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Identifying possible regions for using modified beehives in Saudi Arabia using a geographical information system (GIS)

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Not all regions of Saudi Arabia are suitable for apiculture especially during the summer season. Because the most extreme conditions of elevated temperature and very low relative humidity occur during the summer. Thus, the use of modified beehives is important for saving honey bee lives under such extreme conditions. However, not all regions of Saudi Arabia require the use of modified beehives. The geographical information system (GIS) has been previously used in apiculture for classifying regions according to their suitability for honey bees as well as for other purposes. Therefore, the regions that require the use of modified beehives, generally, for keeping honey bees during the summer were identified using the GIS. The datasets were prepared as layers, consisting of the temperature, relative humidity, precipitation and water resources. The overall map created from these factors classified the regions according to temperatures and drought conditions. Then, the use of the modified beehives was recommended in the harshest regions.

Introduction

The summer season in Saudi Arabia is hot and arid, which negatively affects beekeeping activities and results in great colony losses each year. Not all regions of Saudi Arabia are suitable for beekeeping in summer (Abou-Shaara*et al*., 2013) and the summer temperature in some regions of Saudi Arabia could reach to 45°C (Al-Qarni, 2006). Honey bee colonies require specific microclimatic conditions within their colonies including temperature from 33 to 36°C (Petz*et al*., 2004) and relative humidity approximately 75 % (Ellis *et al.*, 2008). Due to the passive impacts of elevated temperature on honey bees (e.g. Al-Ghamdi, 2005; Al-Qarni, 2006 & Joshi and Joshi, 2010) honey bee workers always try to avoid any increase of temperature in the brood nest (Allen, 1959 & Free and Spencer-Booth, 1962). Also, due to the

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importance of relative humidity for brood rearing and egg hatching (Doull, 1976; Kuhnholz and Seeley, 1997 and Human *et al.*, 2006) honey bee workers try to avoid any dryness within their colonies. One suitable method for keeping honey bee colonies during summer season of Saudi Arabia is the use of the modified beehives.

For different purposes the geographic information system (GIS) has been used including; the identification of land suitability for beekeeping (Estoque and Murayama, 2010; Amiri*et al.*, 2011; Amiri and Shariff, 2012 and Abou-Shaara*et al.*, 2013), or feral honey bees (Coulson *et al.*,2005) and for identifying the suitable growing areas of Acacia for honey bees (Myung-Hee*et al.*, 2001). Recently, Abou-Shaara (2013) used the GIS to create morphometry maps for honey bees as well as to perform the morphometric analysis. The spatial analysis of the GIS requires the insertion of different datasets as layers based on the purpose. Therefore, different layers have been used during the analysis including; vegetation, water resources, relative humidity and temperature (Coulson *et al.*, 2005; Amiri*et al.*, 2011; Amiri and Shariff, 2012 and Abou-Shaara*et al.*, 2013).

In this research, the GIS was used to identify the regions that require the use of modified beehives during the summer season to keep honey bee colonies. A map with regional classification based on temperatures and drought conditions was created using the GIS. Recommendations for the use of the modified beehives in the harshest regions were then made.

Materials and methods

Saudi Arabia contains 13 administrative regions (Fig.1) with a total area of about 1,950,000 km^2 and located between latitudes of 16° 22′ 46″ and 32° 14′ 00″ north and longitudes of 34° 29′ 30″ and 55° 40′ 00″ east (Saudi Geological Survey, 2012). All Saudi Arabian regions were incorporated into the GIS spatial analysis to identify the possible regions requiring the use of the modified beehives to keep honey bee colonies during the summer season.

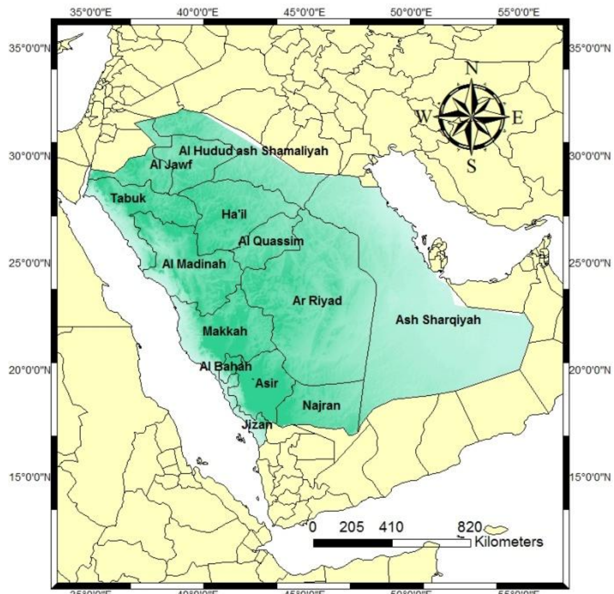

Fig. 1.The location and the administrative regions of Saudi Arabia.

Input datasets

The temperature and drought conditions are the main factors for recommending the use of the modified beehives during the summer season. Therefore, a thermal map for all the regions was created and another map showing drought conditions based on relative humidity, precipitation and water resources was also created. Then, the two maps were combined together to classify the regions according to their temperatures and drought conditions.

Hence, the analysis included the following layers; 1) the maximum temperature layer for summer season (June, July and August) was obtained from the Worldclim website (www.worldclim.org). 2) the means of relative humidity during summer season from 2007 to 2011, were obtained from the Presidency of Metrology and Environment (PME) website, and were used to create the relative humidity layer according to Abou-Shaara*et al.* (2013) using the ArcGIS 10 program. 3) The water resources layer was obtained from the DIVA-GIS website (www.diva-gis.org). The layer was converted into lines and the percentage of lines per each location was then calculated and incorporated into the analysis by using the ArcGIS 10. The line percentages reflect the abundance of water resources per each location. 4) precipitation layer during the summer season was obtained from the Worldclim website.

Regional classification

Three maps classified into five classes based on data ranges and the results of the laboratory experiments were created; 1) thermal map classified into five classes using the maximum temperatures during the summer season. The classes are from 24.9 to 33.7 ºC; 33.7 to 36.6 ºC; 36.6 to 38.8 ºC; 38.8 to 40.7 ºC and 40.7 to 43.7 ºC. 2) drought conditions map classified into five degrees using the combination of relative humidity, precipitation and water resources. Drought conditions were considered as very high: when RH is about 6.7%, precipitation from 0 to 1 mm and water resources less than 20%; as high: when RH from 6.7 to 8.8, precipitation from 1 to 5 mm and water resources from 20 to 40%. Relatively high drought was considered when the RH is between 8.8 to 13.7%, precipitation from 5 to 11 mm and water resources from 40 to 60%; Moderate:when RH is from 13.7 to 27.3%, precipitation from 11 to 16 mm and water resources from 60 to 80%, while drought condition was considered as low when RH % is from 27.3 to 51.2%, precipitation from 16 to 27 mm and water resources from 80 to 100%. 3) overall map for temperatures and drought conditions classified into five classes based on the previous two maps. The most harsh regions with elevated temperatures and drought conditions were then identified. The classification and the combination steps for the datasets were done according to ESRI (2002).

The overall map was compared with an elevation map to check the altitude of the harshest regions. The altitude layer used in creating the elevation map was obtained from the Worldclim website with elevation above sea level in (m) units. Moreover, to identify the vegetation areas within the harshest regions, a land cover map obtained from the DIVA-GIS website was reclassified using the ArcGIS to present vegetation only and it was supported by Landsat images (Landsat with Enhanced Thematic Mapper, ETM+) for the harshest regions. Also, the locations of some valleys within the harshest regions were obtained from the Saudi Geological Survey (2012) and were placed on the vegetation map to recognize the areas at which the beekeeping activity could be found within the harshest regions during the summer season.

Results and discussions

The thermal and drought condition maps

The regional classification according to maximum temperatures as shown in Fig.2 emphasized that the highest heat stress is concentrated in the central regions and some eastern parts. In the drought conditions map, the extreme drought conditions are mainly presented in the central regions and some parts of Hail (Fig.3). It is clear from the two maps that the weather of Saudi Arabia during the summer is hot and arid with the exception of the southwestern areas. That is in line with a previous study by Abou-Shaara*et al.* (2013) on beekeeping suitability in Saudi Arabia where the southwestern regions were considered as more suitable for beekeeping during the summer.

The overall map

The overall map resulted from the thermal and drought condition maps is presented in Fig.4. It is clear that the central region and some parts of Nijran, Al-Madinah, Hail and Al-Qasimoveralped in the overall map to represent the harshest regions with very high drought conditions and with maximum temperatures with a range from 40.7 to 43.7ºC. The elevation of these regions above the sea level is generally low if compared with the other regions as shown in Fig.5. It is known that the temperatures decrease with elevation. Thus, the low elevations of these regions could explain their harsh conditions. It could be expected that honey bee colonies in these regions are impacted greatly by the harsh conditions as found by Al-Qarni (2006) in Riyadh. Within the harshest regions there are some vegetation areas (Fig.6) at which beekeeping activity could be existed during the summer season especially the migratory beekeeping for Acacia and Hegazy clover honey (Personal communications). Thus, the use of the modified beehives is strongly recommended for any beekeeping activity within the harshest regions, with high temperatures above 40.7ºC and very high drought conditions, during the summer season.

Based on the results of the laboratory experiments of Abou-Shaara*et al.* (2012), the highest survival of Yemeni and Carniolan honey bee workers was found at 35ºC while the lowest body water loss rates was found at 35ºC and 50% RH. Also, Yemeni honey bees were found to be with a higher tolerance to elevated temperatures than the Carniolan honey bees. Thus, it could be expected that the regions with temperatures about 35ºC or below and with low or moderate drought conditions (Fig.7) are the more suitable regions for keeping these two races especially the imported Carniolan honey bees during the summer season. Thus, the death of honey bee colonies due to the harsh conditions could be minimized by keeping the colonies at these regions. Also, it is expected that these regions are more suitable for keeping the imported honey bee packages. However, more detailed investigations are required in these regions to characterize the plant species and to determine exactly the suitable locations for apiaries. The regions located between the more suitable and the harshest regions have temperatures between 36.6 to 40.7ºC and with high or relatively high drought conditions. These regions can be used in keeping Yemeni honey bees without the use of any modified beehives while

Caniolanhoney bees at these regions require modified beehives. Because the Yemeni honey bees can tolerate elevated temperature and very low relative humidity than the Carniolan honey bees.

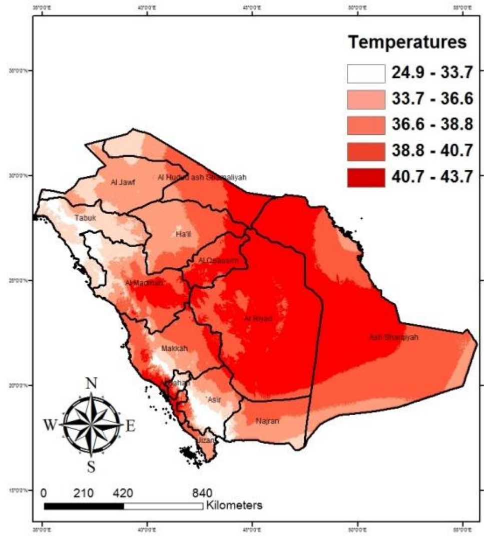

Fig. 2. The classification according to maximum temperatures

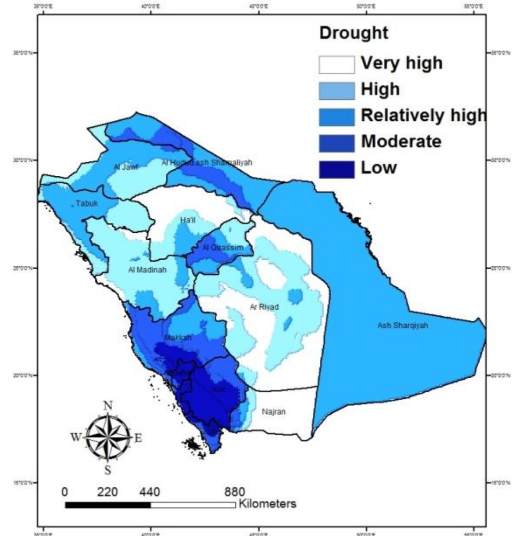

Fig. 3. The classification based on drought conditions

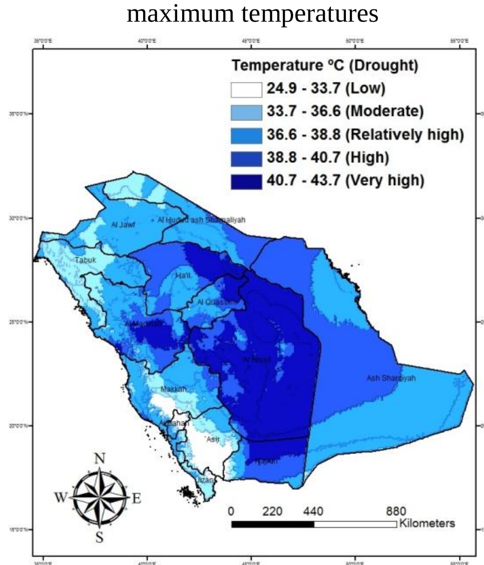

Fig. 4. The classification based on temperatures and drought conditions

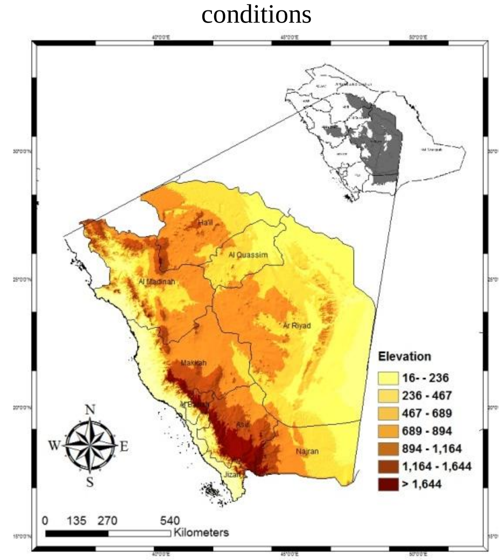

Fig. 5. The elevation of the harshest regions in comparison with the other regions

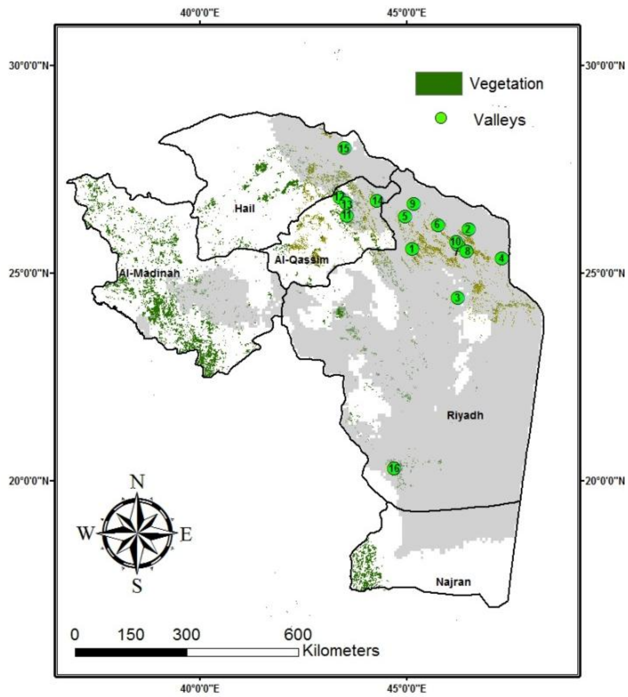

Fig. 6. Vegetation and some valleys within the harshest regions

No.	Name	No.	Name	No.	Name	No.	Name
1	Rawadat Om Alasafer	4	RawadatKhuraim	7	RawadatNoura	10	Alhakaqh
2	RawadatAltneahat	5	RawadatAlsblh	8	Alkhvs	11	Rawadat Om Alhashem
3	RawadatAlkherarh	6	RawadatMatrabah	9	Om shabram	12	Abkarayah
13	Almesaby	14	Mesmarah	15	KhobrahSafaqah	16	WadiAdawaser

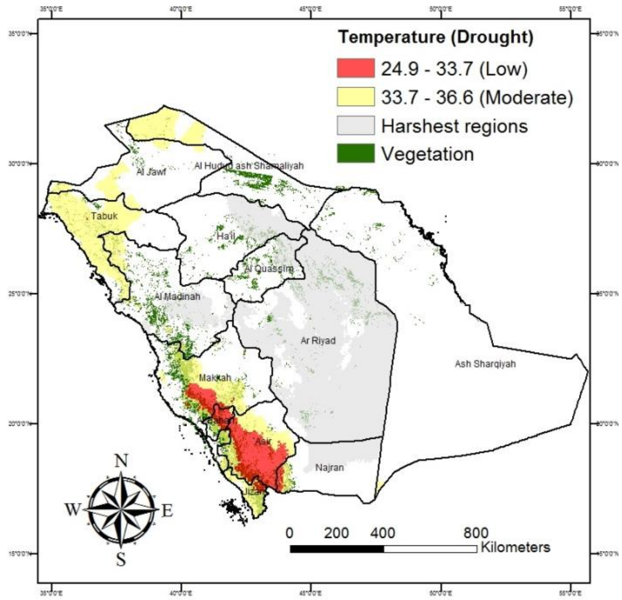

Fig. 7. The areas with the most suitable conditions (temperature is 36.6 ºC or below and with moderate or low drought conditions) for honey bee colonies during the summer

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References

Abou-Shaara, H.F. (2013). A morphometry map and a new method for honey bee morphometric analysis by using the ArcGIS. Arthropods 2(4):189-199.

Abou-Shaara, H.F. ; A.A. Al-Ghamdi and A.A. Mohamed (2012). Tolerance of two honey bee races to various temperature and relative humidity gradients. Environmental and Experimental Biology,10(4):133–138.

Abou-Shaara, H.F., A.A. Al-Ghamdi and A.A. Mohamed (2013). A suitability map for keeping honey bees under harsh environmental conditions using Geographical Information System. World Applied Sciences Journal 22(8):1099 -1105.

Al-Ghamdi, A. (2005). Comparative study between subspecies of *Apismellifera* for egg hatching and sealed brood percentage, brood nest temperature and relative humidity.Pakistan Journal of Biological Sciences 8(4):631-635.

Allen, M.D. (1959). Respiration rates of worker honeybees at different ages and temperatures, Journal of Experimental Biology 36:92–101.

Al-Qarni, A.S. (2006). Tolerance of summer temperature in imported and indigenous honeybee *Apismellifera* L. races in central Saudi Arabia. Saudi Journal of Biological Sciences, 13(2):123-127.

Amiri, F. and A.B.M. Shariff (2012). Application of geographic information systems in landuse suitability evaluation for beekeeping: A case study of Vahregan watershed (Iran). African Journal Agricultural Research 7(1):89-97.

Amiri, F.; A.B.M. Shariff and S. Arekhi (2011). An approach for rangeland suitability analysis to apiculture planning in GharahAghach region, Isfahan-Iran.World Applied Sciences Journal 12(7):962-972.

Coulson, R.N.; M.A. Pinto; M.D. Tchakerian; K.A. Baum; W.L. Rubink and J.S. Johnston (2005). Feral honey bees in pine forest landscapes of east Texas. Forest Ecology and Management 215:91–102.

Doull, K.M. (1976). The effects of different humidities on the hatching of the eggs of honeybees.Apidologie 7:61–66.

Ellis, M.B.; S.W. Nicolson; R.M. Crewe and V. Dietemann (2008).Hygropreference and brood care in the honeybee (*Apismellifera*). Journal of Insect Physiology 54:1516–1521.

ESRI (2002). ArcGIS 9, Using ArcGIS spatial analyst. ESRI, 280 New York Street, Redlands,USA. Chapter 2. P:11-38.

Estoque, R.C. and Y. Murayama (2010).Suitability analysis for beekeeping sites in La Union, Philippines, Using GIS and multi-criteria evaluation techniques. Research Journal of Applied Sciences 5(3):242-253.

Free, J.B. and Y. Spencer-Booth (1962). The upper lethal temperatures of honeybees, EntomologiaExperimentalisetApplicata 5:249–254.

Human, H.; S.W. Nicolson and V. Dietemann (2006). Do honeybees, *Apismelliferascutellata*, regulate humidity in their nest?.Naturwissenschaften 93:397–401.

Joshi, N.C. and P.C. Joshi (2010).Foraging behaviour of Apis*Spp.* on apple flowers in a subtropical environment. New York Science Journal 3(3):71-76.

Kuhnholz, S. and T.D. Seeley (1997).The control of water collection in honey bee colonies.Behavioral Ecology and Sociobiology 41:407–422.

Myung-Hee, J.; K. Joon-Bum and B. Seong-Baek (2001).Selection technique for honey Plant complex area using landsat image and GIS. The 22nd Asian Conference on Remote Sensing, 5- 9 November, Singapore.

Petz, M.; A. Stabentheiner and K. Crailsheim (2004).Respiration of individual honeybee larvae in relation to age and ambient temperature.Journal of Comparative Physiology B, 174:511–518.

Saudi Geological Survey (2012). Kingdom of Saudi Arabia: facts and numbers. 1st edition, Jedda, Saudi Arabia.

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