Factors Affecting the Nesting Success of the Large Carpenter Bee, *Xylocopa californica arizonensis*[1]

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ABSTRACT

The nesting success of *Xylocopa californica arizonensis* Cresson (Hymenoptera:Anthophoridae) is determined primarily by the availability of pollen and nectar and by the presence of a source of nest substrate. *X. c. arizonensis* appears to depend upon the pollen of *Larrea tridentata* or *Prosopis* spp. for larval food, when it is available. Predators, parasites and nest competitors are relatively unimportant in limiting nesting success.

Xylocopa californica arizonensis Cresson is a widely distributed subspecies of the polytypic species *Xylocopa california* Cockerell (Hurd 1955). It inhabits the desert regions of North America and utilizes the dry, inflorescence stalks of *Yucca* spp., *Dasilirion* spp., *Agave* spp. and *Nolina* spp. (Hurd 1958).

Factors that influence the construction or establishment of nests and the provisioning of larval cells are of primary importance in determining the nesting success of solitary bees (Linsley 1958). The purpose of this study was to evaluate some of the biotic factors that influence nesting of *X. c. arizonensis*.

Methods and Materials

The nesting of *X. c. arizonensis* was studied on 6 sites in the southwestern United States. The Bajada site is located on an alluvial fan in the Doña Ana Co., N.M., and is characterized by abundant *Yucca elata, Larrea tridentata* and *Prosopis glandulosa*. The Playa and Grassland sites are located on the Jornada Range, Doña Ana Co., N.M. and are characteristic of desert grassland with scattered shrubs and abundant *Y. elata*. The Mt. Summerford site, in the Doña Ana Mountains, is on rocky slopes with *Dasilirion wheeleri* and *Fouqueria splendens* being the dominant shrubs with *L. tridentata* and *P. glandulosa* being more common on the lower slopes. The Chiricahua Mountains site is near San Simon, Ariz. and is dominated by *Y. elata* and *P. glandulosa*. The Clark Mountains site is located in the Clark Mountains, San Bernardino Co., Calif., and has dense *Agave nevadensis* var. *utahensis* and scattered *L. tridentata* and *Chilopsis linearis*.

Nesting populations of *X. c. arizonensis* were created using pine wood trap-nests attached to natural sources of nest substrate. Trap-nests were made from 5.1×5.1×25.4-cm pieces of straight-grained pine wood similar to those used by Krombein (1967). Thirty trap-nests were set out in a grid arrangement of 10 rows and 3 columns on each site. Trap-nests were firmly attached to natural nest substrate supports with ca. 50 m between columns and 30 m between rows. Weekly observations were made on trap-nests from Mar. through Aug., with monthly observations made on trap-nests from Ariz. and Calif. Nesting success was recorded as successful nests established per site.

A small portion of the pollen-nectar ball from each provisioned trap-nest cell was collected with a dissecting needle and thoroughly mixed with Lactophenol on a glass microscope slide. The 1st 100 pollen grains encountered in a wandering scan with a light microscope (100 X) were recorded for each cell and mean percentages of pollen occurrence of different plant species were calculated for each site. Pollen was identified by using Erdtman (1943), Wodehouse (1960) and a reference collection of local pollen.

Nest substrate availability was determined by direct counts of suitable inflorescence stalks within the 3×10 trap-nest grids on each site. Percentage ground cover of food source shrubs in the general area of each grid was measured by a point-quarter technique (Phillips 1959). Five 500 m north-south lines, with 100 m between lines, were positioned with the central point of each grid bisecting the central line. Five points were selected at random on each line for point-quarter positions.

Surveys of *X. c. arizonenesis* nest borings were taken on 30 sites in Ariz., N. Mex., Tex. and in Chihuahua, Mexico, during the non-nesting periods of 1976–77 (Fig. 1). Survey sites were selected in areas with *Y. elata* inflorescence stalks. Circular plots with a radius of 50 m were arbitrarily placed in a *Y. elata* stand (with stalks) on each survey site. Total number of suitable stalks (basal diam greater than 18 mm) and nest borings were counted for each site. Only intact stalks, that could have served as nest substrate or nests in the previous nesting season, were counted. Percentage food shrub cover was measured using the same point-quarter technique that was used for the trap-nest sites, except that the center line was bisected by the center of the circular plots. The density of nest borings indicated the relative success of the nesting population in that area.

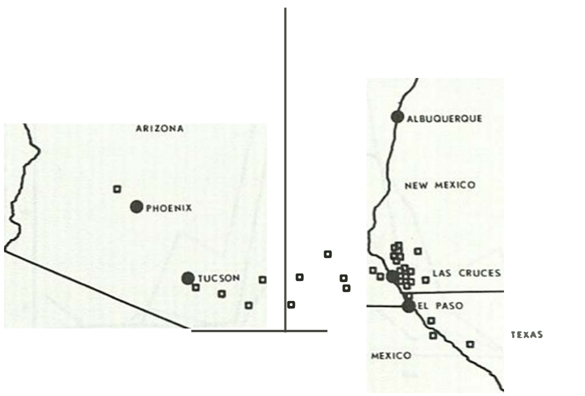

FIG. 1.—Map of Arizona, New Mexico, Texas and Mexico, showing location of study sites for *Xylocopa californica arizonensis*.

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Table 1.—The numbers of trap-nests used by *Xylocopa californica arizonensis*, *Anthidium* spp., nest inquilines and the number damaged by woodpeckers including the percent composition of pollen species.

	Bajada		Playa		Grassland		Chiricahua Mts	Mt Summerford	Clark Mts
	1975	1976	1975	1976	1975	1976	1976	1976	1976
No. *Xylocopa* nests	6	5	3	2	0	1	4	4	1
No. *Anthidium* nests	7	5	2	1	0	0	0	2	0
No. inquilines	5	4	2	1	0	1	3	2	0
No. woodpecker damaged trap-nests	3					0	2	2	4
Mean pollen occurrence	48.4[a]	49.5	10.4	12.1		96.4	86.8	44.7	
	46.2[b]	45.0	66.7	75.2			10.0	44.5	93.6

[a] *Prosopis* spp. pollen occurrence.
[b] *Larrea tridentata* pollen occurrence.

Results and Discussion

Several biological factors appear to influence nesting success of *X. c. arizonensis*. A source of suitable nest substrate is necessary for survival and reproduction and an adequate food source is necessary for maintenance of nesting adult females and development of immature stages. Predators and parasites are apparently involved only in limiting the successful development of larvae.

Available pollen and nectar sources are vital to the successful nesting of *X. c. arizonensis*. A variety of plants are used as nectar sources but pollen source appears to be more specific. Pollen from *L. tridentata* and *P. glandulosa* were the only kinds of pollen found in significant amounts in the larval food stores in the trap-nests (Table 1) even though other food plants were common on some sites.

L. tridentata and *Prosopis* spp. may be preferential pollen sources when they are available, but other sources of pollen such as alfalfa (Bohart 1957), *Solanum elaeganifolium* (Linsley and Cazier 1970) and *Acacia* spp. (Hurd and Linsley 1975) have been reported. Pollen from *Chilopsis linearis, Fouqueria splendens,* and *Fallugia paradoxa* was also found in trap-nest cells, but only in small amounts.

The quantity of stalks or nest substrate in an area is important in determining what total nest density can be, but seems to be less important than food availability in determining nesting success of established populations. Both the Playa site and Grassland site have more stalks available than the Mt. Summerford site (Table 2), but the latter attracted more nesting carpenter bees in 1976 (Table 1). Factors that enhance stalk destruction could be limiting to nesting success in areas of sparse stalk-plants. Browsing cattle can have a devastating effect on *Y. elata* stalks (Smith and Ludwig 1976).

The nest survey data were analyzed by multiple regression to obtain a model utilizing the variables affecting the density of carpenter bee nests. The multiple regression model was: Nest boring density $= -2.45 + 0.067S + 0.355\,PCS$. This gave an r^2 of 0.68 ($F = 24.9$, $P < 0.01$) where S = number of stalks in the circular plots and PCS = percentage cover of food shrubs from point-quarters. The analysis of variance for the multiple regression model is presented in Table 3. The coefficients of predictor variables are significantly different from zero (S, $t = 4.72$; PCS, $t = 6.12$; $P < 0.01$). Variable PCS appears to be more important than S ($r_2^2 = 0.43$ vs. $r_1^2 = 0.25$), derived from simple linear regression analysis. This predictive model is consistent with the nest densities recorded from the trap-nests on the trap-nest sites.

Predation had no effects on nesting success of the carpenter bees in trap-nests. The ladder-backed woodpecker, *Dendrocopus scalaris,* occurs throughout the southwest (Robbins et al. 1966) and we observed one eating *X. c. arizonensis* larvae from a nest in a *Y. elata* stalk on the Jornada Range in New Mexico. Fourteen trap-nests were attacked by woodpeckers (Table 1) but none of them were occupied by carpenter bees.

The bee fly, *Anthrax simson,* has been recorded as a parasite in the nests of *X. c. arizonensis* (Hurd 1959), but no trap-nests in this study contained these parasites. An unidentified tenebrionid larva that feeds on the pollen and nectar ball of the developing carpenter bee larvae was a common inquiline in cells of trap-nests (Table 1). These inquilines do not appear to have a detrimental effect on nesting success.

The carder bee, *Anthidium maculosum,* was a common competitor for available trap-nests on some sites (Table 1). It is difficult to say whether *A. maculosum* nests prevent

Table 2.—Stalk densities and percent cover of shrubs on which *Xylocopa californica arizonensis* had been observed foraging. Shrubs are: *Larrea tridentata, Prosopis glandulosa, Chilopsis linearis, Fouqueria splendens, Fallugia paradoxa, Acacia constricta,* and *Cercidium microphyllum.*

Site	Stalk plant	No. stalks	% shrub cover
Bajada	*Yucca elata*	303	15.3
Playa	*Y. elata*	246	4.6
Grassland	*Y. elata*	160	0.8
Mt Summerford	*Daslyion wheeleri*	105	12.4
Chiricahua Mts	*Y. elata*	277	10.7
Clark Mts	*Agave nevadendis* var. *utahensis*	84	5.3

Table 3.—Analysis of variance for the nest-boring survey data.

Source	df	SS	MS	F
Total	30	1038.0		
Regression - $R(\beta_2, \beta_x/\beta_0)$	2	337.0	168.5	29.4
Residual	27	154.9	5.7	

possible carpenter bee nests from being provisioned, but relative numbers of nests found in trap-nests indicate a competitive situation on some sites.

In conclusion, it can be said that pollen and nectar availability and a source of nest substrate are the most important factors influencing nesting success of *X. c. arizonensis*. *L. tridentata* and *Prosopis* spp. appear to be preferred pollen sources for larval cell provisioning. Predators, parasites, inquilines and nest competitors have only a minor role in limiting nesting success.

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