Honey Production for Assessing the Impact of Climatic Changes on Vegetation

P. Schweitzer[1], I. Nombré[2,3*], J.I. Boussim[3]

Keywords : Climatic changes- Melliferous plants- Honey production- Apiculture- Burkina Faso

Summary

Burkina Faso is experiencing the effects of climate change in all sectors of its agriculture, including honey production. This study assessed the impact of climatic factors on countries' vegetation through honey production. Honey production of nine apiaries consisting of 165 rectangular movable frames beehives was monitored over a seven year period starting from 2002 to 2008. Climatic data such as rainfall, temperature and wind speed were obtained from the nearest meteorological station. Linear regression analysis showed weak positive correlations between honey production and mean temperature (18.3%), rainfall (8.5%) and wind speed (2.6%). There were positive correlations between honey production and rainfall, mean temperature and wind speed. The optimum foraging temperature for local honeybees oscillated between 25°C to 35°C.

Résumé

Evaluation de l'impact des changements climatiques sur la végétation à travers la production de miel

Le Burkina Faso subit les effets des changements climatiques dans les secteurs de son agriculture y compris la production apicole. Cette étude évalue l'impact des facteurs climatiques sur la végétation à travers la production apicole. La production de miel de neuf ruchers constitués de 165 ruches rectangulaires à cadres mobiles a été suivie durant 7 années de 2002 à 2008. Les données climatiques telles la pluviométrie, la température et la vitesse du vent ont été obtenues de la station météorologique le plus proche. L'analyse des régressions linéaires a montré une corrélation positive entre la production de miel et la température moyenne (18,3%), la pluviométrie (8,5%) et la vitesse du vent (2,6%). Il y a une corrélation positive entre la production du miel et la pluviométrie, la température moyenne et la vitesse du vent. La température optimale de butinage de l'abeille locale oscille entre 25°C to 35°C.

Introduction

Burkina Faso, situated in the middle of West Africa, is experiencing the impact of climate changes as is the other countries situated in the South of Sahara region. The fauna, and flora and their relationships in the ecosystems show evidence of this phenomenon. With as far as honeybee activity is concerned, the impact of climatic changes becomes apparent in their ethology and in particular their foraging. At the plants species level, the impact affected the quality and quantity of the nutrients for honeybees, and the plants phenology is a tool to measure the effects of climatic changes.

The honeybee *Apis mellifera adansonii* Latreille is important in providing pollination services to crops and other flowering plants in the ecosystem (2). The honeybees can also serve as a bio indicator for environment changes (1, 5, 11). Moreover, colony performance in general, and honey production in particular are affected by several factors; among these, the race of the honeybee, the materials and beekeeping practices (8) and climatic factors (11). Although, the first factors can be controlled by genetic selections and training in modern beekeeping techniques, the effect of climatic factors on the activities of honeybee and the availability of forage resources remain unpredictable. Climatic factors such as temperature, wind must allow honeybees to fly and forage nutrients for their brood (4). These factors can indeed influence honeybee

1 Centre d'Etudes Techniques Apicole de Moselle, Laboratoire d'Analyses et d'Ecologie Apicole. Lorraine Guenange, France.
2 Institut des sciences, Ouagadougou, Burkina Faso.
3 Université de Ouagadougou 03, Laboratoire de Biologie et Ecologie Végétales, Ouagadougou, Burkina Faso

* Corresponding author : Email: nombre_issa@yahoo.fr

Received on 02.05.12 and accepted for publication on 10.10.12.

colony development and the length of their life-cycle (6). Resources around the apiary (i.e. water, abundance and diversity of melliferous plants, distances between those and the beehives), morphology and accessibility of the flowers as well as nectar secretion (volume and sugar concentration) are dependent on the climatic and edaphic conditions. Moreover, the nectar production in any plant species depends on its age, maturity, flowering period, the hour of day and the position of flowers on the plant.

If a greater knowledge of flowers visited by honeybees constitutes an essential parameter for beekeeping (12), assessing the relationship between climatic factors and beekeeping through honey and nectar productions allows better apprehension of the various aspects of this production. Available data on the impact of climate changes and their influence on all aspects of honeybee development through foraging and reproduction remain largely unknown (3).

This study aimed to assess the impact of climatic changes on the vegetation nectar production through honey production by honeybee colonies in a Soudano-Sahelian zone.

Material and methods

Study area

The study area is characterized by Soudano-Sahelian climate with high temperature and irregular rainfall. The vegetation is mainly savannah, but protected plant species such as *Vitellaria paradoxa* C. F. Gaertn, *Parkia biglobosa* (Jacq.) Benth., *Adansonia digitata* L., *Faidherbia albida* (Del.) Chev. dominate. The agricultural landscape is characterized by trees such as *Mangifera indica* L. Principal crops being cultivated include *Pennisetum glaucum* Linn. R. Br., *Sorghum bicolor* (Linn.) Moench, *Zea mays* Linn., *Arachis hypogaea* L., *Oryza sativa* L., *Solanum nigrum* L., *Lycopersicum esculentus* Mill., *Lagenaria siceraria* (Molin.) Standl., *Allium cepa* L.

Study Methods

Nine apiaries consisting of 165 rectangular movable frame beehives were set up for the study. The beehives were colonized naturally by wild swarms and collected in the apiaries. The honey productions of these apiaries were recorded over a period of seven years (2002-2008). Two honey crops were harvested per year; one during the major honey flow in March to April and the other during the small honey flow in November. The climatic data as temperature, rainfall and wind speed were obtained from the National Meteorological Office located in Ouagadougou. The raining season covered four months (June to September) and the variation in soil water content has an effect on the volume and concentration of nectar secretion with a light time difference (14). For rainfall, the quantity of honey produced during the small honey flow (November) has been added to that produced during the major honey flow of the following year (April) to constitute the honey production for the last year. For the other climatic factors, the quantities of honey obtained during the high and the small honey flow periods from the same year have been added to constitute the annual honey production.

The data were analysed with software JMP 8.0; the linear regression and the coefficients of correlation were determined and applied on the quantity of honey produced per year, as well as annual rainfall, annual mean temperature, and the average wind speed. These analyses established a relationship between the different parameters and expressed the percentage of annual honey production based on the climatic factors.

Results

Annual honey production increased with a peak of production in 2007 (Table 1). The correlation with annual rainfall (Table 2) showed two production peaks in 2004 and 2007 where 1011.3 kg and 1167.1 kg of honey have been respectively harvested. In addition, the production varied according to honey flow type. It was generally high during the major honey flow and low during the small one.

Table 1 showed a high honey production during the major honey flow in 2005 (712.3 kg) and during the small honey flow in 2003 (322.64 kg) and 2007 (625.60 kg).

Table 2 showed that high honey production occurred at 889.30 ml and 756.70 ml of rains with 1011.30 kg and 1162 kg of honey produced.

The linear regression of honey quantity produced in relation to the different climatic factors showed positive slopes for the wind speed (Figure 1), the annual rainfall (Figure 2) and the mean temperature (Figure 3). The correlation between climatic factors and honey production showed that 18.3% of annual honey production was determined by the mean temperature. The correlation was 8.5% for annual

Table I
Annual honey production according to honey flow periods of apiaries settled up in Soudano-Sahelian zone.

Year	2002		2003		2004		2005		2006		2007		2008	
	MH	SH	MH	SH	MH	SH	MH	SH	MH	SH	MH	SH	MH	SH
Honey production (Kg)	192.9	123	337.4	322.64	515.3	299	712.3	163	471.5	281.1	636.9	625.6	536.6	141
Annual honey production (Kg)	315.9		660.04		814		712.3		752.6		1262.5		667.6	

MH: Major honey flow
SH: Small honey flow

Table II
Annual honey production correlated to average rainfall of apiaries settled up in Soudano-Sahelian zone.

Year	2002	2003	2004	2005	2006	2007	2008
Annual production (Kg)	460.4	837.94	1011.3	634.5	918	1162.2	541.6
Average annual rainfall (mm	658	1058.7	889.3	841	840	756.7	1072.9

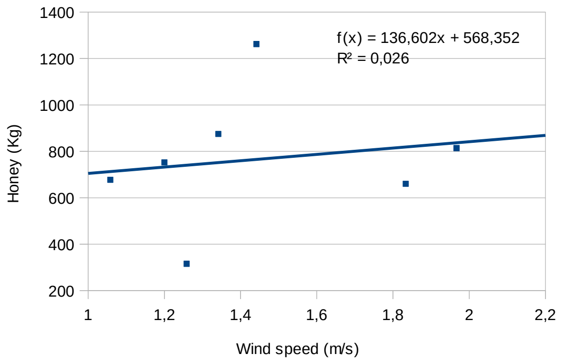

Figure 1: Variation of annual honey production according to wind speed.

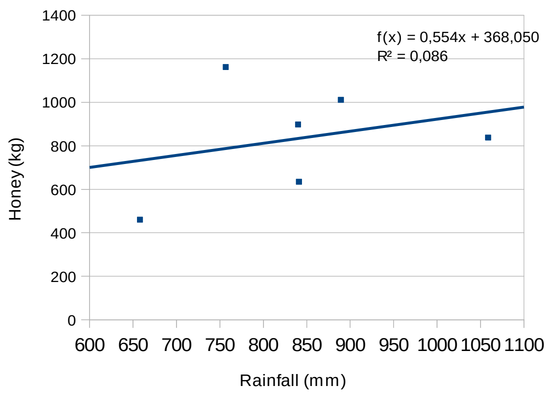

Figure 2: Variation of annual honey production according to annual rainfall.

rainfall and 2.3% for wind speed. The results showed that the mean temperature had a high correlation more than the two others climatic factors.

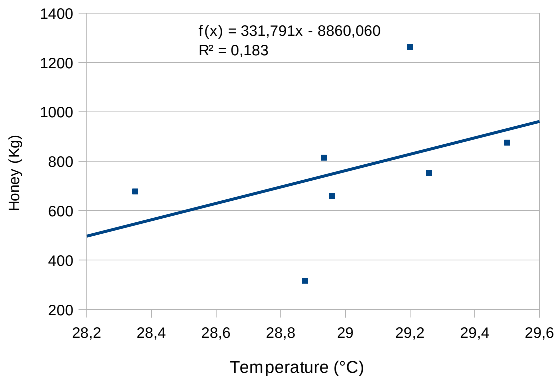

Figure 3: Variation of annual honey production according to annual average temperatures.

The annual mean temperature fluctuated between 28°C and 30°C. The monthly average during the eight years showed that the hottest month was April (33.54°C) and the coldest was January (25.74°C).

Annual rainfall fluctuated between 600 mm to 1100 mm. The highest rainfall occurred in August (251.76 mm).

The wind speed was higher in May (1.98 m/s) and lower in September (0.86 m/s) with the mean of 1.5 m/s. Wind speed varied from 1 to 2 m/s.

Discussion

To understand the relation between climate and beekeeping, it is useful to understand the two concepts linked to honeybees and their environment. There are nectar production and honey production. The nectar production is totally plant species function. Its production from a region depends to plant species present and the meteorological factors those affect these plants species. The climatic and edaphic factors determine the flora of a region and then nectar potentiality.

There are two honey flows periods in Burkina Faso. The first one is the major honey flow period. It occurs in April. The second, called small honey flow period occurs in November (13).

The different climatic factors as annual rainfall, wind speed, temperature and also relative humidity, interact with the different melliferous plants towards nectar production and then have an effect on honey production as stated by Pesson and Louveaux (14). Indeed, they can prevent honeybees to forage (15). Moreover, honeybees foraging depend on several factors among these the quality, the quantity and the availability of nectar those are influenced by climatic factors. Indeed, honeybees visit plant species with some nectar sugar concentration (16, 17). The study has shown that there is high correlation between temperature and nectar secretion. The particular temperature at which nectar is secreted depends to plant species; moreover a temperature as 38°C high induces nectar secretion and also increases nectar sugar concentration (15). Finally a nectar production increase during dry season with the flowering of the woody melliferous plants and the temperature is close to 33.54°C. For Pesson and Louveaux (14) the optimum temperature would always been between 12 and 25°C in the Mediterranean countries whereas in Burkina Faso, situated in tropical sub Saharan zone of Africa, the mean temperature oscillates between 25.74°C and 33.54 °C with a maximum which can reach 45°C in March or April. This period corresponds to the flowering of highly melliferous plant species as the Dawadawa tree (*Parkia biglobosa* (Jacq.) Benth), the Shea tree (*Vitellaria paradoxa* Gaertn), the Grape tree (*Lannea microcarpa* Engl. & K. Krause), the Angole pea (Sclerocarya birrea (A. Rich.) Hochs), *Adansonia digitata* Linn, and *Faidherbia albida* (Del.) A. Chev. This is also the period of the major honeyflow (13). This period of high temperatures corresponds to the active foraging season of the local honeybee *Apis mellifera adansonii* Latreille. Whereas the cold period corresponds to the period of low forage availability because it generally coincides with the lack of flowers in the apiaries environment. During this time the harmattan that is blowing and drying nectar, doesn’t allow honeybees to fly. The correlation between the temperature and the honey production were confirmed by the results of Kajobé (9) who had worked in the tropical Africa rain forest in the Democratic Republic of Congo.

Thus, when the temperatures are high, they correspond to the woody plant species blooming with a high production of honey, and the low temperature correspond to the low production of honey. Also, the temperature action is daily. Indeed, Nombré *et al.* (13) have showed that honeybees foraging activities are important in the morning between 6 h and 10 h and in the afternoon between 16 h and 19 h 30 mn. During those periods, the temperatures are low. Finally, if the internal temperature can be regulated by the worker honeybees, the external temperature which influences flowers nectar secretion must allow honeybee to fly.

The rainfall is the second climatic factor that correlated honey production. It has direct or negative impacts in honey production through the reduction of honeybees foraging activities (it prevent honeybees to go out the beehives and to fly) and also the dilution and/or the washing of nectar and nutrients. These actions could weaken the colonies and influenced honey yield. The rainfall has also indirect or “positive” actions showed by the positive correlation between it and honey production. Indeed, the honey harvest was not carried out during the rainy season (June to September) but two months later (November) for the low honey yield period, or seven month (April) for the high honey yield period. Because the soil water content variation is reflected on the intensity of nectar exudation with a light shift in time and its increasingly has followed by an important nectar production (14). Therefore, a good rainfall induces a significant vegetative development which will later produce a major honey flow. Moreover, if water can be a limiting factor, better nectar production would arise in the years of high precipitations (15). Then, the years of high precipitations are generally followed by high honey productions during the preceding small and major honey flow seasons. These results have confirmed the observations of Karp *et al.* (10) who said that the plant nectar production is especially conditioned by sufficient water content and nutrients in the soil. The low honey productions during the 2008 small honey flow and during the 2009 major honey flow, despite good rainfall in 2008, could be explained by inappropriate beekeeping practices such as the presence of old combs and the bee wax moth or small beehive beetle.

The third climatic factor in that study is the wind speed. The results show that it can have two kind actions as rainfall. Its direct actions are on honeybee activities. Indeed, it prevents honeybees to exit and to forage (17). Its indirect actions are to dry the nutrients. Nevertheless, the correlation was positive because, the wind speeds during the honey flow periods, allowed honeybees foraging activities. Indeed, the high wind speed occurred during the harmattan period (November to the end of February) and often during the raining season. These periods did not affect the honey harvesting periods. During the high honey flow period and small one, the wind speed is less 1.5 m/s.

In short, Climatic factors affected honey production through their impacts on flower development, nectar production and honey bee foraging. Indeed, the climate changes will modify plants phenology, in particular their flowering periods and therefore the honey harvesting calendar (12) and (9). This consequently affects ecosystems' functioning.

Conclusion

Climatic changes affect honey production. Indeed, effects of annual rainfall, temperature and wind speed have been assessed through honey production. Results show positive correlations between honey productions and these climatic factors. They can have a positive action in honey production towards nutrients availability in quantity and quality and towards honeybees foraging behavior. Their negative actions are the obstructing of honeybees to fly for foraging and the washing or drying the nutrients. These factors do not act independently and therefore it is often difficult to disentangle their impacts. Nevertheless, this study shows that temperature has an essential role in the honey yield phenomena and then it will particularly monitor. Others climatic factors as relative humidity, sunniness could have an action on plant species blooming and then honey production; they must be studied.

Literature

1. Bogdanov S., 2006, Contaminants of bee products. *Apidologie*, **37**, 1-18.
2. Bradbear N., 2009, *Bees and their role in forest livelihoods*. A guide to the services provided by bees and the sustainable harvesting, processing and marketing of their products. Non Wood Forest Products 19. FAO, 204 p.
3. Brown M.J.F. & Paxton R.J., 2009, The conservation of bees: a global perspective. *Apidologie*, **40**, 410-416.
4. Bruneau E. & Colin M.E., 2006, Clefs pour l'alimentation des abeilles: stratégie d'approvisionnement. *Abeille et Compagnie*, **1145**, 18-21.
5. Chauzat M.P., Faucon J.P., Martel A.C., Lachaize J., Cougoule N. & Uabert M., 2006, Les pesticides, le pollen et les abeilles. *LSA*, **216**, 443-454.
6. Haubruge E., Nguyen B.K., Widart J., Thomé J.P., Fickers P. & Depauw E., 2006, Le dépérissement de l'abeille domestique, *Apis mellifera* L., 1758 (Hymenoptera: Apidae): faits et causes probables. *Notes fauniques de Gembloux*, **59**(1), 3-21.
7. Human H. & Nicolson S.W., 2008, Flower structure and nectar availability in *Aloe greatheadii* var. davyana: an evaluation of a winter nectar source for honeybees. *Int. J. Plant Sci.*, **169**, 263-269.
8. Janssens X., Bruneau E. & Lebrun P., 2006, Prévision des potentialités de production de miel à l'échelle d'un rucher au moyen d'un système d'information géographique. *Apidologie*, **37**, 1-5.
9. Kajobé R., 2007, Botanical sources and sugar concentration of the nectar collected by two stingless bees species in a tropical African rain forest. *Apidologie*, **38**, 110-121.
10. Karp K., Mänd M., Starast M. & Paal T., 2004, Nectar production of *Rubus arcticus*. *Agron.Res.*, **2**(1), 57-61.
11. Le Conte Y., Navagas M., 2008, Changement climatique: impact sur les populations d'abeilles et leurs maladies. *Revue scientifique et technique de l'Office international des épizooties*, **2**, 485-497.
12. Leclère J., Roberti P.A. & Bruneau E., 2002, Les fleurs de mes abeilles. *Actualités Apicoles*, **17**, 1-8.
13. Nombré I., Schweitzer P., Sawadogo M., Boussim J.I. & Millogo- Rasolodimby J., 2009, Assessment of melliferous plant potentialities in Burkina Faso. *African J. Ecol.*, **47**, 622-629.
14. Pesson P. & Louveaux J., 1984, *Pollinisation et production végétale*. INRA, Paris, 663 p.
15. Pétanidou T. & Smets E., 1996, Does temperature induce nectar secretion in Mediterranean plants. *New phytol.*, **133**, 513-518.
16. Philippe J.M., 1991, *La pollinisation par les abeilles*. Edisud, Aix-en- Provence, France, 182 p.
17. Pinzauti M., 1986, The influence of the wind on nectar secretion from the melon and on the flight of bees: the use of an artificial wind break. *Apidologie*, **17**(1), 63-72.

P. Schweitzer, French, PhD in Beekeeping Ecology, Professor, Responsable for physico-chemical and melissopalynological analysis, Beekeeping Technical Centre of Moselle, France

I. Nombré, Burkinabè, PhD in Plants Biology and Ecology, Research in Plants Biology and Ecology laboratory, University of Ouagadougou, Burkina Faso

J.I. Boussim, Burkinabè, Professor, Doctorate in Plants Biology and Ecology, Head of Plants Biology and Ecology Laboratory, University of Ouagadougou, Burkina Faso