

UTILIZATION OF FOREST BIODIVERSITY: REWARDS OF *CERATONIA SILIQUA L.* FOR *APIS MELLIFERA*

Orman Biyoçeşitliliğinin Kullanımı: *Apis Mellifera* için *Ceratonia Siliqua*'nın Ödülü

(Genişletilmiş Türkçe Özet Makalenin Sonunda Verilmiştir.)

Syouf Maha¹ and Nizar Haddad^{1*}

¹ National Center for Agricultural Research and Extension, Jordan; P.O. Box639 Baqa'(19381) Jordan.
Fax: 009626-5372516.

*Corresponding Author email: drnizarh@gmail.com

ABSTRACT

Plant community of *Ceratonia siliqua* L. at Wasfi Al-Tal forest reserve was investigated during 26 September to 23 December 2004 to assess the utilization of *Ceratonia siliqua* L (Carob) for *Apis mellifera* (Honey bee). Nectar production rate was measured by emptying flowers, covering them for 24 hours with nylon mesh bags, and then sampling their nectar contents. The *Ceratonia siliqua* L. plant showed good results regarding the nectar volume and concentration and there was good honey bee visitation for pollen and nectar. Male trees were higher than the female ones regarding nectar volume and concentration, the mean volume for male trees was $17.4\text{ml} \pm 9.7\text{sd}$ whereas, for the female ones it was only $4.25\text{ml} \pm 4.9\text{sd}$. The mean volume for the nectar concentration for male trees was $63.97\% \pm 10.19\text{sd}$ whereas, for the female ones it was only $29.25\% \pm 34\text{sd}$.

Key Words: Carob, *Ceratonia siliqua*, *Apis mellifera*.

INTRODUCTION

Ceratonia siliqua L. (Carob) a member of the Fabaceae family is considered as one of the important, underutilized and neglected crops in the Mediterranean region (IPGRI, 1997). The Carob is a dioecious species with some hermaphroditic forms; thus male, female and hermaphrodite flowers are generally borne on different trees. The flowers are initially bisexual, but usually one sex is suppressed during late development of the flowers (Tucker, 1992). Flowers are small and numerous, 6-12 mm long, spirally arranged along the inflorescence axis in catkin-like racemes borne on spurs from old wood and even on the trunk. Flowers are green-tinted red. The calyx is disc shaped, reddish-green and bears nectars. Female flowers consist of a pistil (6-8.5mm) on a disk and rudimentary stamens,

Surrounded by 5 hairy sepals. The ovary is bent, consisting of two carpels 5-7 mm long and containing several ovules. The stigma has 2 lobes.

Male flowers consist of a nectar disk with 5 stamens with delicate filaments surrounded by hairy sepals. In the centre of the disk there is a rudimentary pistil. Pollen grains are released from the anthers with a spheroid shape. Pollen diameter is 28-29 μm at the poles and 25-28 μm at the equator (Ferguson, 1980; Linskens and Scholten, 1980).

The carob pods have traditionally been used as animal and human food and recently it is used mainly for gum extraction (Louca and Papas, 1973). Carob powder consists of 46% sugar, 7% protein and small amounts of numerous minerals and vitamins (Whiteside, 1981). Carob pulp was among the first horticultural crops used for the production of industrial alcohol by fermentation in several Mediterranean countries (Merwin, 1981). In Jordan Carob syrup is a popular drink obtained by extracting carob kibbles with water. Furthermore, sugar solutions extracted from carob pods are substrate for culturing fungi such as *Aspergillus*

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niger and *Fusarium moniliforme*. (Imrie, 1973). Other uses are well known such as an ornamental and windbreaks. It is also used in the pharmaceutical and cosmetic industries (NAS, 1979; Esbenshade and Wilson, 1986; IPGRI, 1997).

In this research the nectar concentration, volume, and bee visitation were studied to assess the utilization of Jordanian *Ceratonia siliqua* as honey bee forage plant.

MATERIALS AND METHODS

Plant community of *Ceratonia siliqua* at Wasfi Al-Tal Forest reserve in Balqa province in central Jordan was investigated during 26 September to 23 December 2004. The Latitude, Longitude and elevation of the site was assessed using Garmin 12X Geographical Positioning System (GPS) instrument. A total of 10 male and 10 female trees were marked and flower phenology was studied according to a task on which the following data were taken:

-Plant canopy was measured by a meter taking the maximum plant height, diameter of two cross sections of the whole tree. These were taken for 10 male and 10 female trees.

-Plant distribution was assessed by measuring distance in meter between randomly chosen pairs.

-Flower parameter was determined by counting number of floret per raceme, and measuring length and width of each floret by cm of the surveyed individuals.

-Bee visitation in 10 min per flower on each observation day was recorded in which male and

female flowers were monitored. Observations were conducted during peak of honeybees' activity (typically between 10 and 12 am). A visit was defined as a touch of the corolla, the stigma, or the stamen by a bee.

-Nectar production rate was measured by emptying 20 flowers per male and female trees, covering them for 24 hours with nylon mesh bags; the nectar that accumulated in the sampled flowers represents the plant's 24-h nectar production. We used 1- μ l micro pipettes to measure nectar volume and hand held-pocket refract meters (Japanese made ATAGO N1 0~ 45 and 40~ 80%) to measure sugar (W/W %) concentrations (Wyatt et al., 1992; Corbet, 2003). Sampling was taken over two successive days at least. Nectar yield was

determined by the amount of nectar available to honey bees. The value of the species as a food source for honeybee will be estimated on the basis of nectar volume and sugar concentration.

RESULTS

Population of *Ceratonia siliqua* was studied at Wasfi Al Tal Forest at Baqa site (32 08 47.9N and 35 51 00.6E with elevation of 597.5m). The mean of maximum height for the male and female trees were found to be $6.1m \pm 2.5sd$ and $4.1m \pm 1.5sd$ respectively. The canopy of the male trees was larger than the female as indicated by the maximum average of the two cross diameters and maximum plant height (Table 1 and 2).

Table 1: Maximum plant height and mean of the cross diameter of male *Ceratonia siliqua* trees.

Plant no.	sex	Height (m)	d1(m)	d2(m)	(d1+d2)/2
1	m	5	4.4	2.1	3.25
2	m	4.5	3.1	2.2	2.65
3	m	7	6.5	5.8	6.15
4	m	3	2.6	2.1	2.35
5	m	4	2.5	3.9	3.2
6	m	7.5	3.7	4	3.85
7	m	3.5	3	3.4	3.2
8	m	10	4.1	5.4	4.75
9	m	9.5	4.4	3.4	3.9
10	m	7	3.4	6	4.7
Mean		6.1	3.77	3.83	3.8
std		2.5	1.2	1.5	1.1

Table 2: Maximum plant height and mean of the cross diameter of female *Ceratonia siliqua* trees.

Plant no.	Sex	Height (m)	d1(m)	d2(m)	(d1+d2)/2
1	f	6	2.85	3.6	3.2
2	f	6.5	4.0	4.4	4.2
3	f	4.5	3.0	2.8	2.9
4	f	4.0	3.2	3.2	3.2
5	f	3.5	4.3	3.2	3.8
6	f	2.5	3.7	2.9	3.3
7	f	2.5	3.3	3.3	3.3
8	f	5.0	4.5	4.4	4.5
9	f	3.0	3.2	4.2	3.7
10	f	6.3	3.3	4.6	3.9
Mean		4.4	3.5	3.7	3.5
std		1.5	0.6	0.7	0.5

Plant distribution was assessed by measuring the distance between randomly chosen pairs, the mean

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distance was found to be 8.1 meter \pm 3.6 sd (Table3). The distribution of the carob trees were found to be within the recommended range of tree distribution (IPGRI, 1997)

Table 3: Plant distribution of *Catantonia siliqua* trees.

Plant no.	Distance(m)	Plant no.	Distance(m)
1	2.2	11	7.6
2	6.6	12	15.9
3	12.7	13	10.7
4	13.2	14	9.2
5	5.3	15	5.5
6	7	16	7.6
7	7.8	17	9.7
8	6.2	18	13.4
9	8.3	19	4.9
10	5	20	3.5
Mean	8.1		
Std	3.6		

Floret mean number, were found to be higher than the female inflorescence; 64.9 floret per inflorescence, whereas the mean inflorescence number for female was 57.3 (Table 4 and Table 5).

Mean of the length and width of female trees were found to be higher than the male ones as shown in Table 4 Fig 1(a) and Table 5 Fig 1(b), respectively.

Table 4: Number of floret per inflorescence length, and width of each inflorescence of *Ceratonnia siliqua* female trees.

+Inflorescence no.	No of florets per inflorescence	Length(m)	Width (cm)
1	57	7.4	1.2
2	59	7.6	1.1
3	57	12	1.5
4	45	8.4	1
5	77	9.6	1.8
6	57	8.6	2
7	47	7.5	2
8	52	7	1.9
9	80	6.6	1.5
10	42	7.2	1.4
Mean	57.3	8.19	1.54
Std	12.6	1.6	0.4

Table 5: Number of floret per inflorescence, length and width of each inflorescence of *Ceratonnia siliqua* male trees.

Inflorescence no.	No of florets per inflorescence	Length (m)	Width (cm)
1	67	6	1.5
2	48	5.6	1.4
3	41	5.5	1.5
4	74	6.5	1.6
5	72	5.5	1.5
6	75	5.5	1.5
7	75	6.5	1
8	74	6.5	1
9	62	6.6	1.9
10	61	4.5	1
Mean	57.3	8.19	1.54
Std	12.6	1.6	0.4

Table 6: Number of male and female flowers with nectar volume and concentrations.

No of flowers	Male		Female	
	Volume/ml	Conc. %	Volume /ml	Conc. %
1	30	42.5	0	0
2	17	50	0	0
3	8	50	0	0
4	15	70	12	79
5	7	65	5	48
6	13	69	5	45
7	28	65	0	0
8	5	69	0	0
9	6	50	0	0
10	24	48	0	0
11	40	74	10	67
12	20	72	15	70
13	15	75	0	0
14	28	73	0	0
15	16	74	8	60
16	25	71	10	72
17	6	65	10	77
18	7	67	0	0
19	16	60	5	67
20	22	70	5	0
Mean	17.4	63.97	4.25	29.25
Std	9.7	10.2	5.0	34.1



Fig 1.* Female (a) and male (b) flower inflorescences of *Ceratonia siliqua* trees

*Reference: Photo by Dr Maha Syouf during 22nd December 2004 at Wasfi Altal Forest in Jordan.

While monitoring the honey bees in the field we noticed that they were collecting both nectar and pollen from *Ceratonia siliqua* L. trees. Average of bee visitation every 10 minutes was 2 honey bees per flower, 10 flies and 7 wasps were recorded.

Our measurements indicated that male trees were higher than the female ones regarding nectar volume and sugar concentration. The mean volume for male was $17.4 \text{ ml} \pm 9.7\text{sd}$ whereas, for the female it was only $4.25\text{ml} \pm 5\text{sd}$. (Table 6)

Fig2: Nectar concentration and volume for male *Ceratonia siliqua* trees

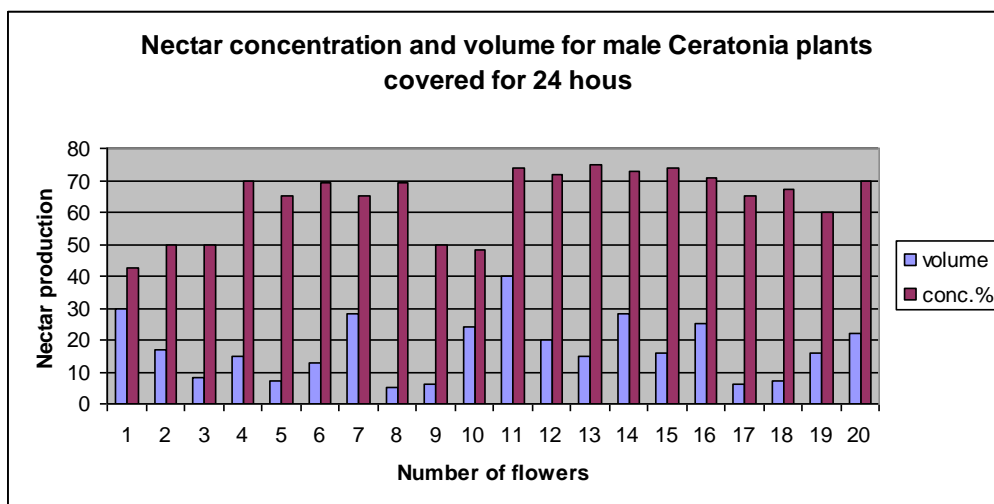
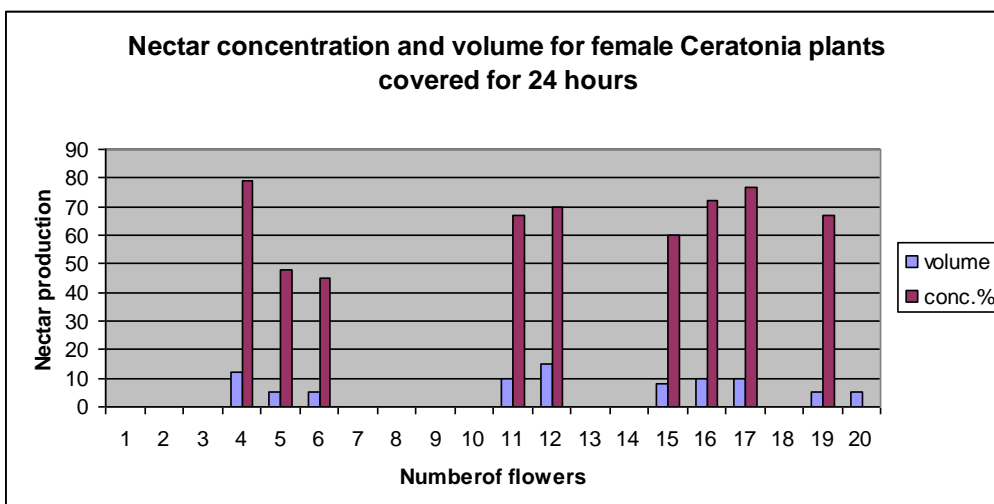


Fig 3: Nectar concentration and volume for Female *Ceratonia siliqua* trees



DISCUSSION

Ortiz *et al.* 1996 found that pollen transport from staminate to pistillate flowers is affected by insects, mainly bees. In this research *Ceratonia siliqua* L. plant showed good results regarding the nectar volume and concentration for honey bees, as assessed by bee visitation on this plant. Our measurements indicated that male trees were higher than the female ones regarding nectar volume and sugar concentration. The mean volume for male was 17.4 ml \pm 9.7sd whereas, for the female it was only 4.25ml \pm 5sd. (Table 6) The low value of the female rewards could be due to the delay in blooming of some of the flowers in this forest since the female trees were planted in relatively lower areas than the male trees also some of the female trees were severely attacked by local people to harvest the pods that might affect the growth habit and imposed certain stress on the flowering habit of the female *Ceratonia siliqua* L trees. It is worth mentioning that *Ceratonia siliqua* L. trees should be considered in reforestation due to its favorable flowering season, low water requirements, large number of flowers, and as pollen and nectar sources for pollinators. The mean volume for the nectar concentration was 63.97% \pm 10.19sd for the male trees whereas for female it was only 29.25% \pm 34 sd (Fig 2 and 3). (Ortiz *et al.* 1996) indicated that flowers of all three sexes were found to secrete nectar which attract insects in general.

These results indicated that this plant is a good source for honey bee feeding, since it shared the following desirable traits: blooming during the autumn, a time of the year where very scarce plant bloom during this part of the year, production of nectar and pollen; high nectar scores, and high rates of visits by honeybees. Our data include some confounding effects this could be due to micro habitat and it could be related environmental effect, which may have affected both the plants' nectar production patterns and insects' foraging activity (Wyatt *et al.*, 1992).

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REFERENCES

- Corbet, S.A. 2003. Nectar sugar content: estimating standing crop and secretion rate in the field. *Apidologie*. 34: 1-10
- Esbenshade, H. W. and G. Wilson. 1986. Growing carobs in Australia Ed. Goddard and Dobson, Victoria, Australia.
- Ferguson, I.K. 1980. The pollen morphology of *Ceratonia* (Leguminosae: Caesalpinioideae). *Kew Bull.* 35(2):273-277, pls 6-7.
- Imrrie, F. 1973. The production of fungal protein from carob in Cyprus. *J. Sci. Food Agric.* 24:639
- International Plant Genetic Resources Institute (IPGRI).1997. Promoting the conservation and underutilized and neglected crops. 17. Carob tree *Ceratonia siliqua* L. *edt.* I. Batlle and J. Tous.79 pps.
- Linskens, H.F. and W. Scholten. 1980. The flower of carob. *Portug. Acta Biol. (A)* XVIII-4:95-102.
- Louca, A.and Papas. 1973. The effect of different proportions of carob pod meal in the diet on the performance of calves and goats. *Anim. prod.* 17: 139-146
- Merwin, M.L.1981. The culture of carob (*Ceratonia siliqua*) for food, fodder, and fuel in semi-arid environments. International Tree Crops Institute USA Inc., California.
- NAS. 1979. Tropical Legumes: Resources for the Future, pp.109-116. National Academy of Science, Washington, DC. USA.
- Ortiz P.L., M. Arista and S.Talavera.1996. Production denectar y frecuencia de polinizadores en *Ceratonia siliqua* L.(Caesalpinaceae).*Anales del Jard in Botanico de Madrid* 54:540-546
- Tucker, S.C. 1992. The developmental basis for sexual expression in *Ceratonia siliqua* (Leguminosae: Caesalpinioideae: Cassieae). *Am. J. Bot.* 79(3):318-327
- Wyatt, R. Broyles, S. B., Derda, G.S.1992.Environmental influences on nectar production in milkweeds (*Asclepias syriaca* and *A. exaltata*) *Am. J. Bot.*79: 636-642.
- Whiteside, L. 1981. The carob cook book. ed. Thorsons Plishers Limited, Wellingborough, Nthamptonshire

ARI BİLİMİ / BEE SCIENCE

GENİŞLETİLMİŞ ÖZET

Giriş: Bu çalışmada Ürdün'de *Ceratonia siliqua* L. Keçiboynuzu bitkisinin nektar miktarı, konsantrasyonu, arı ziyareti belirlenmeye çalışılarak keçiboynuzu bitkisinde arıcılık açısından besin potansiyelinin araştırılmıştır.

Ceratonia siliqua L. Fabaceae ailesinden olup Akdeniz Bölgesinde yeterince yararlanılmayan önemli bir bitkidir. Çiçekleri küçük olup yeşil-hafifi kırmızımsı rektedir. Keçiboynuzu meyvesi %46 şeker ve %7 protein ve mineral ve vitaminlerden oluşur. Keçiboynuzu insanlar tarafından besin olarak kullanılmanın yanında hayvan yeni olarak da geleneksel olarak kullanılmaktadır. Keçiboynuzu şerbeti Ürdün'de yaygın olarak öğütülmüş keçiboynuzunun su ile karıştırılıp yapılmakta ve tüketilmektedir. Son yıllarda tutkal yapımında da kullanılmaktadır. Keçiboynuzu bitkisi ayrıca ilaç ve kozmetik sanayinde kullanılmaktadır.

Gereç ve Yöntem: Bu çalışma 26 Eylül- 23 Aralık 2004 tarihlerinde Ürdün'de yapılmıştır. Çalışılan bölgenin konumu enlem, boylam ve yüksekliği GPS kullanılarak belirlenmiştir. Toplam 10 erkek ve 10 dişi ağaç işaretlenmiş ve çiçeklenme biyolojisi çalışılarak veriler kaydedilmiştir. Bitkide çiçek parametreleri olarak salkımdaki çiçekler sayılmış, enine ve boyuna ölçümleri yapıp cm düşen bireyler sayılarak kaydedilmiştir. Arı ziyareti her çiçek için 10 dk olarak gözlemlenip kaydedilmiştir. Arı ziyaretinin en yoğun olduğu zamanlarda genellikle 10:00-12:00 saatleri arasında gözlemler yapıp bir ziyaret arının çiçeğin korolla, stigma veya stamene değmesi olarak belirlenmiştir. Çiçeklerin önce içi yani nektarı

boşaltılıp nektar üretimi 24 saat içinde naylon torbalarda 24 saat bekletilen 20 erkek ve dişi çiçekleten ölçümler yapılarak belirlenmiştir. Bu örnekleme en az 2 başarılı ölçüm için yapılmıştır. 24 saat içinde ölçülen nektarın miktarı ve konsantrasyonu belirlenip bitkinin arı için nektar üretimi belirlenmiştir.

Sonuçlar: Bu çalışmada bal arılarının keçiboynuzundan hem nektar ve hem polen topladığı bir çiçeği 10 dk içinde 2 bal arısının ziyaret ettiği, erkek ağaçların nektar miktarı ve konsantrasyonu açısından dişi çiçeklerden daha fazla nektar ürettiği ve ortalama miktar olarak erkek ağaçlarda 17,4ml+9,7sd ve dişi çiçeklerde 4,25 ml+ 5sd olduğu belirlenmiştir. Bunun için 1ul hassasiyetde mikropipet ve el rafktometre kullanılarak çiçeklerdeki üretilen nektar miktarı ve konsantrasyonu belirlenmiştir. Dişi çiçeklerde daha az üretim olmasının nedeni geç çiçeklenme periyodundan, dişi çiçeklerden daha düşük zeminlerde olmasından ve insanları genelde dişi ağaçlarda stres oluşturmasından kaynaklanabileceği düşünülmektedir. Genelde keçi boynuzuerkek çiçeklerde 63.97%± 10.19sd ve dişi çiçeklerde ise 29.25%±34 sd gibi yüksek üretime sahiptir. Ayrıca düşük su isteği nedeni keçiboynuzu bitkisi ağaçlandırma amacı ile kullanılmaya uygun bir bitkidir.

Bu sonuçlar keçiboynuzunun arılar için önemli bir besin kaynağı olduğunu, sonbahar gibi besinin kıt olduğu bir zaman diliminde çiçeklenerek arılara nektar ve polen sağlaması açısından yararlanması gereken bir bitki olduğu görülmektedir.

Anahtar Kelimeler: Keçiboynuzu, *Ceratonia siliqua*, *Apis mellifera*.