Available online at www.elixirpublishers.com (Elixir International Journal)

Earth Science

Elixir Earth Science 122 (2018) 51690-51693

ISSN: 2229-712X

Effects of Climate Variability on Foraging Behaviour of Bees: A Case Study of Marigat and Ratat locations in Baringo County, Kenya

Akala, H, Makindi, S.M. and Esilaba, M.O.

Department of Environmental Science, Egerton University, Kenya.

ARTICLE INFO

Article history:

Received: 11 July 2018;

Received in revised form: 26 August 2018;

Accepted: 6 September 2018;

Keywords

Climate variability,
Foraging Behaviour,
Honey production,
Phenology.

ABSTRACT

Beekeeping is among the livelihood diversification strategies likely affected by climate variability. The variation in temperature and rainfall influence forage phenology impacting on honey production in arid and semi-arid lands (ASALs) in Kenya. The study focused on the relationship between rainfall variability on honey production among the pastoral communities. Rainfall variability was exhibited in the study area and in some circumstances drought was experienced annually. On average, 19 plant species were recorded that the bees prefer in the study area. Rainfall variability has significant positive correlation (r=0.423;p=0.001) on the effect on plant phenology thus altering flowering periods of many of the forage plants, changing the foraging behaviour of bees resulting to decrease in honey production. The findings of this study indicate that variation in rainfall has had an adverse effect on honey production and therefore there is need to incorporate land management strategies that will improve honey production in ASALs for sustainable livelihoods among pastoral communities in the context of climate variability.

Introduction

Climate variability is associated with extreme weather condition that affects farmers' output (Davis and Ali, 2014). Kushnir, and Wallace (1989) and (Trenberth *et al.*, 1998) predicted that some regions would experience different weather condition in the late 1990s. Some areas will be drier, whereas others areas will experience warmer and others cooler weather conditions thus unpredictable weather with increasing temperature and change in the onset of rainfall altering the growth of fauna and flora (Roncoli *et al.*, 2010). Therefore, this erratic nature of weather patterns results in reduction in agricultural production thus affecting the socio economic activities of many farmers (Cassman, 1999) impacting on livelihood of people who live in marginal areas because of fragile ecosystem (Maracchi, 2005; IPCC, 2007).

The abundance of flora differs depending on landscape composition and complexity (Tscharntke *et al.*, 2012; Shackelford *et al.*, 2013). This differs depending on environmental condition, soil and other physical characteristics that influence species richness, density and population performance (Riedinger *et al.*, 2014) since climate variability affects the ecological process that affects the spatial and temporal population and species composition (Stenseth *et al.*, 2003). Plants are more sensitive to the growing season since they have different stages of growth that depends on environmental condition. Therefore, climate anomalies affect the growth at different season, for example, variation in temperature induces difference in floral and anthesis development (Hegland *et al.*, 2009) and variation in evapotranspiration determines vegetation cover (Keane *et al.*, 2002). This will affect structure and composition of species density in relation to the soil and water content (Gao *et al.*, 2014). Plants produce nectar and pollen grain and during pollination, the bees are able to collect pollen grain that is essential for honey production (Kirsten *et al.*, 2015).

Bee keeping has been practiced for many years with only about a quarter of honey produced in arid and semi- arid lands of Kenya (Carroll, 2006). In Baringo County, bee keeping is among the top important income generating activities. It is a source of livelihood to many households. The County Government of Baringo currently has embarked on how to increase honey production. The decline in honey production has led to indigenous communities of Baringo to engage in charcoal burning and other socio-economic activities. According to the Baringo County development plan of 2014-2015, the major problems facing Baringo County include environmental degradation due to mostly deforestation, desertification, pollutions and climate change. Climate change and variability have led to the increased intensity and rate of recurrence of extreme weather conditions, floods, landslides and drought in the area (GoK, 2014). This paper examines the relationship of temperature and rainfall on honey bees; forage, absconding and migration.

Statement of the problem

Variation in temperature and rainfall has led to habitat loss, fragmentation and unfavourable condition for the organism to perform their duties. Honey production is the basic natural resource livelihood support systems that complement livestock production activities in ASALs. Current trends in climate warming coupled with the increase in human populations are placing new stresses on the production ability of the fragile ecosystem to sustain the indigenous populations of Baringo. There is need to establish the nexus between land management in the context of honey production in the light of climate variability, and change.

Tele: +254720778218
E-mail address: akalaharon3@gmail.com

Materials and Methods

The study was conducted in Marigat and Ratat locations of Baringo County that is situated in the Rift Valley region. It is located between 36º31′ and 36º30′ E and between latitudes 0º10′ and 1º40′ S with an altitude of between 3000m-700m above sea level. The county has both exotic and indigenous forests. The exotic trees are *Grevillea robusta, Cupressus lusitanica, Eucalyptus saligna and Prosopis juliflora (*dominant in Marigat location) (GoK, 2013). The study applied a social survey research design. Purposive random sampling technique was used in selecting the village and the respondents. A total of 100 bee farmers both male and female were interviewed using a questionnaire for data collection in Marigat and Ratat locations. Key informants were also interviewed and focused group discussion conducted.

Data Analysis

The data was coded and summarized for analysis using SPSS (version 22.0) software. Inferential and descriptive statistics were used to determine frequencies and percentages on various responses for qualitative information whereas inferential statistics such as Chi-square, Correlation analysis were used to determine the relationship between the honey production and climate variability, frequency and percentage for qualitative description

Results

Rainfall Variability

The rainfall amount has decreased drastically from the year 2012 (Figure 1). It is clear that rainfall amount was high in the year 2012 (1623.4 mm per year) and low in year 2015 (470mm per year) and slightly increased in 2016 (700 mm) thus a significant decrease (1153.4 mm and 923.4 mm) between 2012 and 2015 and between 2012 and 2016. This is depicted by the trend line y= -255.57x+1433.5. Despite the decrease in rainfall, the maximum rainfall amount was high in the year 2012 (331.5 mm) and decreased throughout the year (160 mm, 145 mm, 125 mm and 115 mm respectively) with a minimum rainfall amount of 0 mm for 2012/13/14/16 and 2 mm for 2014. In the year 2012, this area received rainfall above the average rainfall for ASALs while 2015 received rainfall below the average level.

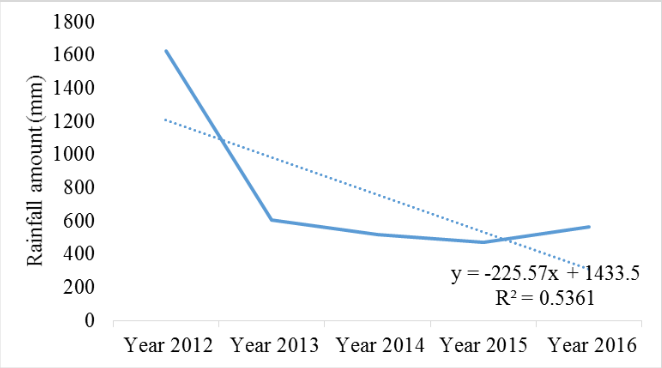

Figure 1. Annual trend in rainfall amount based on the data provided by Marigat District water office.

Plant species preferred by the bees

Nineteen plant species were identified that the bees prefer which include trees, shrubs, grass and farm crops (Table 1). Information from the FGDs and the key informant was that immediately it rains the *Acacia tortolis* flowers immediately thus nectar available for brood development by bees. However, the respondents acknowledged that the bees prefer collecting nectar from particular plant species. The results imply the ability of the local people to understand importance of the different types of plant species that the bees prefer and their flowering period. The forage availability varied from one area to another and from one season to another. For instance, the abundance of the *Acacia mellifera* and *Acacia tortolis* varied from lowland valleys towards the hills and were more abundant in valleys and less abundant on the hills. *Acacia brevispa* and *Acacia reficiens* are dominant plant species in Ratat which was in contrast to Marigat where *Acacia mellifera* is dominant.

Table 1. Ranking of the common preferred bee flora.

Rank	Scientific name	Local name	Frequency	Status
1.	*Acacia mellifera*	Ng'orore	78	More abundant
2.	*Acacia tortolis*	Sesiet	73	More abundant
3.	*Croton dichogamus*	Kelelwet	46	More abundant
4.	*Acacia eliator*	Trionde	41	More abundant
5.	*Acacia reficiens*	Parsul	36	Abundant
6.	*Acacia brevispa*	Kornis	31	Abundant
7.	*Euphobia species*	Mutangari	26	Abundant
8.	*Balanites aegyptiaca*	Ng'oswe	25	Abundant
9.	*Acacia senegal*	Chemanga	19	Abundant
10.	*Combretum mollel*	Kemel	15	Abundant
11.	*Mimusops ku mmel*	Lolowe	13	Abundant
12.	*Terminalia brownie*	Bromi/ Koloswo	13	Abundant
13.	*Euclea divinorum*	Uswe	8	Medium
14	*Boscia angustifolia*	Likwonde	5	Medium
15.	*Terminalia superba*	Noiwet	4	Medium
16.	*Cissus rotundiflora*	Rorowo	3	Medium
17	*Olinia rocheatiana*	Chepchob oiwo	3	Medium
18	*Grewia similis*	Sitewo	2	Medium
19	*Zea mays*	Maize	2	Seasonal

Status of honey bee forage and their migration patterns

Majority (70%) of the respondents indicated a decrease in the duration of flowering of plants due to the decrease in rainfall and prolonged drought (Table 2). With the decreasing duration of flowering and number of flowers on the plants species will have an impact on the foraging activity of bees.

Frequent droughts enhance migration of bees to areas with nectar and return when there are more nectar and pollen. For example, *Balanites aegyptiaca* (Ng'oswe) flowers once per year and the flowers have a long duration. The respondents affirmed that the duration of flowering of forage plants has changed due to the erratic pattern of rainfall. This implies that the shorter the duration of flowering of plants the less the nectar availability thus low honey production and vise versa.

Table 2. Respondents perception of the relationship of rainfall variability on bee forage (%).

Variable	Duration of flowers	Quantity of flowers preferred by bees	Poisonous plant
Decreasing	70	16	4
Increasing	13	51	21
Stable	17	33	77

Seasonal variation in rainfall and forage phenology

The results in table 3 show that there is a very highly significant correlation between rainfall amount and quantity of flowers (r=0.423; p=0.001). Increase in rainfall increases flowering among plant species that results high honey production due to nectar availability. With the erratic cyclone rainfall, bee forage becomes scarce and therefore this influences the activity of the bees. It was depicted that the shortage of forage for bees starts from the November through December to March. During January to March, there is a critical shortage of forage for bees due to the dry conditions that prevalent in ASALs areas. This was attributed to low rainfall that is received during the period between January to March.

Table 3. Correlation of change in rainfall amount and change in quantity of flowers.

		Quantity of flower
Variation in rainfall amount	Correlation coefficient	.423**
	Sig.(2 tailed)	.001

**correlation is significant at 0.001

Discussion

The 19 plants species identified by the respondents was an indication that pastoral communities have knowledge on the foraging preference by bees. Delaplane *et al.* (2010) reported that local farmers are well informed about the type of forage the bees prefer and their flowering period. According to the study of Mattu *et al.* (2012) in Himalaya and Abou-Shaara (2014) in Egypt, bees have the preference on type of forage that they collect nectar and pollen and source of water. This was similarly reported in the study area of Baringo. However, with changing weather patterns, there is the decline in plant species diversity in ASALs due to the frequency of droughts that have negative impacts on bee population and hence low honey production (Wasonga *et al.*, 2011). According to Ngaira (2005), the severity, frequency, and magnitude of drought have increased in Kenya from the year 2000. In some circumstances, it is usually experienced yearly in dry areas of Kenya, and this has a major influence on vegetation cover (Kosonei *et al.*, 2017) and plant phenology (Davies *et al.*, 2013). Because of water stress resulting from decrease in rainfall, plants limit their physiological process to cope with the changing conditions and hence a decrease in forage for bees in the study areas. According to Goodwillie, and Ness (2005), change in pollination mode leads to changing a number of flowers produced by plant reducing the amount of nectar and pollen available for the bees. Barrett *et al.* (1994) also found out that pollination would influence the number of flowers and the longevity of the flowers display.

There has been a decrease in number of grass species that bees use as forage plants in the study area as a result of the decrease in rainfall. Wasonga *et al.* (2011) reported that sprouting of grass plant species and their abundance has decreased drastically in Baringo.

In another study at Marigat by Kosonei *et al.* (2017) found out that, there have been a decrease in grass plants species which corresponds to the decline of trees species in riparian zones in Baringo. This was expressed because of the decrease in the amount of rainfall and increase in the temperature. This result implies that the erratic rainfall has led to plants to change their physiological process to adjust to the condition. There is evidence to suggest that, the erratic cyclonic rainfall has led to variation in flowering thus affecting honey production. As the distance from the beehive to nearby forage increases, honey production decreases. The bees will consume more honey for daily activity and hence the available honey will be low. Bees migrate from lowland to highland because of high flow of nectar in the Tugen Hills with high diversity of forage plants. However, information from the respondents and focus group discussions revealed that, honey from forage plants on the hills was of poor quality. This may be because bees may collect nectar from poisonous plants that have a long flowering duration. This was in agreement with Primack (1985), (1989) and Miranda *et al.* (2011) results who reported that, it is because of decrease of rainfall that has led to bees collect nectar and pollen from other plants whose nectar and pollen does not provide quality honey.

Variation in rainfall has had an impact on plant phenology altering the availability of forage for the bees and hence decline in amount affected plant phenology. The findings of this study is in agreement with the study by Elsa *et al.* (2007) who reported that plant phenology depends more on variation in precipitation in the tropics than observed in variation in temperature regimes. Some plant species can alter their phenology to respond to change in weather (Elsa *et al.*, 2007) reported that bee forage is decreasing because of seasonal variation in climate. In a study by Tessega (2009), Gebremedhn *et al.* (2013) and Yetim (2015) in Ethiopia, revealed that the seasonal variation in flowering affects honey production. According to Bista, and Shivakoti (2001), the seasonal variation in plant phenology is because of the seasonal fluctuation of climatic conditions and topographic characteristics of the area. Furthermore, the soil characteristics vary with topography. Thus plants will blossom seasonally causing variation in the bee production and the well-being of various organisms inherent in such ecosystems (Gao *et al.*, 2014).

Conclusion

In conclusion, there is evidence to suggest climate variability has had a negative impact on honey bee foraging behaviour. The results indicated there has been a variation in rainfall that has led to increase in severity and magnitude of drought thus impacting on rainfall patterns which has had a significant effect on honey production by affecting plant phenology and forage availability for bees.

Acknowledgement

Special thanks to Department of Environmental Science, Egerton University for overall support. Our gratitude goes to all the respondents, Key interviews and government staffs for their relevant information during data collection.

Reference

Abou-Shaara, H. (2014). The foraging behaviour of honey bees, Apis mellifera: a review. Veterinarni Medicina, 59(1).

Barrett, R., Berry, M., Chan, T. F., Demmel, J., Donato, J., Dongarra, J., Eijkhout, V., Pozo, R., Romine, C., and Van der Vorst, H. (1994). Templates for the solution of linear systems: building blocks for iterative methods: SIAM.

Bista, S., and Shivakoti, G. P. (2001). Honey bee flora at Kabre, Dolakha district. Nepal Agriculture Research Journal, 4, 18-25.

Carroll, T. (2006). A beginner's guide to bee keeping in Kenya. Baraka Agricultural training college Nakuru, Kenya.

Cassman, K. (1999). Ecological intensification of cereal production systems: yield potential, soil quality, and precision agriculture. Proc. Nat. Acad. Sci. U.S.A, 96, 5952–5959.

Davies,T.J., Wolkovich,E.M., Kraft,N.J., Salamin,N., Allen,J., Ault,T.R., Betancourt,J.L., Bolmgren,K., Cleland,E.E., and Cook, B. I. (2013). Phylogenetic conservatism in plant phenology. Journal of Ecology, 101(6), 1520-1530.

Davis, P., and Ali, S. (2014). Exploring Local Perceptions of Climate Change Impact and Adaptation in Rural Bangladesh.IFPRI Discussion Paper 01322. Washington, DC: International Food Policy Research Institute.

Delaplane, K. S., Thomas, P. A., and McLaurin, W. J. (2010). Bee pollination of Georgia crop plants.

Elsa, C., E, Chuine, I., Menzel,A.,Mooney,H.,A,andSchwartz, M., D. (2007). Shifting plant phenology in response to global change. Trends in ecology & evolution, 22(7), 357-365.

Gao,X.,Wu,P.,Zhao,X.,Wang, J.,and Shi,Y.(2014).Effects of land use on soil moisture variations in a semi-arid catchment: implications for land and agricultural water management. Land Degradation & Development, 25(2), 163-172.

Gebremedhn, H., Tesfay, Z., Murutse, G., and Estifanos, A. (2013). Seasonal honeybee forage availability, swarming, absconding and honey harvesting in Debrekidan and Begasheka Watersheds of Tigray, Northern Ethiopia. Livestock Research for Rural Development, 25(4).

GoK. (2013). First County Integrated Development Plan 2013-2017. Kenya: County Government of Baringo.

GoK. (2014). Annual County Integrated Development Plan 2015-2016. . Kenya: County Government of Baringo.

Goodwillie, C.,and Ness, J. M. (2005). Correlated evolution in floral morphology and the timing of self-compatibility in Leptosiphon jepsonii (Polemoniaceae). International Journal of Plant Sciences, 166(5), 741-751.

Hegland, S. J., Nielsen, A., Lázaro, A., Bjerknes, A. L., and Totland, Ø. (2009). How does climate warming affect plant-pollinator interactions? Journal of Ecol Letters, 12, 184-195.

IPCC. (2007). Climate change 2007: synthesis report. Contribution of Working Groups I, II and III to the fourth assessment report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on ClimateChange, 1.

Keane, R. E., Parsons, R. A., and Hessburg, P. F. (2002). Estimating historical range and variation of landscape patch dynamics: limitations of the simulation approach. Ecol. Modell, 151, 29-49.

Kirsten, S. T., Yves Le Conte, E., R., and Jr., P. (2015). Age matters: pheromone profiles of larvae differentially influence foraging behaviour in the honeybee, Apis mellifera. Animal Behaviour, 99, 1-8.

Kosonei, R. C., Abuom, O., Bosire, E., and Huho, J. (2017). Effects of drought dynamics on vegetation cover in Marigat Sub-county, Baringo County, Kenya. International Journal of Scientific and Research Publications, 7(5).

Kushnir, Y., and Wallace,J.M. (1989).Low frequency variability in the Northern Hemisphere winter, geographical distribution, structure and time dependence. Atmos. Sci., 46, 3122–3142.

Maracchi, G. O. (2005). Impacts of presentv and future climate variability on agriculture and forestry in the regions: Europe.

Mattu, V., Raj, H., and Thakur, M. (2012). Foraging behavior of honeybees on apple crop and its variation with altitude in Shimla hills of western Himalaya, India. Int. J. Sci. Nat, 3, 296-301.

Miranda, J. d. D., Armas, C., Padilla, F., and Pugnaire, F. (2011). Climatic change and rainfall patterns: effects on semi-arid plant communities of the Iberian Southeast. Journal of Arid Environments, 75(12), 1302-1309.

Ngaira, J. (2005). Hydrometeorological disasters and their impact on development: The Kenya experience. Maseno journal of education, arts and sciences, 5(1). Primack, R. B. (1985). Longevity of individual flowers. Annual review of ecology and systematics, 16(1), 15-37.

Riedinger, V., Renner, M., Rundlof, M., Steffan-Dewenter, I., and Holzschuh, A. (2014). Early massflowering crops mitigate pollinator dilution in late-flowering crops. Landsc. Ecol, 29, 425-435.

Roncoli, C., Okoba, B., Gathaara, V., Ngugi, J., and Nganga, T. (2010). Adaptation to climate change for smallholder agriculture in Kenya: community-based perspectives from five districts. Report to the World Bank of the project:" Adaptation of Smallholder Agriculture.

Shackelford, G., Steward, P. R., Benton, T. G., Kunin, W. E., Potts,S.G.,Biesmeijer, J.C.,and Sait, S. M. 2013). Comparison of pollinators and natural enemies: ameta-analysis of landscape and local effects on abundance and richness in crops. Biol, Rev, 88, 1002.

Stenseth,N.C.,Ottersen,G.,Hurrell, J. W., Mysterud, A., Lima, M., Chan, K.-S., Yoccoz, N. G., and Ådlandsvik, B. (2003). Studying climate effects on ecology through the use of climate indices, the North Atlantic Oscillation, El Niño Southern Oscillation and , El Niño Southern Oscillation and beyond. Biol. Sci, 270, 2087–2096.

Stratton, D. A. (1989). Longevity of individual flowers in a Costa Rican cloud forest: ecological correlates and phylogenetic constraints. Biotropica, 308-318. Tessega,B.(2009).Honeybee production and marketing systems, constraints and opportunities in Burie District of Amhara Region, Ethiopia. Bahir Dar University.

Trenberth, K. E., Branstator, G. W., Karoly, D., Kumar, A., Lau, N. C., and Ropelewski, C. (1998). Progress during TOGA in understanding and modeling global teleconnections associated with tropical sea surface temperatures. Geophys, 103, 14291–14324.

Tscharntke,T.,Tylianakis, J. M., Rand, T. A., Didham, R. K., Fahrig, L., Batary, P., Bengtsson, J., Clough, Y., Crist, T. O., Dormann, C. F., Ewers, R. M., Frund, J., Holt, R. D., Holzschuh, A., Klein, A. M., Kleijn, D., Kremen, C., Landis, D. A., and Laurance, W. (2012). Landscape moderation of biodiversity patterns and processes—eight hypotheses. Biol. Rev, 87, 661–685.

Wasonga,V.O.,Nyariki,D.M.,andNgugi,R.K.(2011).Assessing socioecological change dynamics using local knowledge in the semi-arid lowlands of Baringo district, Kenya. Environmental Research Journal, 5(1), 11-17.

Yetim, G. G. (2015).Characterization of Beekeeping Systems and Honey Value Chain, and Effects of Storage Containers and Durations on Physico-Chemical Properties of Honey in Kilte Awlaelo District,Eastern Tigray,Ethiopia.(PhD Program in Animal Production), Addis Ababa University,, Ethiopia