. In the villages of the Far North region in particular, beekeeping is an age-old practice. A study on the technical characteristics and socio-economic importance of beekeeping has been carried out in the Far North region, with a view to contributing to the elaboration and facilitation of the development of the beekeeping sector in this zone. Ethno-beekeeping surveys of 52 beekeepers were carried out between July-August 2019 in six villages using snowball strategies, including four villages (Maga, Ngoulmoung, Modiogo, and Gamack) for the Maga subdivision and one village each for the Kaélé and Mindif subdivisions respectively. The main sections of the questionnaire concerned the socio-

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demographic characteristics of beekeepers, the use of hive products, and, finally, beekeepers' perception of their knowledge of beekeeping plants. It was noted that beekeeping in the area is a secondary activity (89%), mainly practiced by men (98%) and farmers (63.46%). Beekeeping practices are still predominantly traditional (68.57%). Apiaries are preferably located in orchards (37.14%). Swarm capture technical are still based on traditional technical, with satisfactory hive populating rates (94.28%); however, wax remains the most common bait used by beekeepers. Beekeepers make an average of 3 visits a month, mainly to stock the apiary, monitor the hives, and harvest the honey. Insufficient supervision, financial problems, humidity, hive theft, pesticides, wind, and bush fires are the main obstacles to beekeeping in the area. Honey is the main product exploited by all beekeepers. Honey is a key element in the treatment of cough/colds (25.83%), skin ailments, and wounds (25.95%). It is also used to soothe memory disorders. Some thirty plants have been recognized by beekeepers as food resources for bees. For sustainable beekeeping, there is an urgent need to review the issue of hive management and suitable technical for a better yield of hive products in the area.

Keywords: Honey; beekeeping technical; monetary income; uses; Cameroon.

1. INTRODUCTION

Beekeeping is an important activity for the development of agriculture through the pollination provided by honey bees, its various productions, the jobs it generates, and the substantial income it provides. Worldwide, honey is one of mankind's oldest foods [1]. It is undoubtedly the first natural sweet substance produced by the *Apis mellifera* bee, from plant nectar or from the excretion of foraging insects left on living plant parts, which the bees gather, transform by combining them with specific substances they secrete themselves, deposit, dehydrate, store and allow to refine and mature in the hive combs (Ben et al., 2019). Beekeeping is the keeping of bees for the production of honey and other products of the hive [2].

In Cameroon, beekeeping is an age-old tradition [3]. Since 1990, it has been encouraged as a vegetation conservation strategy [4]. It is becoming an important socio-economic activity in some regions of Cameroon [5]. National beekeeping and honey production, at the forefront in the Central African region, are growing strongly in the Adamaoua, West, North-West, and East regions [6]. Optimizing honey production in an area requires a thorough understanding of the area's technical potential, the climatic factors involved, the importance of integrating beekeeping into the agricultural sector, the commercial channels for hive products and the impact of beekeeping on other economic activities [1]. In the Far North region, research into the relationship between plants and honey bees is recent and little known. Studies carried out here include those by Dounia et al. [7] and Tchindebe et al. [8], who, respectively, studied the foraging and pollination activity of *Lipotriches collaris* (Hymenoptera: Halictidae) on *Glycine max* (Fabaceae) flowers and on the diversity of floricultural insects and its impact on fruit and grain yields of *Arachis hypogaea* (Fabaceae). The Far North region is by far the most northerly part of Cameroon to experience major environmental uncertainties (Jebkalbe, 2010), which could have an impact on the diversity of bee flora in this part of the country. To successfully promote the beekeeping sector in this region, it is essential to extend the study to its socio-economic importance. The aim is to identify the beekeeping practices used and to assess the socio-economic importance of honey production, with a view to better diversifying the sources of income of agro-apiculturists in this region of the country.

2. MATERIALS AND METHODS

2.1 Study Site

The study was conducted between July and August 2019 in six villages, belonging to three subdivisions: Maga, Mindif and Kaélé, in the Far North region of Cameroon. The Far North region (Fig. 1) is located between the 10th and 11th degrees of north latitude and between the 14th and 15th degrees of east longitude. The climate is a tropical Sahelian type which is marked by spatio-temporal rainfall variability that tends towards drought (Jebkalbe, 2010). It comprises a long dry season (November-May) and a short rainy season that generally lasts three months (June-October) (Jebkalbe, 2010). Annual rainfall is 811mm. Annual rainfall is concentrated for the most part in the 4th to 5th months from June to October [9], with a maximum observed in August.

The annual temperature fluctuates between 21 and 22°C, with a daily temperature range of between 6 and 7°C [8]. This region has an area of 3,424,600 ha with a population of around 3,480,414 inhabitants for a density of 101.6 inhabitants/km2 [10]. The ethnic groups found here are the Moundang, Toupouri, and Guiziga, the majority of whom live in Mayo Kani. The Massa, Toupouri, Kanouri, and Peul people live in Mayo Danay [11]. Agriculture is therefore the main activity practiced by the people of the Far North. The categorization of vegetation in the Sudano-Sahelian zone is as follows: thorn steppes in the peneplains, vast grasslands covering areas that are periodically flooded or yaéré, wooded savannahs and open forests in the highlands [12]. The most widespread vegetation types are shrub savannahs and tree savannahs, with plant species dominated by *Anogeissus leiocarpus*, *Balanites aegyptiaca*, *Guiera senegalensis*, *Piliostigma thonningii*, *Acacia seyal*, *Ziziphus mauritiana*, *Acacia albida*, *Acacia nilotica* and *Acacia senegal* (Beidi, 2020). Cotton, onions and irrigated rice are the main export crops. Other crops such as millet, maize, groundnuts, and cowpeas are the dominant crops in the region.

2.2 Ethno-Beekeeping Surveys

Surveys were carried out among 52 beekeepers in six villages (Maga, Ngoulmoung, Gamak, Modiogo, Garey, and Mindif) belonging to three different subdivisions. The choice of villages took into account the presence of beekeepers and the presence of beekeeping practices using snowball strategies. Honey hunting activities were also considered.

Information on beekeeping practices among villagers and semistructured interviews were conducted with beekeepers in the six villages, using a preestablished questionnaire. The questionnaire consisted of three types of questions: open-ended, closed-ended, and leading questions. Open-ended questions allowed respondents to answer according to their knowledge. Closed-ended questions were answered with "Yes" or "No", while open-ended questions allowed respondents to choose one or more answers. The main sections of the questionnaire dealt with the socio-demographic characteristics of beekeepers, the use of hive products, and, finally, beekeepers' perceptions of their knowledge of honey bees plants. The survey was followed by a visit to the apiaries to observe the nature of the apiary and the types of hives set up by each beekeeper.

The socio-demographic characteristics of the beekeepers covered: sex, age, main activities, level of education, reasons for beekeeping practices, type of apiary and hive, beekeeping technical and practices used, economic

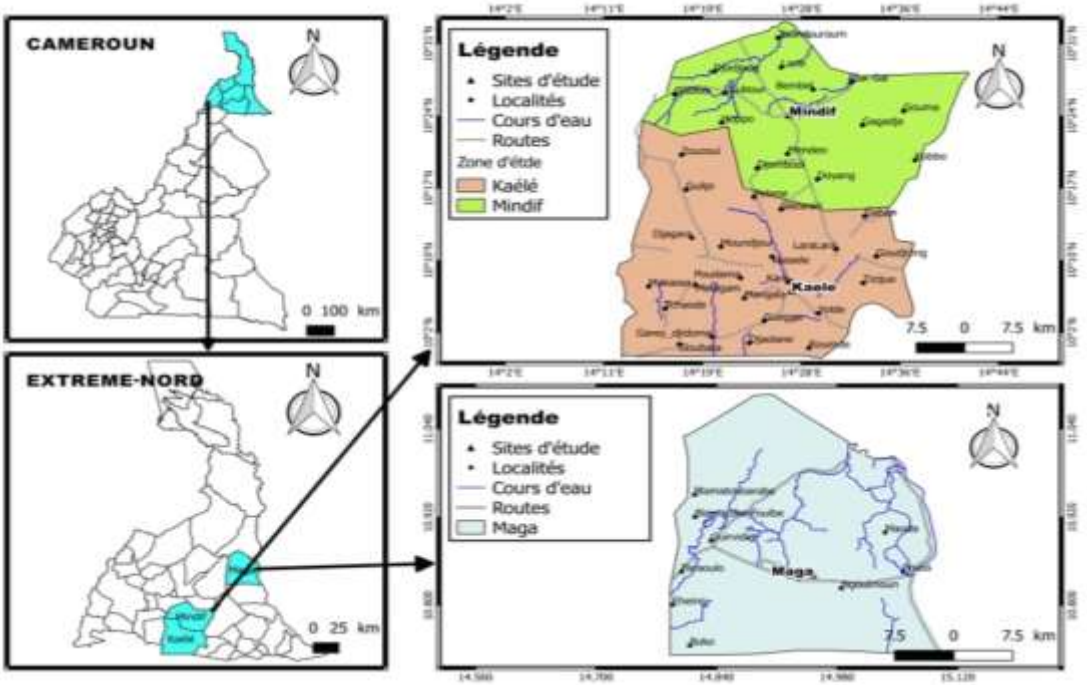

Fig. 1. Map of the study area

importance of honey production, use of hive products, length of time in beekeeping, and constraints and prospects linked to honey production. The ages of the beekeepers, expressed in years, were subdivided into five classes ≤ 30, [30-40], [40-50], [50-60], >60. Seniority in beekeeping expressed in years was grouped into four classes (≤ 10 [10-20], [20-30], > 30).

Based on the survey, data, productivity was assessed by the type of hive and apiaries for each locality. The parameters that were evaluated were: the quantity of honey harvested per hive, the period of honey harvest in the year, the quantity of honey produced by the beekeeper, the number of honey harvests/hive/season/year, other products of the hive and their uses. The beekeepers cited plants whose flowers are commonly visited by bees near their apiaries. The frequency with which species were cited was expressed as a percentage according to the use value that beekeepers attach to these species.

2.3 Data Processing

The sphinx software was used to create the questionnaire and to process the survey data. All data collected was coded using Excel 2016, which was also used to produce the graphs. Statistical analyses of the data (frequencies, cross-tabulation) were coded using R software version 4.1.0.

3. RESULTS AND DISCUSSION

3.1 Socio-Demographic Characteristics of Beekeepers

3.1.1 Distribution of beekeepers by gender

Beekeeping in this zone is an activity that is essentially carried out by men (98%) compared to women. Beekeeping remains essentially a male activity because of the social charges, the aggressiveness of the honey bee *Apis mellifera,* and the nocturnal activities required. These results are in line with those obtained by Issaka et al. [13] in south-central Burkina Faso and those of Savadogo et al. [14] in Baoulé society in Côte d'Ivoire. On the other hand, Kenmogne et al. [15] obtained a fairly significant involvement of women (13 to 28%) in beekeeping activities in the North-West region of Cameroon, although it is still fairly low. Furthermore, the dominance of traditional male perception and practice of honey production activities in the study area showed that original male work should only be done by men as reported by Amare et al*.* [16] in Ethiopia. There is also a report indicating a cultural barrier to the prohibition of women going out at night preventing them from undertaking honey harvesting [17].

3.1.2 Distribution of beekeepers by age group

All five age groups are observed in the zone (Fig. 2). The highest number of beekeepers were recorded in the [30-40] age group, with a rate of 30.7%. Next come those aged]40-50] (26.92%), which represents the middle class, followed by those aged [50-60] (23.07%). The age groups ≤ 30 years and > 60 years are the least represented with 11.53% and 7.69%, respectively. The number of beekeepers aged between [30-40] is very high due to the fact that beekeeping is considered a secondary activity to agriculture, carried out by this age group, which makes up the majority of the working population and has heavy responsibilities towards their household. Similar results were obtained by Ahouandjinou et al. [1] in north-west Benin and by Issaka et al. [13] in south-central Burkina Faso. However, the age range of beekeepers in the study area is different from that found in the highland area of West Cameroon [15]. Around 55% of the beekeepers identified are government employees and artisans. This represents an asset to the development of modern beekeeping, as optimizing yields requires producers to have a sufficient number of colonized hives and endogenous knowledge [18]. This means that the financial resources needed to set up a beekeeping business are within the reach of this segment of the farming community.

3.1.3 Distribution of beekeepers according to the length of time in beekeeping

In terms of seniority in beekeeping, the number of years spent in beekeeping varies from one beekeeper to another. Beekeepers between [10-20] years of beekeeping activity are the most represented, followed by those with less than 10 years (36.53%). The least represented are beekeepers in between [20-30] and those with more than 30 years' experience in beekeeping (Fig. 3). This shows that beekeeping is not a very old activity in the study area. Similar results were recorded by Ahouandjinou et al. [1] who worked on the technical characteristics and socio-economic importance of beekeeping in north-west Benin.

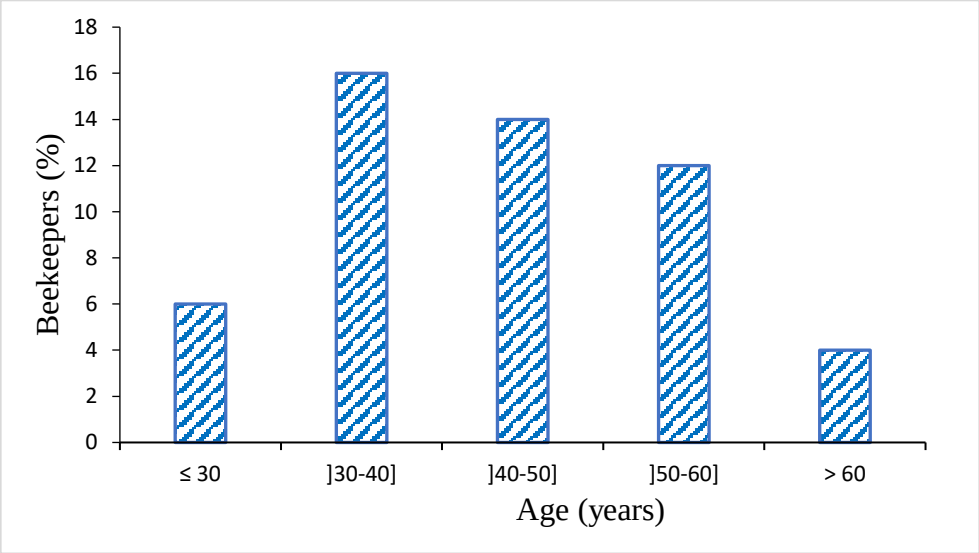

Fig. 2. Distribution of beekeepers by age group (years)

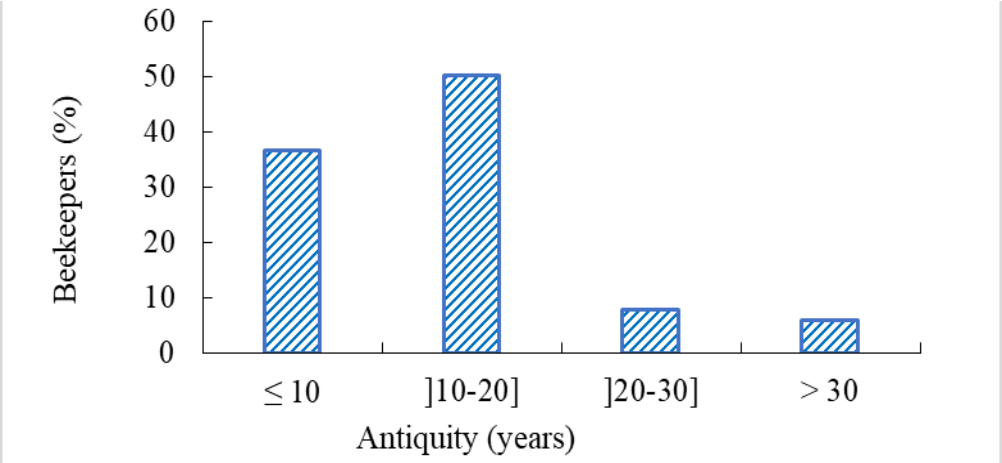

Fig. 3. Distribution of beekeepers according to the number of years in beekeeping

3.1.4 Beekeepers by occupation

Beekeepers' activities are diversified, with a very high proportion (63.46%) of farmers, followed by shopkeepers (26.82%) and employees (9.61%) (Fig. 4). Farmers are the most represented; agriculture is the main source of financial income for the population. The predominance of farmer beekeepers has also been found in the locality of Oku [12]; in the Sudano-Guinean zone of Adamaoua [19], in the highlands of West Cameroon [20,21,22] and in North-West Cameroon [23] on gender and beekeeping.

A proportion of 9.61% of beekeepers, exclusively in the Maga area, have received training in beekeeping and are able to put into practice the new beekeeping technical they have acquired. In general, more than 94.23% of beekeepers used their own funds as their main source of financing. The beekeepers who received training (9.61%) work in a joint initiative group called GIC ABAKAI. Training and/or refresher courses were provided by an organization called SANA Logone and co-financed by ACEFA. Approximately 40.38% of beekeepers belong to an association and 59.61% do not benefit from supervision (Table 1). The aim of these structures is to promote activities that complement agricultural work in rural areas, such as modern beekeeping, in order to build farmers' capacity, combat food insecurity, and preserve natural resources such as melliferous plants, which are the basis for ensuring that optimum quantities of honey are harvested [1]. The results are similar to those obtained by Kenmogne et al. [15] in north-west

Cameroon on the socio-economic and technical characteristics of beekeeping in the Bamboutos, Mifi and Menoua Divisions.

3.1.5 Distribution of beekeepers according to educational status

Concerning their educational status, 5.76% can neither read nor write French. Beekeepers with secondary education (48.07%) are the most represented, followed by those with primary education (25%) and university education (21.15%) (Table 2). Around 46.15% of beekeepers (Table 2) have received a school education (secondary and university), which could be an asset in the implementation and adoption of new beekeeping technical. The interest in beekeeping shown by young secondary school and university graduates is an important asset for training in modern beekeeping and for promoting and intensifying honey production. However, the lack of education does not have enough impact on the activity, since they have already been harvesting honey or practicing traditional beekeeping for several years, and thus have the knowledge likely to have a positive impact on modern beekeeping [13].

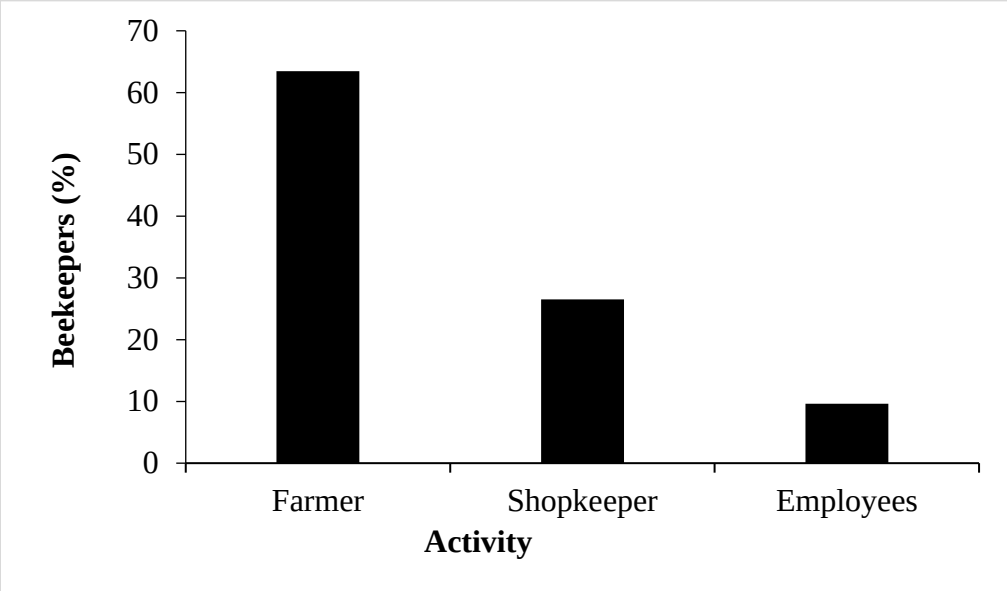

Fig. 4. Distribution of beekeepers according to their main activities

Table 1. Distribution of beekeepers (number) according to: training in beekeeping, sources of funding and membership of an association

Activity		Subdivisions			Totality
		Maga	Kaélé	Mindif	
Beekeeping formation	**Yes**	5	0	0	5
	No	45	1	1	47
Source of funding	**Clean bottom**	47	1	1	49
	Clean bottom and donations	3	0	0	3
Membership in an association	**Yes**	21	0	0	21
	No	29	1	1	31

Table 2. Distribution of beekeepers according to educational level

Level of study	Nomber of beekeepers	%
No school	05	5,76
Primary	25	48,07
Secondary	13	25
University	11	21,15
Totality	**52**	**100**

3.1.6 Warm capture and honey harvesting periods at the site

The swarming period varies from one subdivision to another. Bee swarm capture and honey harvesting correspond to the dry season (October to June) in the Maga district. Bee swarms are collected between April and August, and honey is harvested between March and June in the Mindif and Kaélé areas (Table 3). Harvesting is carried out once a year. The reason for this is that it is difficult to handle the hives during the wet season due to the flatness of the ground in the Maga area, which gives way to marshland, and there are very few bee colonies in the Kaélé and Mindif areas due to honey hunting, which affects honey production. The results are similar to those of Kenmogne et al. [15].

3.1.7 Beekeepers by type of hive used

Two types of hives are known to be used by beekeepers: traditional hives and modern hives (Fig. 5). These types of hives are designed in different forms thanks to indigenous knowledge and the availability of local raw materials: conical straw hives, basket hives (Maga and Kaélé, Mindif), canary hives and hives in an empty tree hole (Kaélé, Mindif). Modern hives are found exclusively in Maga. More than 2/3 of beekeepers (68.75%) used traditional hives, followed by those using both traditional and Kenyan hives (22.91%). Very few (8.33%) use Kenyan hives. Traditional hives are still the most widely used, certainly due to the availability of raw materials and indigenous knowledge. This situation could also be explained by the inability of most beekeepers to find the financial means to purchase modern hives. The work of Meutchieye et al. [24] shows that fixed and movable frame hives are the two types used in Cameroon, with fixed hives commonly used in savannah areas because of their ease of use. The results are in line with previous studies carried out in south-central Burkina Faso [25], (Nombre, 2003), which show that modern hives are rarely used. Similar results were observed by Amare et al. [16] in Ethiopia where 70.75% of beekeepers use traditional hives followed by 19.81% who use modern hives and about 9% of beekeepers who use both types of hives at the same time. However, the results are not in agreement with those of Ahouandjinou et al. [1] who observed a higher use of mixed hives showing a modernization of beekeeping in the commune of Cobly in the north-west of Benin. The combination of modern and traditional hives increases beekeepers' income [1].

3.1.8 Types of bait used and honey bee swarm capture

A total of six baits were used by beekeepers: wax, perfume, fresh sorghum bran, and citronella (Fig. 6). Wax was the most popular bait (80.36%), followed by perfume (12.50%), fresh sorghum bran (3.57%), and citronella (3.57%). The success rate for capturing swarms of honey bees varies from 50% to 100% from one beekeeper to another. Irrespective of the district, wax is the bait most frequently cited by beekeepers. The availability and easy accessibility of wax to beekeepers justifies its frequent use. Various types of bait (wax, palm oil + cooking salt, cane sugar, honey, raffia wine, citronella and/or palm oil, bee hornwort) used were also reported by Kenmogne et al. [15] in the North-West and by Tchoumboué et al. [20], Njia [21] and Zango [22] in West Cameroon. Regarding the organs used to attract swarms, our results complement those of Issaka et al. [13] who also used organs of certain species such as leafy stems of *Combretum glutinosum*; bark of *Vitellaria paradoxa* and fruits of *Piliostigma thonningii* to attract the bee colony.

3.1.9 Hive products harvested in the area

Four main hive products are harvested: honey, wax, propolis, and pollen (Fig. 7); however, the proportions vary according to the beekeepers and the study areas: honey is the main product harvested by all beekeepers, followed by wax (92.30%), pollen (88.46%) and finally propolis (15.38%). Propolis remains by far the least sought-after product in the hive. Honey is harvested during the lean season (October to May), as is their custom. The lack of outlets, the inability to process certain products (wax and propolis) from the hive, or ignorance of harvesting techniques could explain the low use of these products by beekeepers. This observation has also been made by certain African authors [20], (Nombre, 2003); [26]. In fact, beekeepers use wax and propolis mainly as bait to attract bees to the next hive [13], since they are not intended for marketing.

Table 3. Distribution of swarm capture periods and annual honey harvest according to borough (the letters correspond to the months of the year)

Districts	Period of the year (month)											
	J	F	M	A	M	J	J	A	S	O	N	D
Maga												
Kaelé												
Mindif												

Legend: Swarming period, Harvested honey period

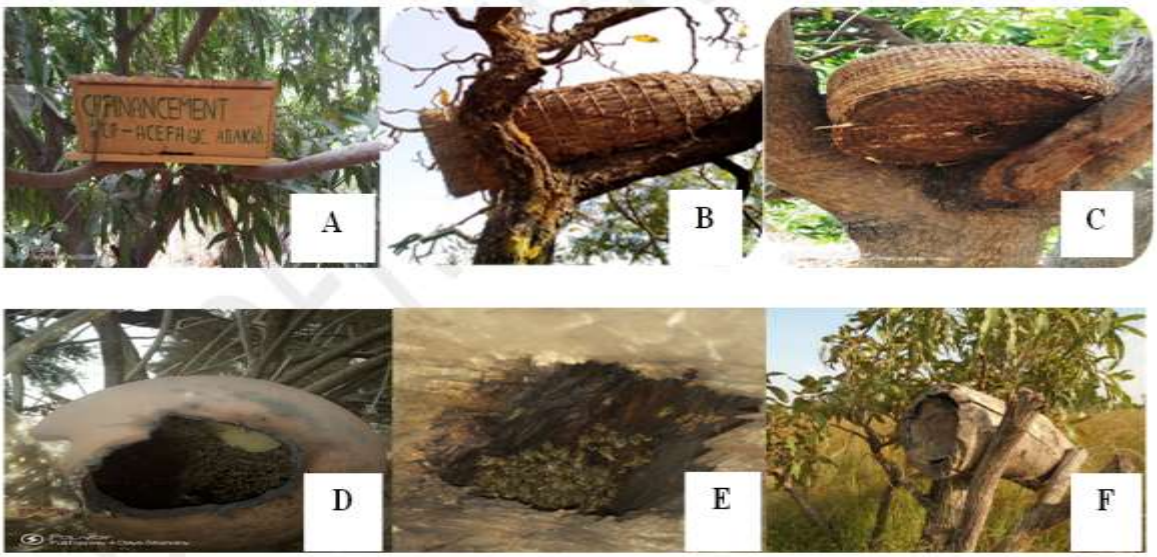

Fig. 5. Types of hives in different shapes: A modern hive (Kenyan hive) was placed on a *Mangifera indica* stand (Maga). B Traditional straw-covered conical hive with a stand of *Terminalia macroptera* (Maga, Kaélé and Mindif). C Traditional hive in a basket with a stand of *Mangifera indica* (Maga). D Traditional hive in a canary pot with the branches of *Jatropha curcas* (Kaélé). E Natural beehive in a hole of *Anogeissus leocarpa* (Kaélé). F Traditional hive in a hollowed tree trunk at the foot of *Terminalia macroptera* (Mindif)

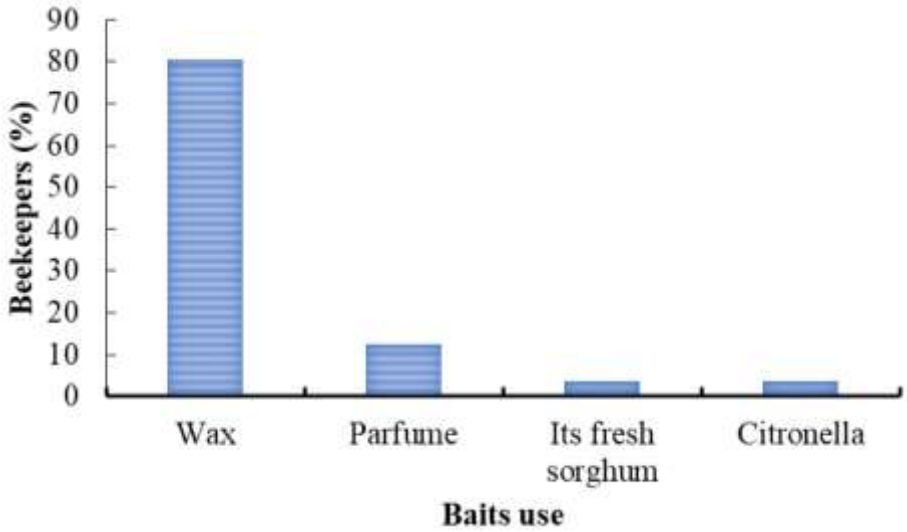

Fig. 6. Distribution of beekeepers (%) according to the type of bait used

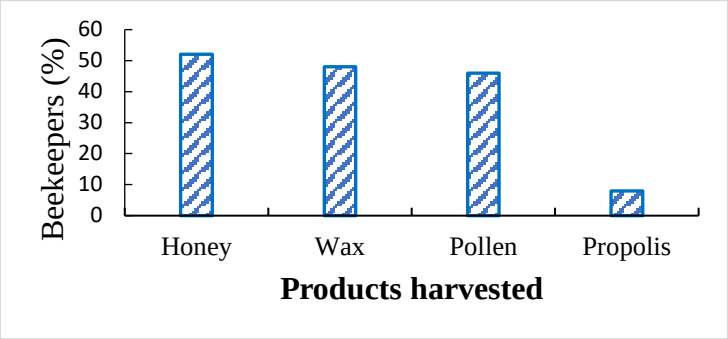

Fig. 7. Distribution of beekeepers according to the products harvested from the hive

3.1.10 Types of plant formation hosting apiaries

Three types of vegetation were identified for apiaries: orchards, fields, and savannah/ fallow land. Orchards are the plant formation where 61.53% of beekeepers set up their apiaries. They are followed by fallow land/savannah (32.69%), and fields (5.76%) (Table 4). The reason for locating apiaries in orchards is to bring the hives closer to the concessions to facilitate surveillance, water supply, and honey harvesting. In these agrosystems, the feet of the trees also provide support for the hives. Dongock et al. [27] pointed out that certain agroforestry species are maintained in agrosystems because of their multiple uses by local populations. Agrosystem beekeeping plants include fruit trees (*Mangifera indica*, *Psidium guajava*, *Citrus lemon,* and *Eucalyptus camaldulensis*), cereal crops (*Phaseolus vulgaris* and *Arachis hypogea*), vegetable crops (*Hibiscus esculentus* and *Gossypium hirsutum*) and cereals (*Zea mays* and *Sorghum bicolor*). However, the installation of apiaries in fields and savannah poses problems of pesticides and uncontrolled bush fires, which can easily destroy bees and hives. In the field, certain pesticides, even in low doses, affect bees [13].

In general, the time devoted to monitoring beekeeping activities and hives is very negligible at 3 visits per month. This result corroborates that of Tsafack et al*.,* [28], who estimated in a study carried out in north-west Cameroon that beekeeping operations were very little monitored. Beekeeping therefore remains a secondary activity and most visits are devoted to harvesting honey and weeding apiaries [14].

3.1.11 Beekeeping plants identified by beekeepers

The forage plants visited by the honey bees, most of which serve as capture sites for wild colonies and are known to beekeepers, are presented in Table 5. A total of 30 beekeeping species, grouped into 30 genera and 21 families, were identified. The most important families are Fabaceae (19%), Myrtaceae (16.65%), Anacardiaceae (11.89%), and Poaceae (10.11%). Caricaceae (8.92%) and Araliaceae (7.14%) are in the majority. They are followed by species such as *Citrus lemon* with a citation rate of 5.95%; *Faidherbia albida* (5.35%) and *Acacia seyal* (4.76%). This would be justified by the fact that the area is characterised by vegetation dominated by Fabaceae, Myrtaceae, and Anacardiaceae, which are the plants found in orchards. The results are similar to those of Amare et al*.*, [16] in Ethiopia, who revealed that Fabaceae are the most represented (12.10%), followed by Asteraceae (9.7.5%). Euphorbiaceae, Poaceae, and Rosaceae are represented by five species each (4.17%). The results of Dongock et al. (2017) on the ecological importance and beekeeping potential of the periphery of the Manda National Park in the

Table 4. Distribution of beekeepers according to the type of plant formation housing their apiaries

Types of plant formation	Number of beekeepers	%
Orchard	32	61,53
Field	03	5,76
Savannah/fallow	17	32,69
Totality	**52**	**100**

Sudanian zone of Moyen-Chari (Chad) confirm that the foraging behaviour of bees is linked to the structure of the vegetation.

The most common morphological types are trees (56.66%), followed by grasses (23.33%), shrubs (16.66%), and bushes (3.33%). The dominance of trees can be explained by the fact that beekeepers devote more time to beekeeping during the dry season, which is the best time for trees to flower. Similar results were obtained by Ahouandjinou et al. (2021) in north-west Benin, where woody species (trees, shrubs, and lianas) represent the most abundant source of nectar for bees, with 55.75% of the melliferous plants recorded. Of the 35 melliferous plants recorded by Dongock et al. [29] in the ethnobotanical study of melliferous plants in the Sudano-Sahelian zone of Chad more than 90% are trees. Trees (54.90%) are also more represented in the work done by Dongock et al. [30] on plants foraged by *Apis mellifera* in southern Chad. However, the work of Dongock et al. [31] on the inventory and identification of melliferous plants in the highland Sudano-Guinean zone of western Cameroon shows that grasses are the most represented (36.5%). This is due to the fact that these studies were carried out in very different agro-ecological zones.

The distribution of honey plants according to flower colour shows a great diversity of colours within and between families. A total of ten flower colours were observed (white, yellow, whitish, greenish-yellow, yellow-green, yellowish, red, yellow-white, pink-white, and greenish). White flowers (43.33%) were the most common, followed by yellow (13.33%) and red (10%). This suggests that the attractiveness of white flowers is linked to their brightness and/or their easily identifiable odour for honey bees. In addition, the white colour of the flowers was the biochemical factor that attracted the bees, certainly due to the presence of flavonoids, a group of floral pigments that contribute to cyanic colours such as white, orange, red, blue and yellow [32]. This work corroborates that of Dongock et al. [31] in the highland Sudano-Guinean zone of western Cameroon and that of Dongock et al. [33] in southern Chad, who emphasised that white flowers were the most represented.

Plants with a high frequency of visits are represented by species such as: *Mangifera indica* (11.30%), *Eucalyptus* sp (8.92%), *Carica papaya* (8.92%), *Psidium guajava* (7.73%), *Zea mays* (7.73%) and *Azadirachta indica* (7.14%). These plant species are the most visited by bees, certainly because they are the plants in the agrosystems where beekeepers set up their apiaries. Plants such as *Zea mays*, *Carica papaya,* and *Azadirachta indica* represent, respectively, the crops surrounding orchards, home gardens, and the plant physiognomy of dwellings throughout the study area. The results are not in agreement with those of Issaka et al. [13] who worked on the characterisation of beekeeping in the riverside villages of corridor n°1 of the Pô-Nazinga-Sissili Complex (PONASI) in the Centre-South of Burkina Faso and showed that *Vitellaria paradoxa*, *Parkia biglobosa* and *Lannea microcarpa* are the species with the highest foraging intensity. Work by Dongock et al. (2007) on the spectrum of melliferous plants in the highland Sudano-Guinean zone of western Burkina Faso showed that 60% of plants are visited by Eucalyptus pollen.

3.1.12 The economic importance of honey

The price of a litre of honey varies from 1000 to 3000 FCFA. Independently of the beekeepers, 38.86% of beekeepers sell their honey at 2500 FCFA, followed by those selling at 3000 FCFA (32.69%) and 2000 FCFA (26.92%) respectively. However, beekeepers who sell their honey at 1500Fcfa and 1000Fcfa are less represented.

Table 6 shows that the gross profit can vary from simple to double depending on whether the beekeeper uses traditional or modern hives. The gross profit varies from 2000Fcfa to 4500Fcfa and is 30000Fcfa, respectively, for traditional and modern hives per year. The price of a litre of honey varies from 1000 to 3000 FCFA depending on the beekeeper. Nearly 38.86% of beekeepers sell their honey at 2500 FCFA followed by those selling at 3000 and 2000 FCFA, respectively, with 32.69% and 26.92%. The high cost per litre of honey is justified by the fact that the demand is higher than production in the study area. The results differ from those of Founadoudou [19] in the Sudano-Guinean zone of Adamaoua, where prices vary from 300 to 1700 FCFA. In the rural areas of Adamawa, irrespective of the groups, nearly 84% of beekeepers sell their honey for between 500 and 1000 FCFA [6]. The work of Tchuenguem et al. (2007) has shown that the largest amount of honey consumed on the market in Cameroon comes from the Adamawa region, thanks to its melliferous potential.

Table 5. List of bee species known by beekeepers around their apiaries

Species	Familly	Biological type	Colour of flowers	Frequency
Acacia seyal Del.	Fabaceae	Tree	Yellow	4.76
Adansonia digitata L.	Malvaceae	Tree	White	1.78
Annona senegalensis Pers.	Annonaceae	Shrub	Whitish	2.38
Anogeissus leiocarpa (DC.) Guill.& Perr.	Combretaceae	Tree	Yellow-greenish	0.59
Azadirachta indica A.Juss.	Araliaceae	Tree	White	7.14
Bidens pilosa L.	Asteraceae	Herb	White	1.19
Carica papaya L.	Caricaceae	Small tree	White	8.92
Citrus lemon (L) Burm. f.	Rutaceae	Small tree	White	5.95
Combretum glutinosum Perr. Ex DC.	Combretaceae	Tree	Yellow-green	2.38
Cucurbita pepo L.	Cucurbitaceae	Herb	Yellow	1.78
Diospyros mespiliformis Hochst. Ex A.DC.	Ebenaceae	Tree	White	1.19
Eucalyptus sp. Dehn.	Myrtaceae	Tree	White	8.92
Faidherbia albida Del.	Fabaceae	Tree	Yellow	5.35
Hexalobus monopetalus (A.Rich)Engl.&Diels	Annonaceae	Tree	Yellowish	2.38
Hymenocardia acida Tul.	Phyllantaceae	Small tree	Red	1.19
Hyphaene tebaica (L) Mart.	Arecaceae	Tree	Whitish-yellow	1.19
Mangifera indica L.	Anacardiaceae	Tree	White-pink	11.30
Parkia biglobosa (Jacq.) R.Br. ex Benth	Mimosaceae	Tree	Red	0.59
Phaseolus vulgaris L.	Fabaceae	Herb	White	1.19
Psidium guajava L.	Myrtaceae	Tree	White	7.73
Sclerocarya birrea (A. Rich) Hochst.	Anacardiaceae	Tree	Red	0.59
Sesamum indicum L.	Pedaliaceae	Herb	White	1.19
Sorghum bicolor L.	Poaceae	Herb	Yellow-green	2.38
Tamarindus indica L.	Fabaceae	Tree	Yellowish	2.97
Tridax precumbens L.	Asteraceae	Herb	White	0.59
Vitellaria paradoxa C.F Gaerth	Sapotaceae	Tree	White	1.19
Vitex doniana Sweet.	Lamiaceae	Tree	White	1.78
Ximenia americana L.	Ximenaceae	Small tree	Greenish	1.19
Zea mays L.	Poaceae	Herb	Yellow	7.73
Ziziphus mauritiana L.	Rhamnaceae	Small tree	Greenish	2.38

The average volume of honey harvested per hive which is 11 ± 3.47 litres for a modern hive and 3 litres for a traditional one indicates a good yield in the study area. This average honey yield per hive is similar to that of the Cobly commune, which is 10.55 ± 3.56 litres [1], and the West Cameroon highlands, which is 10 litres [20]. However, this is significantly higher than the 3.95 litres obtained in the Lama [34] and the 8.4 to 15 kg (i.e., around 4 to 7.5 litres) of honey indicated for West Africa [35]. It reveals the availability of wild colonies of the local bee that can be enriched by beekeepers in modern and/or traditional hives, and the availability of melliferous plants and nutrients throughout the year, allowing good continuous foraging activity by honey bees in the study area [1]. This confirms that the honey production potential of a region is determined by many factors, including the type of hive, the importance of multispecific natural formations constituting abundant nutritional resources for bees, and control of the floral calendar [36].

3.1.13 Food, therapeutic and magical uses of honey

Honey is increasingly in demand for its many uses. In food, they use honey as a source of sugar for coffee and/or porridge. In traditional medicine, honey is used to treat 10 ailments (Table 7). Cough and burns are the ailments for which honey is most commonly used (22.87% each), followed by headaches (16.25%). Other conditions for which honey is used in small proportions include fever in children (8.77%), insomnia and earaches (7.02%), mental fatigue (5.86%), malaria (3.58%), hypertension (3.22%) and common cold (2.96%).

In terms of form of use, honey is used in its raw state to treat 93.38% of illnesses and symptoms, and in its pure state to treat 47.22% of ailments. It is diluted in other solutions for 39.14% and mixed with plant organs for 13.18% of the diseases and symptoms cited.

As far as the routes of administration of honey-based remedies are concerned, the oral route predominates with 87.14%, 63.71% of which is by mouth and 24.43% as a drink. Massage (5.22% each) is the external route, and auricular instillation accounts for 2.37%.

Dosage varies according to the condition and how far it has progressed. In fact, 53.56% of diseases must be treated by taking two or three doses a day for at least a week. The remainder (48.32%) must be treated with a single dose taken once a day for a week for rapid relief. The therapeutic virtues we have gathered, complement, or confirm the results of other studies already carried out in Burkina Faso [1] and in certain African countries [34,1]. These results show that honey is sold, consumed, and used in the treatment of various ailments depending on the different cultures. The relatively high frequency (22.87%) of citations recognised by the beekeepers interviewed for the treatment of cough and burn by honey confirms the results obtained by Ahouandjinou et al. [1] which reveal that burn (16.27%) and cough (16.27%) are the most common ailments in the study area for which honey is solicited for their treatment. Similarly, coughs are the illness most frequently recognised by beekeepers in Lama (46.70%) and Manigri (88.57%) [34]. This is justified by the effectiveness of honey-based treatment against these diseases. This finding can be explained by honey's numerous antibacterial and anti-inflammatory properties, and its osmotic effect, which allows bacteria to be dehydrated, thereby reducing pain and inflammation and promoting the formation of granulation tissue and rapid wound healing [1]. Similarly, honey has antitussive, expectorant, and soothing effects that help combat respiratory ailments [37]. In addition, the plants visited by bees contain essential oils that are well known for their antiseptic effects on the respiratory system [38].

3.1.14 Constraints and prospects for beekeepers

The main constraints vary from site to site. Beekeepers (86.53%) are faced with problems of inadequate supervision, followed by financial problems (84.61%), humidity (75%), and hive theft (40.38%). Other constraints include strong winds (32.69%), the use of pesticides in the fields surrounding the apiaries (28.84%), the destruction of hives (25%), bee enemies (15.38%) and bush fires at the end of the rainy season (13.46%) (Fig. 8). This can be justified by the fact that beekeepers spend less time on beekeeping and by the abusive use of pesticides in the fields without taking account of the ecosystem value that bees play. Bush fires are also a problem, as they often escape hunters during the hunting season, when the grassy savannah is easily invaded. Other authors [21,22,20,23,19], (Fotso 2014; Ngamadjeu 2016) have identified constraints linked to financial problems and inadequate supervision in the

West and Adamawa regions. The phenomenon of bush fires has also been reported by Tchoumboué et al. [20]; Lekane (2018); Nassé (2018) in the West, Centre and Adamawa regions.

Some 92.30% of beekeepers have opted to continue beekeeping as a secondary activity by increasing the number of hives. Nearly 82.76% of beekeepers would like to receive training to develop beekeeping, allowing them to exploit certain products of the hive such as pollen and royal jelly (44.23%). Next come those who want to choose the location of their apiary (42.30%) for the development of uncultivated land unsuitable for agriculture. The case of abandonment is only represented by 5.76% of beekeepers. Around 92.30% of beekeepers have opted to continue beekeeping as a secondary activity. This is justified by the fact that beekeepers want to increase their financial income and to develop uncultivated land unsuitable for agriculture.

Table 6. Beekeeping budget by type of hive

Beekeeping budget	Traditional hives			Modern hives		
	Maga	Kaélé	Mindif	Maga	Kaélé	Mindif
Purchase of the hive	2000	/	1000	15000	/	/
Average duration of use of hives	2	5	1	10	/	/
Annual honey production (liter/hive/year)	4	2	3	11	/	/
Sale of honey/liter (FCFA)	3000	1000	1500	3000	/	/
Gross profit of honey/year (FCFA)	12000	2000	4500	30000	/	/

Table 7. Therapeutic use of honey

Diseases / symptoms	Route of administration	Dosage	Frequency (%)
Cough	Oral	1 spoon / morning and enening	22.87
Burn	Extern	Apply 3 times/day	22.87
Headache	Oral	1 spoon /day	16.25
Children's fever	Oral	1 spoon /day	8.77
Insomnia	Oral	1time/day for 1 week	7.02
Earache	Hearing	2 drops/ear	7.02
Fatigue	Oral	½ glass honey + lemon juice/day	5.86
Malaria	Oral	1 glass / morning and enening	3.58
Hypertension	Oral	½ glass honey + sugar	3.22
Common cold	Oral	½ glass honey + lemon juice	2.96

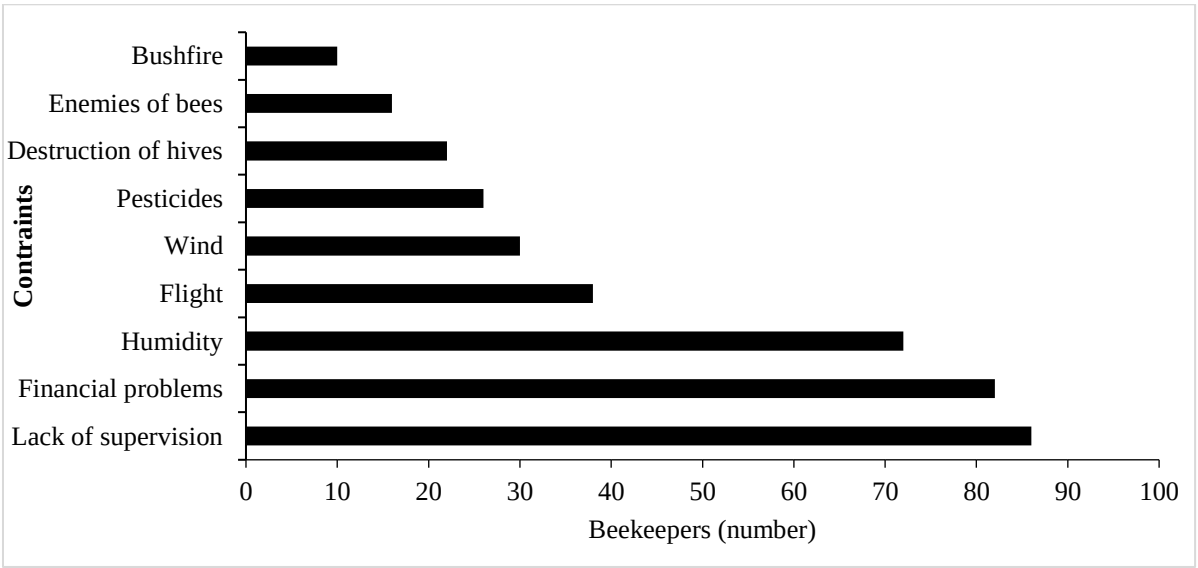

Fig. 8. Constraints encountered by beekeepers

4. CONCLUSION

Most people in the study area practice traditional beekeeping and have the basic knowledge essential for modern beekeeping. Most of the honey produced is intended for sale. However, some of it is used for human and animal consumption and care. If beekeeping is to develop properly, there is an urgent need to resolve the issue of hive location and technical to combat the phenomenon of humidity, which could reduce the impact of parasites and increase hive yields in the study area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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