



Beekeeping diagnostic in four production basins in Senegal: an analysis of opportunities and weaknesses

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ABSTRACT

In Senegal as everywhere in Africa, apiculture is a branch of agriculture that can help people from rural and remote villages to diversify their activities and generate incomes. Honeybees are also involved in the pollination services process in agriculture and a good indicator to environmental degradation. The aim of this cross-sectional study was to diagnose problems encountered by beekeepers in four production basins in Senegal, to guide policy makers and attract investment in the sector. A questionnaire and an interview guide were designed together and distributed to 138 single beekeepers and 32 groups of beekeepers between September 2014 and January 2016. Beekeepers (93.75%) were men aged more than 50 years and (74.7%) didn't have any knowledge about bee diseases. Modern beekeeping was unequally observed in the four basins. Honey was the most significant preferred commodities followed by the bee's wax. Lack of beekeeping modern equipment, climate change (environment), and funding were identified and listed as major weaknesses respectively. Nevertheless, beekeepers in the Thies region were (100%) modern, compared with those to Fatick and Velingara who were still doing traditional beekeeping at 9.7% and 91% respectively. However, our study areas with the rich and diversified natural resources remain conducive to beekeeping.

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INTRODUCTION

Bee as livestock can play an important part in rural economy and can be seen as income generating activity added on its role on plants and crops pollination and their potential as environmental bio indicators by giving the alert on damage of environmental and biodiversity and the production of valuable beehive products as honey, beeswax, propolis, royal jelly, etc. which are sources of incomes. (Gerster, 2012).

Moreover, *Apis mellifera* (Linnaeus, 1758) is very sensitive to environmental variations and ecosystem modifications, by the way it is a good sentinel of environmental and an interesting ecological bio-indicator of health ecosystems (Audusseau et al., 2008; Gerster, 2012). Human communities need to protect this wild and domesticated insect because of the above cited roles played in the human lives (Audusseau et al., 2008). In 2009, the INRA (Institut National de la Recherche Agronomique) estimated to 153 billion Euros per year the economic value of pollination by honeybees which is equivalent to 9.5% of the global food production in the world (Mollier et al., 2009). From this fact, pollination done by honeybees is a common property belonging to beekeepers, farmers and the entire society (Gerster, 2012). In Senegal, livestock breeding is an important sector of economy involving 60% of rural families (ANSD, 2014), but its contribution to the country's income is less than expected by the government in terms of food security (ANSD, 2016). With 3150 tons of honey produced in 2012, Senegal was the first in West Africa and rank 12th on the continent (Mbahin, 2017).

Despite multiple actions of modernization put in place by Senegalese government since 1961, the honey sector is not doing very well, and it seems that all aspects of development of the sector are mainly focused on honey production (Diouf, 2002). The aim of this study was to diagnose problems encountered by beekeepers in four production basins in Senegal, see opportunities and guide policy makers on

what to do to attract investment in the sector and more specifically to identify:

- Existing beekeeping practices and beehives products,
- Major constraints faced by beekeepers and available short and long-term solutions for this sector.

MATERIALS AND METHODS

Study area

The study was conducted in four sites located in three different regions of Senegal. Velingara, Kolda region located in the south is the second beekeeping region of Senegal. It is in the Sudano-Guinean domain (Leroux, 1983) with a rainy season lasting from June through October and a dry season for the rest of the year. The mean rainfall varies between 700 and 1300 mm with temperatures ranging between 25 and 40 °C (ANSD/SRSD Kolda, 2011). Toubacouta, Fatick region, the Niayes and Bandia village in Thies region are in the West part of Senegal, in the Sub canarien zone (Leroux, 1983), with nine months dry season beginning in October and ending in June and three months rainy season (July-September). In Toubacouta, the temperatures oscillate between 20 and 45 °C according to the seasons and the mean annual rainfall is 871.45 mm (ARD Fatick, 2016). The Niayes and Bandia village area, record low rainfall (average 350 mm) but being under the influence of the maritime they trade winds enjoys moderate temperatures rarely exceeding 30 °C (Camara, 2010; Diop, 2013) (Cf. Figure 1).

Data collection and analysis method

This cross-sectional study was conducted from September 2014 to January 2016. This due to the remoteness of study areas and the fact that, most beekeepers are farmers and usually busy during the rainy season. The information was collected from 138 single beekeepers and 32 beekeepers organizations. Without exact data on the total number of individual and organizations in the study areas, we worked on the template

elaborated following recommendations from consultants in apiculture and other beekeepers training organizations who gave us some gathered data in the subject (localities where apiculture is done, sometimes identity of beekeepers and names of some organizations of beekeepers). The data was collected through individual interviews and focus groups using a questionnaire and interview guide respectively for individual and groups

beekeepers. Those data included socio-demographic, beekeeping techniques, activity constraints and perspectives. Direct interviews were also held and information gathered from 21 representatives of structures and NGOs advising and funding beekeeping activities in the study areas. Data were analyzed using Epi info 200 version 3.5.4 software (CDC, 2012) with provided the descriptive statistics and graphs were done with Microsoft Excel 2016.

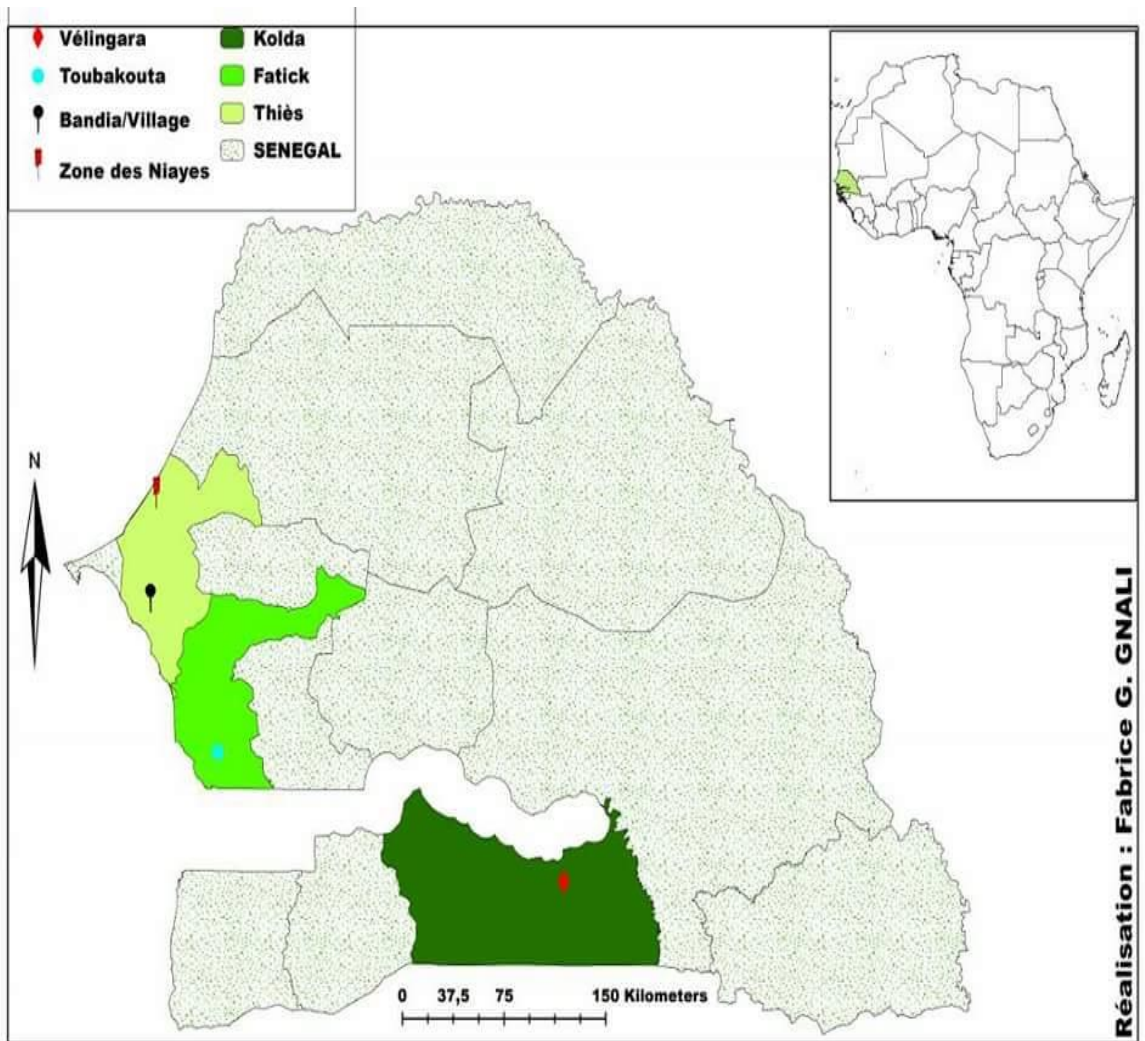


Figure 1: Map of Senegal showing the study areas.

RESULTS

Socio-demographic data

Our results showed that single beekeepers were only male average 49 years old and the majority (74.70%) were over 50 years old (Figure 2).

Out of 32 beekeepers organizations studied, women were only in 2 associations and represented only 6.25%, while men accounted for 93.75%. Beekeepers' activities were diversified with a high proportion (86.20%) of farmers and only 9.40% with apiculture as their main activity (Figure3).

Out of 12 organizations studied in Velingara, only 3 (25%) had a legal existence, while in Toubacouta, 11/14 (78.57%) and Thies, 4/6 (66.66%) had a formal legal status.

Beekeeping practices

Practical experience of individual beekeepers ranged from 1 to 50 years, with 20 years mean. For beekeeping organizations, this practical experienced ranged from 1 to 29 years with a mean of 9.5 years (Tables 1 and 2).

Globally, the results of our investigation showed that traditional beekeeping was still practised in Toubacouta and Velingara. In these areas, individual modern beekeepers represented 74.2 and 4% respectively. We also found 40% honey hunters in Velingara; for the beekeepers organizations, 16.70% practiced traditional apiculture and 25% were using both traditional and modern hives. However, in Fatick and Thies regions, beekeepers organizations were using 100% modern beekeeping equipment like modern beehives, smoker, honey extractor etc. (Figure 4).

The use of chemical products in beekeeping activity was essentially limited to equipment disinfection and swam bee attraction.

Products collection

Honey was the main product collected by beekeepers (100%). Bee wax was also collected but in low proportion (Tableau 3). In

the study zone, farmers rented hives from beekeepers for pollination service.

Hives are installed during 4 months (November, January, February, May) by beekeepers organizations and 8 months between October to May without April by individual beekeepers. However, honey harvesting was done from January to July depending on the study site, and the annual harvesting per hive averaged twice for organizations and once for individual beekeepers (Figure 5). Also, the mean number of hives by apiary was 14 hives for the individual beekeepers and 44 for the organizations.

Beekeepers knowledge

The mean proportion of trained beekeepers was 3 in Thies, 2.5 in Toubacouta and 1.8 in Velingara. Almost 80% of individual beekeepers and 88% organizations beekeepers were aware of the role of bees in agriculture and environment, while only 10 and 31% of individual and beekeepers groups respectively has some knowledge about bee diseases.

Several parameters influence bees production; those observed in our study are summarized in (Table 4) below.

Weakness and opportunities in beekeeping

Constraints that limit bees production as well as the prospects from our surveys and interviews with beekeepers organization and individual are listed in (Table 5) like strengths, weaknesses, opportunities and Threats as part of our (SWOT). This table shows weaknesses and threats such as the lack of training, the low representative of youth, the lack of financing in the sector and the desertion of bees (absconding). However, existence of the beekeeping platform remains a significant hope to boost beekeeping sector in Senegal.

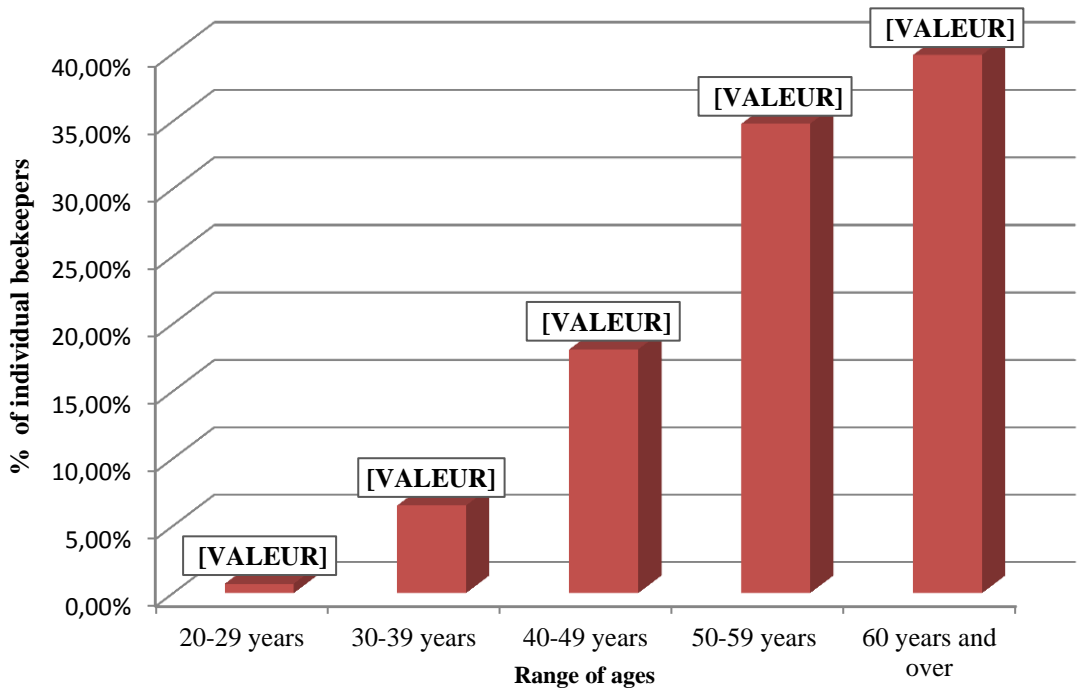


Figure 2: Beekeepers range of ages.

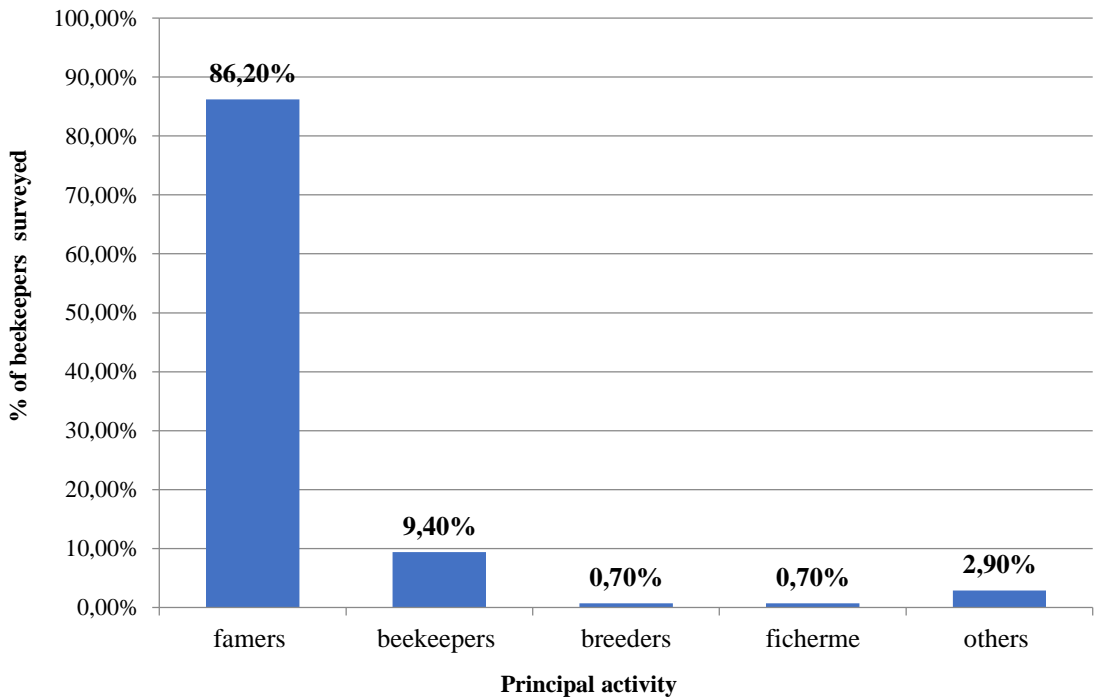


Figure 3: Composition of beekeepers according to their main activity.

*Others = Butchers, Businessman, Forest workers, retired drivers, Imam, Gardener, Painter.

Table 1: Experience of individual beekeepers in the activity.

Experience (years)	Number	Percentage (%)
1-10	44	31.88
11-20	45	32.61
21 and more	49	35.51
Total	138	100
Minimum Experience = 1 year Mean Experience = 19.75 years Maximum expérience = 50 years		

Table 2: Experience of beekeeper groups in the activity.

Experience (years)	Number	Percentage (%)
1-5	12	37.5
6-10	9	28.1
11-15	5	15.6
16-20	4	12.5
21-30	2	6.3
Total	32	100.0
Minimum experience = 1 year ; Mean experience = 9.5 years ; Maximum expérience = 29 years		

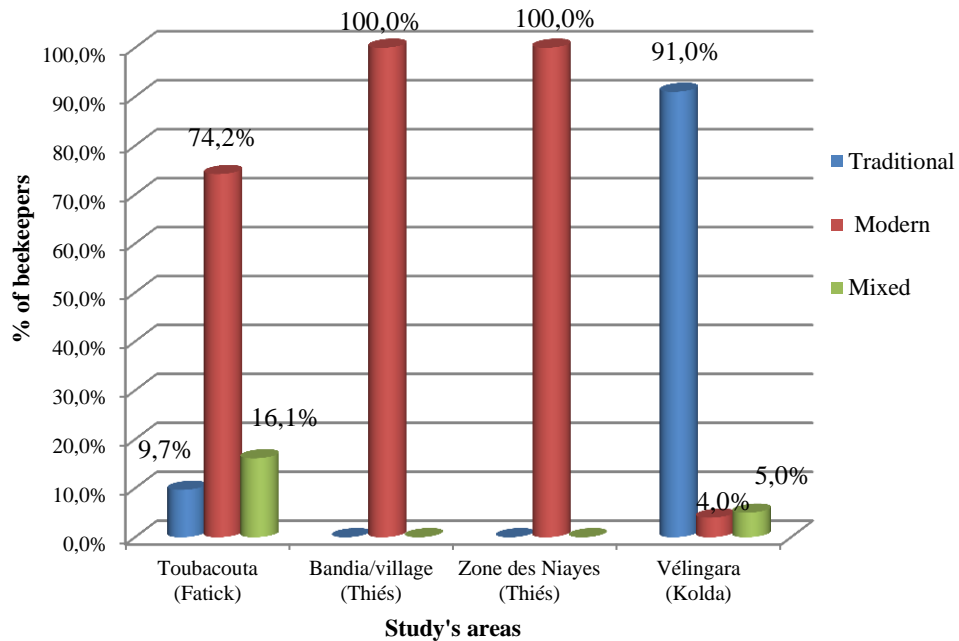
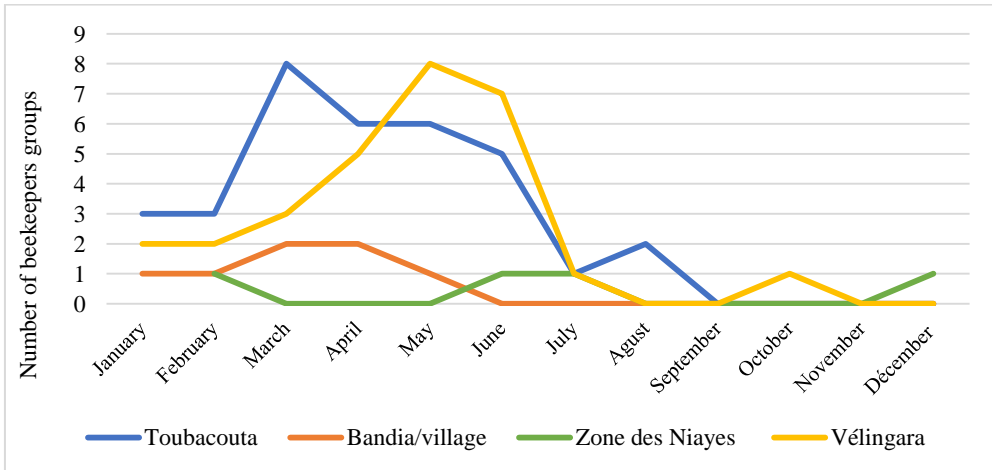


Figure 4: Methods of beekeeping practiced by individual beekeepers according to site.

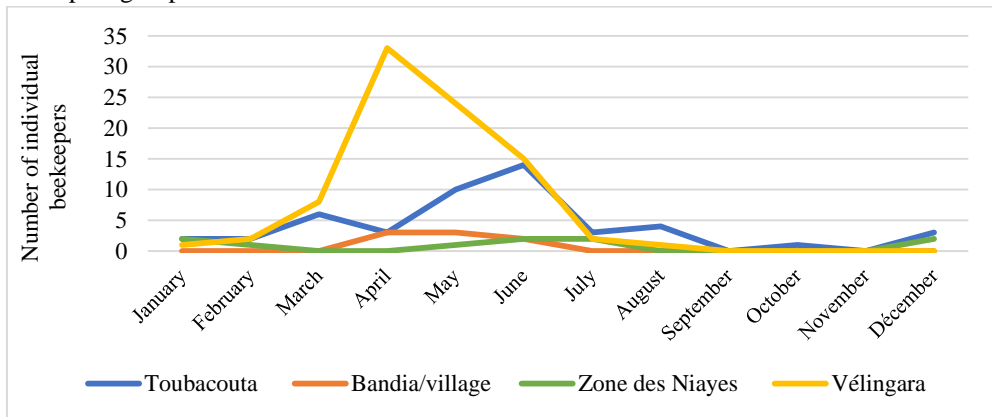
Table 3: Mean annual production (kg) of honey and bee wax by group of beekeepers from 2011 to 2014.

Honey and Wax Production (Kg) /years Study areas	2011		2012		2013		2014	
	Honey	Wax	Honey	Wax	Honey	Wax	Honey	Wax
Toubacouta	27.28 (34.87)	4.67 (6.30)	52.42 (74.06)	3.00 (0.00)	68.22 (98.19)	1.33 (0.58)	201.12 (430.46)	2.25 (1.89)
Bandia/village	ND	0.00 (0.00)	355.67 (151.48)	0.00 (0.00)	3130 (0.00)	0.00 (0.00)	1353.50 (1744.43)	0.00 (0.00)
Zone des Niayes	1907.50 (2273.35)	0.00 (0.00)	1132.50 (1443.20)	0.00 (0.00)	3130 (0.00)	0.00 (0.00)	1353.50 (1744.43)	73.00 (0.00)
Vélingara	648.33 (947.15)	55.00 (0.00)	227.14 (348.39)	41.67 (31.75)	371.78 (540.21)	37.75 (21.30)	484.17 (663.75)	ND

ND : Non determined; () : Standard deviation



a: beekeepers groups



b: Individual beekeepers

Figure 5: Honey harvesting periods by organizations (a) and by individual beekeepers (b) by study site.

Table 4: Technical characteristics of beekeeping.

Parameters	Characteristics	Toubacouta (Fatick)		Bandia/village (Thies)		Zone des Niayes (Thies)		Vélingara (Kolda)	
		Gp. Beep. (N=14)	Ind. Beep. (N=3)	Gp. Beep. (N=4)	Ind. Beep. (N=4)	Gp. Beep. (N=2)	Ind. Beep. (N=3)	Gp. Beep. (N=12)	Ind. Beep. (N=100)
Number of training by beekeeper	Minimum	1	1	2	2	2	3	1	1
	Mean	3.50 (1.33)	2.55 (1.47)	4.25 (1.50)	3.75 (1.50)	2.50 (0.71)	3.00 (0.00)	2.00 (0.89)	1.81 (1.04)
	Maximum	8	7	5	5	3	3	4	5
Apiary size by group of beekeepers	Minimum	8	1	17	5	35	2	10	2
	Mean hives	39.07 (39.17)	7.31 (6.78)	23.00 (5.71)	11.25 (8.09)	42.50 (10.61)	7.33 (4.62)	69.50 (60.34)	17.69 (13.20)
	Maximum	150	32	30	23	50	10	200	74
Types of hives by beekeeper	Moderns (mean)	36.21 (39.77)	5.65 (5.20)	23.00 (5.71)	11.25 (8.09)	41.00 (12.72)	7.33 (4.62)	45.50 (62.73)	1.34 (4.05)
	Traditionals (mean)	0.00 (0.00)	1.59 (4.62)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	11.30 (22.45)	16.39 (14.06)
Number of harvests per year/hive	Mean haversting by hive	1.78 (0.69)	1.45 (0.51)	1.75 (0.50)	1.25 (0.50)	2.00 (0.00)	1.67 (0.58)	1.58 (0.90)	1.44 (1.72)
	Maximum	3	2	2	2	2	2	4	2
Knowledge of bee roles in the environment (%)	Yes	78.60	93.50	100	100	100	100	100%	69,00%
	No	21.40	6.50	0.00	0.00	0.00	0.00	0.00	31.00
Knowledge of bee diseases (%)	Yes	42.90	22.60	50.00	0.00	100	66.70	0.00%	5.00%
	No	57.10	77.40	50.00	100	0.00	33.30	100	95.00
Place of honey selling (%)	In the village	77.27	75.00	77.78	50.00	100	61.00	72.42	55.30
	NGOs, Private or in the Large surface	18.18	14.00	22.22	50.00	0.00	0.00	13.79	9.70
	Markets	4.55	11.00	0.00	0.00	0.00	34.00	17.24	35.00

NB: Gp. Beep. = Group of Beekeepers; Ind. Beep= Individual Beekeepers; N= Number of respondents by site; () = standard deviation

Tableau 5: SWOT analysis of Senegal beekeeping sector.

<p>Strengths:</p> <ul style="list-style-type: none"> - Biodiversity: rich and diversified natural resources, - Limited use of agrochemicals products in the apicultural activity - Several projects in the field - The sector modernization in progress - Diversity and abundance of honey plants - Mechanical intervention (without the use of chemicals) in case of attack of hives 	<p>Opportunities :</p> <ul style="list-style-type: none"> - Existence of the beekeeping actors' platform - Start of organization of beekeepers in groups - Presence of numerous organizations and actors supporting the sector - Fewer attacks by bee diseases - Resistance of bees to their diseases
<p>Weaknesses:</p> <ul style="list-style-type: none"> - Low representation of young people in the sector - Low representation of women in the sector - - Use of traditional apicultural equipment - Lack of national rules - Activity not yet considered by the credit system - Difficulties in financing the beekeeping sector - Repetitions of training topics - Lack of funding for research - Insufficiency of formalization - Lack of coordination between NGOs and state structures operating in the beekeeping field - Bad harvesting practices (use of fire during honey harvesting, etc.) - No control of the marketing circuit - Enclosure of the production areas - Disparities in the sector modernization - Insufficient of equipment and beekeeping infrastructures (48% of constraints noted) - seasonal nature of the activity - Lack of exploiting of the other hives products 	<p>Threats:</p> <ul style="list-style-type: none"> - Desertion of bees in hives (52%) for individual beekeepers and 58% for beekeeper organizations) - Reducing the size of bee colonies - Presence of predators (79, 65, 33 and 68%) at the four sites - Insufficient of specialized technicians - Activity practice by an aging population - Competition between actors - High use of pesticides in agriculture - Deforestation (felling of honey trees) - Bad knowledge of bee predators - Lack knowledge of the pathologies of bees - Hives steal - Rarefication of bee colonies - Lack of awareness of some people that creates an unfavorable environment for beekeeping

DISCUSSION

The present study focusing on apiculture in Senegal was undertaken to have an inventory of major strengths, weaknesses, opportunities and threats that limit apiculture development and to guide policy makers, attract investments and stimulate honey production. The results showed that women were poorly represented (6.25% in beekeeping organizations). These observations of poor women's involvement in beekeeping are similar to those obtained by Diouf (2002) in Senegal, Tchoumboue et al. (2001) in the highlands of West Cameroon and in North-East Benin by Ahouandjinou (2016) and Paraíso (2017). Those studies showed that beekeeping was essentially practiced by men around Africa. Furthermore, women represented less than 10% of populations investigated, those statistical data obtained were contrary to those reported by Kenmogne et al. (2014) in West-Cameroun, by Abera et al., (2016); Gebretsadik and Negash, (2016) in Ethiopia and Niyonsenga (2016) in Rwanda where women represented 20.4, 20, 16, and 23.8% of beekeepers interviewed respectively. In Somalia Regional State (Ethiopia), Fikru et al. (2015) observed 100% of men involved in beekeeping while in Bourgogne (France), Adrien et al., (2014) noticed 86.8% of men only. All those studies showed that women represented less than half of men in beekeeping activities. This could be due to a cultural aspect or can be explained by the fact that traditional beekeeping being practiced very often at night to avoid bee stings and also hives are often hung on the trees generally and this is considered as men activity. Despite this low proportion, women's implication in this activity can be considered as a progress linked to the advent of modern beekeeping or more importantly in the value addition part of beekeeping products.

The mean age of beekeepers population in our study (49 years) was close to that given by Yédomonhan (2009) in Manigri, Benin (50 years), Kenmogne et al. (2014) in Cameroon (50 years) and Laignere (2001) in New-Caledonia (52.5 years). In Bourgogne also, age class of 54 years old and more was mostly represented with 39.5 % of beekeepers (Adrien et al., 2014). In those regions, beekeeping was mostly practiced by an ageing population.

That could be due to a lack of considerable profitability of the activity and its valorization by the authorities in these regions.

However, the beekeeper's mean age (30 years) given by Gebretsadik and Negash (2016) in Ethiopia is less than those found above. Another study conducted in the same country also showed that 50% of beekeepers interviewed had an age ranging from 30 to 39 years (Abera, 2016) while 74.7% of our studied population was more than 50 years old. In Togo also, 58.62% of beekeepers interviewed had less than 50 years old (Sokemawu 2015), in Benin, mean age was 35.75 years (Paraíso, 2017). Those data show the interest that young people have for beekeeping in Ethiopia, Togo and South Benin. Thus, it shows the necessity to integrate more women and to interest young people in this activity, source of additional income, generation employment, and environmental conservation.

The mean experience of Ethiopian in beekeeping is 4 years, while our Senegal's population had 9 and 20 years experience for organizations and single beekeepers respectively. Our results differ from those of Tchoumboue et al. (2001) in Cameroon who showed that approximately half of their population studied had less than 5 years experience. This shows that beekeeping is a very old activity in Senegal that deserves to be developed further, given the experience accumulated over the years by both organized and non-organized beekeepers.

Beekeepers principal employments were diversified with a proportion of farmers (86.20%). Our results confirm Diouf's (2002) who showed that 85% of beekeepers interviewed had farming as their main activity. They are also similar to those obtained in Benin by Yédomonhan (2009) and Paraíso (2017) where beekeepers had farming as main activity. In highlands of West Cameroon, Tchoumboue et al. (2001) found that most farmers were state workers (16.3%) and students (5.4%) This was also observed in Togo with 58.92% of farmers (Sokemawu, 2015). That confirms beekeeping is a secondary activity in general but can be practiced by all, regardless of the main activity of the person. The percentage (86.20%) of beekeepers is explained by the fact that beekeeping is used as a source of

employment and income generating activity in the dry season. Unknowingly, farmers save bees for the pollination service so valuable for crop production and the conservation of biodiversity.

Beehive products results (Table 3) showed that the exploitation of bee wax was very weak or even non-existent in some study areas and was practiced only by few groups of beekeepers this could be explained by the lack of training on the bee wax treatment and also lack of interest for this important product of the hive. We also observe the absence of other beehive products (pollens, propolis, royal jelly, bee venom...). Thus, awareness and training on the importance of bee wax and other beehive products is an urgent necessity in Senegal and the Senegal Apiculture Platform can put that on his agenda.

In our study areas, honey harvesting and hives setting by traditional beekeepers was done during the dry season, and harvesting from January to July, but most of beekeepers collected between April and May. This is because hives are mostly made by straw and cannot resist to rainfall during the rainy season and May is also the time of bee swarming. In Senegal, harvesting started at the same time as in Togo (Sokemawu, 2015) and Cameroon (Tchoumboue et al., 2001), but time to set hives (September to March) was longer in Cameroun. The time of harvesting honey given by Diouf (2002) was approximately similar to those that we observed during our studies but the time for setting hives was more longer. It could be justified by a greater interest in the activity but also the training received, or the rarefaction of bee colonies noticed by beekeepers. In addition, the fact that harvest periods delayed from one site to another could be considered as an advantage because it shows that it would be possible to have honey for a good part of the year. Also, news technologies such as queen rearing and colonies multiplication should be introduced in all beekeeping study areas to boost the honey production.

The level of beekeepers training changes from one site to another. These results are similar to those found by Kenmogne et al. (2014). In addition, beekeeping organizations received more training than individual beekeepers and there

was a lack of knowledge about bee diseases. That could be related to a lack of training or extension workers on those topics in the area. Thus, it seems essential and important for trained beekeepers to popularize the knowledge already acquired by sharing it between them and from zone to zone.

Despite the important number of structures and projects supporting apiculture in the area there are still some discrepancies regarding modernization of beekeeping activities.

Beekeepers organizations were more equipped with modern hives than individual beekeepers. Beekeepers of Thies region was well equipped with modern equipment (100%) followed by Fatick and Kolda where traditional tools were still in use. The low level of organized beekeepers in Velingara, can explain these disparities. Furthermore, only one beekeeper's organization holding 200 hives and can be classified as professional, in this study. But if we refer to the one of European Union, there were two professional groups (holders more than 150 hives). Within the individual beekeepers, we only found family producers with (1 to 30 hives) and multi-active beekeepers with (30 to 150 hives).

Traditional equipment was still found in Velingara within beekeeper organizations with (80%) and (20%) using modern one. However, single beekeepers do not have any modern equipment. After harvesting, honey was sent to beekeeper organizations for extraction and packaging, what justify the need of more organization in the area. This could be explained by the lack of means of beekeepers to acquire modern equipment. However, in the study area there is a considerable modern beekeeping structures using new tools compared with those described by Hussein (2001). The mean number of hives (14) held by one single beekeeper in this study was less than those found in Democratic Republic of Congo (DRC) Ndola (2014), but close to the mean held by organizations of beekeeper. Our results also differ from those found by Abera (2016) in Ethiopia with only a total of 200 traditional hives, 70 intermediate hives and less than 25 modern hives listed in the study area. So, we invite individual beekeepers to join existing beekeeper association groups or

to make new beekeeper organizations to embrace modern beekeeping with modern honey processing equipment.

Most of beekeepers sold their product in their villages, and remote village beekeepers has a problem to sell their products at decent prices. This could be explained by the lack of price regulation of honey sales in Senegal but also the lack of beekeepers organization in remote areas. However, NGOs and private sector became potential customers of those beekeepers. Some beekeepers sent their production to families and friends around the country, mostly during religious events. That's the case in Kolda, with the «Daaka of Medina Gounass (Kolda region) and Touba (Diourbel region) during the pilgrimage or « Magal ». As said by Diouf (2002), beekeepers had several routes to sell their products.

Observed inventory of major strengths, weaknesses, opportunities and threats (SWOT analysis) that limit apiculture development in Senegal listed by beekeepers in the Table 5, were noticed in other areas of Africa, notably by Tchoumboue (2001); Kenmogne et al. (2014); Ndola (2014); Gebretsadik et Negash (2016) and Ahouandjinou (2016).

Conclusion

In conclusion, this study made possible a large diagnosis of the sector in the study areas. It appears that, beekeeping is a secondary and very old activity carried out largely by men, especially the elders. This shows that it needs to integrate the aspect of gender and included youth in this sector. Despite the existence of multiple sources of income, only honey is exploited by beekeepers. A view of the rich biodiversity of the study areas, and efforts made by the State to boost the sector, this production is still low compared with existing potential, hence the need to move to modernize beekeeping equipment and transformation. In addition, with the presence of traditional beekeeping in some areas, individual beekeepers need to organize themselves to enjoy capacity building that is indispensable especially on production and transformation of other beehive products, bee health and value addition.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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