Apidologie (1994) 25, 71-83

Original article

Improvement of field management of *Osmia cornuta* (Latreille) (Hymenoptera, Megachilidae) to pollinate almond

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(Received 5 October 1992; accepted 30 July 1993)

Summary — Trap-nested populations of *Osmia cornuta* were reared in the laboratory at room temperature, over-wintered at 4°C, and released in almond orchards in NE Spain in 1989 and 1990. Bees emerged over a longer period and over-wintering mortality was higher in 1990 than in 1989. These results are associated with the over-wintering period to which bees were exposed, which was longer in 1989 than in 1990. Females preferred to nest in small nesting shelters rather than in large ones, and significantly selected holes with 8 mm id and 21 cm long as nesting cavities. Dispersal rates of pre-nesting females were higher in 1989 than in 1990, but in both years the bee population obtained at the end of the bloom period notably increased with regard to population released.

***Osmia cornuta* / bionomics / nesting materials / management / almond pollination**

INTRODUCTION

Inadequate pollination is one of the main causes of low almond production in Spanish orchards (Vargas and Romero, 1987). Present numbers of honey bee hives (especially hives prepared for pollination) are insufficient to pollinate the large acreages planted in eastern and southern Spain (Bosch *et al*, 1992). For this reason, a search for native pollinators other than honey bes (*Apis mellifera*) was initiated in Spain, and Asensio (1984) found *Osmia cornuta* to be a potentially effective pollinator of almond. This solitary bee occurs in central and southern Europe, Turkey, and northern Africa (Peters, 1977).

The first managed populations of *O cornuta* were released in Spanish almond orchards in Huelva (southwestern Spain) and Murcia (southeastern Spain) (Asensio, 1984; Lacasa, personal communication). In 1978 and 1985, 2 populations were trap-nested in Spain, transported to the US and released in apple and almond orchards in Utah and California, respectively (Torchio and Asensio, 1985; Torchio *et al*, 1987). *O cornuta* has also been tested on apple in Yugoslavia (Krunic *et al*, 1989, 1991). In the last 4 yr, studies have been conducted in Spain to further investigate the pollinating potential of *O cornuta* (Bosch 1992, 1994a, 1994b, Further 1994c; Bosch and Blas, 1994a, 1994b; Márquez *et al*, 1994).

As with other Megachilidae used for crop pollination (*Megachile rotundata, Osmia cornifrons, Osmia rufa, Osmia lignaria propinqua*; Stephen, 1962; Maeta, 1978; Kristjansson, 1989; Torchio, 1993), *O cornuta* nests in pre-established holes, and managed populations are left to emerge at release sites in or near plantations, provided with nesting materials. Difficulties encountered in the multiplication of managed populations of these species include: 1) drifting or dispersal of prenesting bees (females that do not nest in the nesting materials provided); 2) mortality due to parasitism, predation, and developmental failure; and 3) deviations in the progeny sex ratio.

This study reports on the results of 2 field studies made in 1989 and 1990, which show that each of the 3 above-mentioned factors can be reduced through adequate management practices. These include appropriate over-wintering temperature treatments, distribution and attractiveness of nesting materials, and nest hole size.

MATERIALS AND METHODS

Life cycle of Osmia cornuta

In northeastern Spain, *O cornuta* flies in synchrony with almond bloom during February and March. Males emerge first, followed a few days later by females. Mated females search for holes to build their nests, which consist of linear series of cells separated by mud partitions. Typically, female eggs are laid on the larger pollen-nectar provisions placed in the innermost cells of the nest, whereas male eggs are deposited on the smaller provisions in the outermost cells. The entrance of each nest is sealed with a mud plug. Nesting females die near the end of March. Hatching takes place a few days after eggs are laid and adult stage is reached by October. Bees remain inside their cocoons for the winter until they emerge in February.

1989 Studies

Two groups, each with 273 females and 351 males, were released in an almond orchard in the Parc de Samà (Montbrió, northeastern Spain) in February 1989. The orchard measured 10 Ha and included both mid- and late-blooming cultivars.

The bees had been trap-nested in February 1988 at different sites in the province of Tarragona (northeastern Spain). Nests were kept at room temperature (25°C) for the spring and summer, and in autumn, prior to introduction into a refrigerator at 4°C on November 6, they were dissected and parasites were removed.

On February 19 1989 the bees were removed from the refrigerator, and each female cocoon was inserted into a paraffinated paper straw. Five different types of straws were used: 7 mm (inside diameter) x 15 cm (length), 8 mm x 15 cm, 9 mm x 15 cm, 8 mm x 18 cm, and 8 mm x 21 cm. Female cocoons were proportionately distributed according to the number of straws of each type. These "seeded" straws were introduced in milk-carton-type nests similar to those described by Torchio (1979, 1982).

On February 20 the bees and the nesting materials were taken to the orchard and were distributed in several nesting shelters as shown in figure 1. Each shelter was composed of a 5-sided wooden box positioned 1 m above the ground and supported by 4 metal fence stakes. One shelter (BC, fig 1) measured 100 cm wide x 60 cm high x 40 cm deep, and the others measured 70 cm wide x 40 cm high x 40 cm deep. All shelters faced east. A water dispenser filled with mud was placed near each shelter as a source of nesting material for the bees.

The first group of 273 females and 351 males (group A) was released in 3 small central shelters (AC1, AC2, AC3) (fig 1). Distance between shelter AC2, and shelters AC1 and AC3 was 14 m (2 rows of trees). Each of these shelters was supplied with 13 randomly distributed seed-

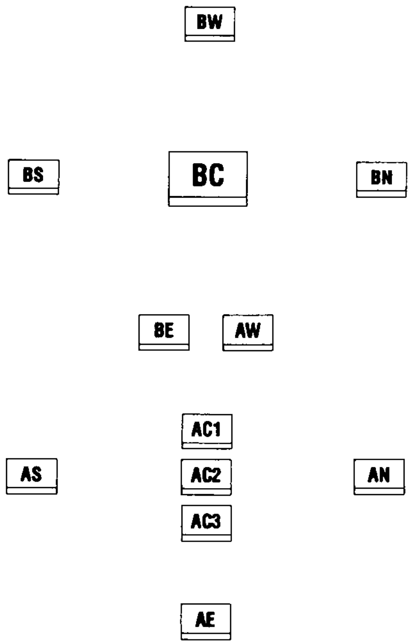

Fig 1. Distribution of nesting shelters in an almond orchard in Parc de Samà in 1989. AC1, AC2, AC3 and BC: central ("seeded") shelters; AN, AS, AE, AW, BN, BS, BE, BW: drift ("unseeded") shelters.

ed milk-carton nests containing 200 straws per shelter (45 (7 x 15) straws, 45 (8 x 15) straws, 45 (9 x 15) straws, 44 (8 x 18) straws, and 21 (8 x 21) straws). Ninety-one of these straws each contained 1 female bee cocoon. Male cocoons were placed in trays which were placed inside the shelters. Shelters AC1, AC2, and AC3 were surrounded by 4 drift shelters (AN, AS, AE, AW) 70 m away from shelter AC2. These 4 drift shelters were supplied with the same nesting materials as shelters AC1, AC2, and AC3, but they contained no seeded straws.

The 2nd group of bees (group B) was released in the same way as group A, in a large central shelter (BC) 140 m from shelter AC2 (fig 1). Shelter BC contained exactly the same nesting materials and numbers of seeded straws as shelters AC1, AC2, and AC3, together. Four additional drift shelters (BN, BS, BE, BW) containing equal nesting material as shelters AN, AS, AE and AW, and no seeded straws, were placed 70 m away from shelter BC (fig 1).

Censuses of nesting bees were made at the nesting shelters every 3–5 d throughout the flowering period. These censuses were made in the morning, when nesting bees were fully active.

When blooming in the orchard ceased, nesting materials were removed and taken to the laboratory where they were kept at 25°C throughout the spring and summer months. At the beginning of October, when bees reached the adult stage inside their cocoons, all straws containing 1 or more cells were dissected and their contents recorded. Cocoons were sexed according to their size and position within the straw (see above), or a slit was cut beneath the nipple of the cocoon, to permit inspection and sex determination of the adult.

1990 Studies

In 1990, 2 populations each composed of 480 females and 1 000 males were released at the Parc de Samà in the middle of 2 different orchards 2 km apart. The 1st orchard (A) was the same as the one used in 1989, and the 2nd orchard (B) measured 7 Ha. Both orchards were planted with the same mid- and late-blooming cultivars.

Both release sites were provided with the same nest materials and equal number of holes: 120 pine wood blocks (9 cm wide x 9 cm high x 16 cm long) each with 25 holes (15 cm deep) and a paraffinated paper straw (15 cm long) inserted in each hole. Sixty blocks at each site contained 8 mm (inside diameter) straws, and the remaining 60 contained 7 mm (id) straws.

In orchard A nesting materials were placed inside 3 nest shelters similar to those described for the 1989 release, and they were spaced 1 m apart facing east. The largest of these 3 shelters was provided with 66 wood blocks, the second largest with 50, and the smallest with 4. The 8 and 7 mm strawed blocks were distributed alternately within each shelter.

In orchard B 30 small shelters (each 20 cm wide x 30 cm high x 30 cm deep) were attached, approximately 1 m above the ground, to each of 10 trees in 3 rows. Shelters were attached to every other tree in 1 row of trees that were, in turn, separated from other nest shelters by 2 rows of trees without shelters. Two blocks with 8 mm holes and 2 with 7 mm holes were alternately placed in each shelter. All shelters faced east.

The bees used in 1990 were reared from nest-trap materials placed at different localities in Tarragona and Lleida provinces the previous year. The trap nests were kept at room temperature throughout the 1989 summer, and dissected in September. Cocoons containing live adults were placed in a 4°C refrigerator on November 23. These bees were removed from the refrigerator on February 6, and 480 females were individually inserted in 8 mm paper straws and another 480 were inserted in 7 mm paper straws.

On the following day, 240 of these seeded straws of each type were inserted into the longest diagonal row of each wood block, so that each block contained 4 female cocoons at each site. Males were realeased in trays placed inside each shelter.

A few days after emergence was completed, the number of nesting females at each shelter was counted as in 1989.

At the end of the flowering period, nesting materials were taken to the laboratory and maintained in a room at 22–30°C, except for some blocks from orchard B that were kept in a cool room (22–25°C). In October, when most bees had reached the adult stage, straws were extricated from wood blocks and X-rayed (Stephen and Undurraga, 1976) to determine their contents.

RESULTS AND DISCUSSION

Emergence and establishment

In 1989, the first males began to emerge a few minutes after they were released in the orchard. Upon emergence the bees deposited their meconium on the bee shelter or on the nesting material and flew off. The first matings were observed the day after, and the first females carrying pollen were seen 2 d later, in synchrony with peak bloom of the mid-blooming cultivars and bloom initiation of the late-blooming cultivars. One female was seen emerging as late as March 1, so emergence of the whole population lasted around 9 d.

In 1990, male emergence began the day after the bees were released (February 8), but the first females emerged on February 14. Over the next 2 d, 80 seeded straws were inspected, and only 2 cocoons had been chewed open. On February 16, male activity around the shelters increased considerably, and the noise of females chewing their way out of the cocoons could be clearly heard. Most matings were seen from February 19–21, but on that date there were still a few unemerged females. Therefore, it took the bees more than 2 weeks to complete emergence.

Laboratory experiments showed that emergence of *O cornuta* was extended as over-wintering periods were shortened (Bosch and Blas, 1994b). While the 1989 population was over-wintered for 105 d, the 1990 population was over-wintered for only 75 d. This was because the 1990 population was placed in the refrigerator later (end of November) than the 1989 population (beginning of November), and the winter in 1989–1990 was very mild (bloom was advanced at least 15 d with regard to normal years), and the bees had to be taken out of the refrigerator earlier than planned. Therefore, differences in the length of the over-wintering period to which bees were exposed can explain differences in the length of the emergence period between the 2 populations. This is further supported by the fact that a second population released in La Selva (Tarragona) in 1990, which received the same over-wintering treatment as the 1990 population of this study, emerged over 20 d (Bosch, 1994b).

Over-wintering mortality

Over-wintering mortality was very low in 1989: only 23 females failed to emerge (4.21% over-wintering mortality).

Conversely, in 1990, as many as 19.52% of the females released in orchard A, and 17.50% in orchard B were found dead inside their cocoons when nesting materials were dissected. Many of these cocoons were partially chewed, indicating that the female bee was alive when it was taken out of the refrigerator but was not vigorous enough to bite its way out.

Torchio *et al* (1987) reported that *O cornuta* populations exposed to mild wintering regimes expressed higher mortalities than populations exposed to colder temperatures for longer periods of time. Again, a short over-wintering period was probably the main cause for the abnormally high over-wintering mortalities registered in 1990. The above-mentioned population released in La Selva in 1990 also expressed high (14.38%) over-wintering mortality rates (Bosch, 1994b).

Dispersal rates

Overall dispersal (percentage of females that did not nest in the nesting materials supplied) in 1989 was 48.35%. Of the 546 females released, 88 (16.12%) nested in shelters AC1, AC2, and AC3, and 69 (12.64%) nested in shelter BC. These differences in number of nesting bees failed significance ($ch - sq = 3.60$; $df = 2$; $p > 0.05$).

A considerable number of bees nested in drift shelters (125 = 4.33% of the nesting females), but these were not evenly distributed between shelters (range: 5 to 29 bees).

Dispersal rates were lower in 1990, and significantly more bees dispersed at orchard A (105 = 27.21% of the emerged females), than at orchard B (46 = 11.62%) ($ch - sq = 27.88$; $df = 1$; $p < 0.001$). Furthermore, in orchard A, the number of nesting bees per available hole was highest at the smallest shelter (0.330), intermediate at the medium-sized shelter (0.106), and lowest (0.070) at the largest shelter. For this reason, 86% of the available straws were utilized at the smallest shelter, compared with 30.8% at the medium-sized shelter, and only 21.39% at the largest shelter. These differences in nest utilization at the 3 shelters were highly significant ($ch - sq = 209.48$; $df = 2$; $p < 0.00001$).

These results indicate that dispersal rates can be reduced when bees are released in separate small groups, rather than in one large group. Similar results have been reported for the New World orchard pollinator *O lignaria propinqua* (Torchio, 1984), and suggested for the sunflower pollinator *Eumegachile pugnata* (Parker and Frohlich, 1985). Furthermore, pollination levels tend to be more uniform when populations of bees are released in small groups dispersed throughout the orchard than when bees are released in one large group, as reported for *O cornifrons* on apple (Yamada *et al*, 1971). The fact that a considerable percentage of bees (44.33%) nested in the drift shelters in 1989, reinforces the idea that distribution of nesting materials throughout the orchard helps diminish dispersal rates.

Nesting and nesting periods

O cornuta females expressed gregarious nesting, that is, there was a tendency for females to nest adjacent to one another, even when there were plenty of straws of all sizes available throughout the nesting shelters. The mud dispensers supplied were rarely used by *O cornuta* females, which preferred to collect moist soil in crevices on the ground surface.

In 1989, the highest numbers of bees were counted on the censuses of March 2 and March 5. From then on, numbers of nesting bees steadily declined (fig 2). When nesting materials were removed from the orchard on March 20, there were still 43 nesting females. Therefore, the flying period of the bees lasted over a month.

In 1990 nesting materials were removed on March 20 when almond bloom in the orchard had completely disappeared but there were still a few females nesting. The flying period lasted about a month and a half.

Selection of nesting materials

O cornuta females preferred to nest in 8 mm straws rather than in 7 or 9 mm straws (tables I and II), and these differences were highly significant in both 1989 (*ch – sq* = 135.49; *df* = 2; $p < 0.00001$), and 1990 (orchard A: *ch – sq* = 51.32; *df* = 1; $p < 0.0001$; orchard B: *ch – sq* = 42.25, *df* = 1; $p < 0.0001$).

The mean number of cells produced per plugged nest in 15 cm long, 3 diametered straws also differed (tables I and II). Significantly more cells per nest were produced in 8 mm straws than in the other 2 diameters in both 1989 (F = 7.86; *df* = 2; $p < 0.0001$), and 1990 (orchard A: *t*-student = 8.10; *df* = 745; $p < 0.0001$; orchard B: *t*-student = 93.69; *df* = 1; $p < 0.0001$).

As in other cavity nesters (Stephen and Osgood, 1965; Maeta, 1978; Torchio and Tepedino, 1980) the sex ratio (males/females) of the progeny produced clearly increased with decreasing diameters (tables I and II), both in 1989 (*ch – sq* = 80.16; *df* = 2; $p < 0.0001$) and in 1990 (orchard A: *ch – sq* = 93.69; *df* = 1; $p < 0.0001$; orchard B: *ch – sq* = 124.96; *df* = 1; $p < 0.0001$). As a consequence, although in 1989 9 x 15 straws were used less than 7 x 15 straws, more females were produced in the larger diameter. The theoretical or optimal sex ratio (see Torchio and Tepedino, 1980) in *O cornuta* is around 1.7 males per female (Bosch, 1994c), and sex ratios of wild populations trap-nested with 8 mm straws in 1988 and 1989 ranged from 1.1 to 1.5 (Bosch, un-

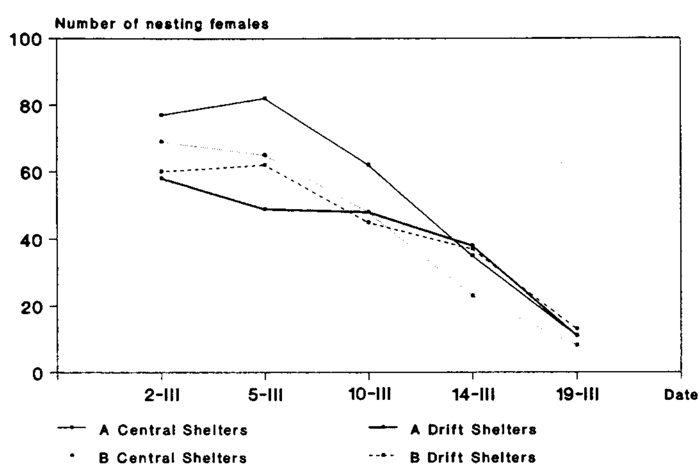

Fig 2. Number of female *O cornuta* nesting in central and drift shelters throughout the flowering season in Parc de Samà in 1989.

Table I. Rates of utilization of different types of straws by *O cornuta* females in Parc de Samà in 1989.

Type of straw [a]	*No straws available*	*No straws utilized (%)*	*Cells/Nest* [b,c]	*Sex ratio (males/ females)*	*Mortality (%)*	*Females produced/ nest offered*
7 x 15	630	300 (47.62)	4.29 ± 1.68	4.56	33.69	0.33
8 x 15	630	335 (53.17)	4.90 ± 1.70	2.51	25.87	0.70
9 x 15	630	144 (22.86)	4.76 ± 2.13	1.74	20.27	0.39
8 x 18	615	211 (34.31)	5.23 ± 2.56	2.17	26.58	0.52
8 x 21	291	184 (63.23)	6.00 ± 2.65	1.57	27.47	1.28

[a] Diameter in mm x length in cm; [b] only plugged nests; [c] mean ± standard deviation.

published results). Although 8 mm straws were preferred to 9 mm straws, progeny produced in 9 mm straws was nearer to optimal sex ratio rather than progeny produced in 8 mm straws. The 7 mm straws were moderately attractive, and yielded higher levels of male-biased sex ratios.

The most attractive straw length tested in this study was 21 cm (table I) ($ch - sq$ = 78.34; df = 2; $p < 0.0001$). Since numbers of cells per plugged nest increased as straw length increased (F = 14.25; df = 2; $p < 0.001$), and male-favored sex ratio decreased with straw length ($ch - sq$ = 29.36; df = 2; $p < 0.001$) (table I), the 21 cm long straws gave the highest number of female cells produced per straw offered. Future studies should compare 9 *versus* 8 mm diameter holes with 21 cm long straws to determine the most suitable hole size for *O cornuta*.

In 1990, utilization of straws from which a female had emerged (seeded straws) was tested against utilization of previously unoccupied straws (unseeded straws). Both types of straws were similarly accepted in both orchards (orchard A: $ch - sq$ = 3.21; df = 1; $p > 0.05$; orchard B: $ch - sq$ = 0.0036; df = 1; $p > 0.9$) (table III). The number of cells produced per plugged nest

Table II. Rates of utilization 15 cm straws of 7 and 8 mm id by *O cornuta* females in orchards A and B in Parc de Samà in 1990.

Orchard	*Diameter of straw (mm)*	*No straw available*	*No straw utilized (%)*	*Cells produced*	*Cells/ Nest* [a,b]	*Female cells produced*	*Sex ratio (males/ females)*	*Mortality (%)*
A	7	1 500	343 (39.70)	1 481	4.49 ± 1.84	287	4.16	147 (9.93)
A	8	1 500	521 (60.30)	2 848	5.62 ± 1.86	951	1.99	318 (11.17)
B	7	1 500	387 (41.30)	1 752	4.69 ± 1.89	329	4.33	239 (13.64)
B	8	1 500	550 (58.70)	3 043	5.81 ± 1.83	1 031	1.95	377 (12.39)

[a] Only plugged nests; [b] mean ± standard deviation.

was lower in seeded straws than in unseeded straws at both sites (orchard A: *t* – student = 2.46; *df* = 745; $p < 0.05$: orchard B: *t* – student = 2.63; *df* = 775; $p < 0.01$) (table III), and the sex ratio was similar in seeded and unseeded straws (orchard A: *ch* – *sq* = 0.64; *df* = 1; $p > 0.6$; orchard B: *ch* – *sq* = 0.27; *df* = 1; $p > 0.7$) (table III).

Mortality of progeny

Overall mortality in 1989 was 27.34% (table I). Rainy conditions permitted moisture to accumulate on the floor of some nesting shelters, and this moisture was absorbed by milk-carton boxes. As a result, fungi developed in some nests, in which many immatures died. Most of these immatures (57.62%) died in the prepupal stage after spinning a thin soft cocoon. Since excess of moisture within milk-carton nesting units accumulated towards the bottom of straws where female cells are preferentially constructed, mortality rates were significantly higher for females (40.49%) than for the males (20.72%) (*ch* – *sq* = 237.12; *df* = 1, $p < 0.00001$).

Mortality due to parasitism was very low. Only 5 cells (0.09%) were infested by the cleptoparasitic mite *Chaetodactylus osmiae*.

A total of 172 prepupae or pupae did not develop to the adult stage by November, and as a consequence, they were over-wintered as immatures. A small percentage of these individuals developed into adults after over-wintering and emerged out of their cocoons in late summer or early autumn. Over-wintering immatures were considered unviable and accounted for 11.39% of the mortality.

Moisture in nest units was not a problem in 1990 and, as a result, mortality rates (11.85%) were lower than in 1989 (table II). Most individuals died as early immatures for unknown reasons, and parasitism was again very low: 0.13% were attacked by *C osmiae* and 0.54% by the chalcid wasp *Monodontomerus obsoletus*.

The percentage of individuals from orchard B that over-wintered as live immatures was much higher (21.75%, *n* = 1 033) in the nests retained at 20–25°C, than in those kept at 22–30°C (3.93%, *n* = 3 762), and these differences were statistically significant (*ch* – *sq* = 321.26; *df* = 1; $p < 0.00001$). In early-flying (February) wild populations trap-nested in Ribera d'Ebre (Tarragona, northeastern Spain) in 1988 and 1989, the percentage of individuals failing to reach the adult stage in November was 11.58 and 19.46%, respectively, whereas in late-flying (March) wild populations trap-nested in Les Garrigues (Lleida, northeastern Spain) percentages were only 1.98 and 4.55% respectively (unpublished data). *O cornuta* from central France reared at 21°C developed from egg to adult in 19 weeks (Tasei, 1973), whereas it took bees from the 2 above-mentioned areas in northeastern Spain from 24 to 28 weeks to complete development at 20–25°C (unpublished data). Therefore, inability to reach the adult stage seems to be a consequence of slow immature development due to cool temperatures, especially in those populations adapted to warmer climates.

Cell production

In the 1989 release, 282 females (53.92% of the emerged females) nested in the nesting material provided. These females built 1 189 nests and produced 5 679 cells, of which 1 687 were female cells. Therefore, 5.98 female cells were produced per nesting female, and 3.23 were produced per emerged female. Of the 1 687 females produced, 683 (40.49%) died before reaching the adult stage. Therefore, 1 004 fe-

Table III. Utilization of seeded straws and previously unoccupied straws (unseeded) by nesting *O cornuta* females in Parc de Samà in orchards A and B in 1990 (7 and 8 mm straws grouped together).

Orchard	*Type of straw*	*No straws available*	*No straws utilized (%)*	*Cells produced*	*Cells Nest* [a,b]	*Females produced/ available straw*	*Sex ratio (males/ females)*	*Developmental failure (%)*	*Parasitism (%)*
A	Seeded	396	99 (25.00)	467	4.74 ± 1.88	0.32	2.71	66 (14.13)	0 (0.00)
A	Unseeded	2 604	765 (29.38)	3 862	5.25 ± 1.93	0.43	2.48	373 (9.66)	26 (0.67)
B	Seeded	386	120 (31.09)	564	4.87 ± 1.88	0.33	2.65	84 (14.89)	1 (0.18)
B	Unseeded	2 614	817 (31.25)	4 231	5.41 ± 1.94	0.47	2.52	496 (11.72)	35 (0.83)

[a] Only plugged nests; [b] mean ± standard deviation.

males survived to be used as pollinators in the next flowering season, so the multiplication rate of females was 1.84 with regard to the number of females released. Since progeny were male biased with respect to parent population and since male mortality was lower than female mortality, the number of live males obtained was even higher (3 165), and therefore the male population was increased by 4.51.

In 1990, the 281 females that nested in orchard A constructed 864 nest and 4 329 cells, of which 1 238 were female cells. Thus, 4.41 female progeny were produced per nesting female or 3.24 female progeny produced per emerged female. In orchard B, 4 795 cells were produced, of which 1 360 were female. Therefore, 3.89 female progeny were produced per nesting female, and 3.43 per emerged female. Although these 1990 figures on nesting success are lower than those of 1989, mortality was much reduced in 1990 and this permitted an increase of female progeny by 2.23 in orchard A, and 2.33 in orchard B. Male population was increased by 2.78 in orchard A and by 2.98 in orchard B.

These results and other studies (Bosch, 1994a; Bosch and Blas, 1994a) are very encouraging with regard to the possible establishment of *O cornuta* as a commercial pollinator of almond, since they show a great reproductive potential of this bee in orchard environments, and the possibility to reduce dispersal of prenesting bees and mortality rates through adequate management practices. Other studies (Bosch, 1994c) have demonstrated that *O cornuta* also has a great pollinating potential in almond orchards.

ACKNOWLEDGMENTS

I acknowledge the assistance of R Magrinyà and J Losarcos in field and laboratory work, respectively. I am also grateful to J Retana (CREAF), who reviewed a draft of the manuscript, and to GC Eickwort (Cornell University) and EE Grissell (USDA, Washington DC) for identifying the parasites. This study was supported by an FPI grant from the MEC, and by funds of the INIA (project no 8191) and the CIRIT (AR87).

Résumé — Amélioration de la gestion en champ des populations d'*Osmia cornuta* (Latr) (Hymenoptera, Megachilidae) pour la pollinisation de l'amandier. Ce travail relate le lâcher de 2 populations du pollinisateur *Osmia cornuta* dans des vergers d'amandiers en 1989 et 1990. Des nids placés dans la nature ont permis de capturer des populations en début de printemps ; puis les larves ont été laissées à température ambiante au laboratoire pour achever leur développement. L'hiver, les adultes dans leur cocon ont été conservés à 4°C en chambre froide. Le printemps suivant ils ont été placés dans des nichoirs pourvus de tubes de papier de diamètre et de longueur variés et les nichoirs ont été installés dans les vergers d'amandiers. La période d'émergence des abeilles a duré 9 j en 1989 et 15 j en 1990. La mortalité due à l'hivernage a été faible (4,21%) en 1987 mais élevée (18,54%) en 1990. Ces différences sont dues à la durée d'hivernage (105 j en chambre froide en 1989 et seulement 75 j en 1990). En 1989, avec des emballages de lait en carton comme matériaux de nidification, le taux de dispersion (femelles n'ayant pas nidifié dans les matériaux mis à disposition) a été de 48,35% ; en 1990, avec des blocs de bois perforés, il a été de 19,31%. Le nombre de femelles ayant nidifié dans les nichoirs a été suffisant pour assurer un accroissement de la population pendant les 2 années. La population femelle s'est accrue de 1,84 en 1989 et de 2,3 en 1990 par rapport à la population introduite au départ. Le nombre de cellules femelles produites par femelle ayant nidifié a été respectivement de 5,98 et 4,41 en 1989 et 1990. On a observé une tendance des femelles à nidifier dans de petits nichoirs plutôt que dans des grands. Elles ont choisi de façon significative des trous de 8 mm de diamètre interne plutôt que ceux de 7 ou 9 mm et préféré les tubes de 21 cm aux autres (18 et 15 cm). Le nombre de cellules construites par nid a augmenté et le sex-ratio de la descendance a diminué avec le diamètre du trou (tableaux I et II) et avec la longueur du tube (tableau I).

La mortalité a été supérieure en 1989 (27,34%) par rapport à 1990 (11,85%) car les blocs de bois ont mieux protégé les nichoirs de l'humidité que les emballages de lait en carton. La plupart des individus sont morts pour des raisons inconnues (développement perturbé) et le parasitisme est resté très bas les 2 années. Quelques individus n'ont pu accomplir leur développement avant la fin de l'automne et ont hiverné à l'état de prénymphe ou de nymphe vivante. Leur pourcentage a atteint 21,75% lorsque les larves ont été élevées entre 20 et 25°C, mais est tombé à 3,93% pour des températures d'élevage comprises entre 22 et 30°C.

Osmia cornuta* / cycle évolutif / gestion population / pollinisation dirigée / *Prunus amygdalus

Zusammenfassung — Verbesserung der Freilandhaltung von *Osmia cornuta* Latr (Hymenoptera, Megachilidae) zur Bestäubung von Mandeln. Diese Untersuchung berichtet über die Freilassung von zwei Populationen der als Bestäuberin tätigen Wildbiene *Osmia cornuta* in den Jahren 1989 und 1990 in Mandel-Anlagen. Die Populationen wurden durch Aufstellung von Ködernestern im Feld gefangen und dann ins Laboratorium gebracht, wo sich die Larven bei Raumtemperatur entwickelten. Im Winter wurden die Bienen bei 4°C in einem Kühlschrank gehalten. Im Frühjahr wurden sie an geeigneten geschützten Nistplätzen im Mandelgarten ausgesetzt und mit Nistmaterial, bestehend aus Papierhalmen verschiedenen Durchmessers und Länge versehen.

Die Schlüpfperiode der Bienen dauerte im Jahre 1989 9 Tage, aber 15 Tage im Jahre 1990. Die Mortalität während des Winters 1989 war gering (4,21%), aber 1990 mit 18,5% wesentlich höher. Diese Unterschiede hängen offenbar mit der Länge der Winterperiode zusammen, denn 1989 wurde die Population für 105 Tage im Kühlschrank gehalten, 1990 aber nur für 75 Tage.

Die Abwanderungsrate (Anteil der Weibchen, die das angebotene Nistmaterial nicht annahmen) betrug 48,35% im Jahre 1989 (als Milch-Kartonhalme als Nistmaterial angeboten wurden) und 19,31% im Jahre 1990 (mit gebohrten Holzblöcken). In beiden Jahren war die Anzahl der Weibchen, welche in dem angebotenen Material nisteten, ausreichend, um die Population zu vegrößern. Die weibliche Population wuchs 1989 gegenüber der ursprünglich 1989 freigesetzten Population um den Faktor 1,84 und um 2,3 im Jahre 1990. Die Anzahl der von einem nistenden Weibchen erzeugten weiblichen Brutzellen betrug im Mittel 5,98 und 4,41 in den Jahren 1989 und 1990.

Es wurde eine Tendenz der Weibchen festgestellt, kleine Nistplätze gegenüber größeren vorzuziehen. Die Weibchen bevorzugten signifikant Löcher von 8 mm Durchmesser gegenüber solchen mit 7 und 9 mm. Mit dem Durchmesser des Nistlochs stieg die Zahl der Zellen pro Nest an, das Geschlechtsverhältnis (Männchen/ Weibchen) jedoch fiel ab (Tabelle I, II). Die längsten Halme (21 cm) wurden gegenüber kürzeren (18 und 16 mm) bevorzugt. Die Zahl der Zellen stieg mit der Länge der

Nisthöhlung an, und das Geschlechtsverhältnis fiel (Tabelle I).

Die Mortalität lag höher in 1989 (27,34%) als 1990 (11,85%), weil die Holzblöcke die Nester besser vor Feuchtigkeit schützten als die Milchhalme aus Karton. Die meisten Tiere starben aus unbekannten Gründen (Entwicklungsstörungen); in beiden Jahren war die Parasitierung sehr gering. Einige Individuen waren unfähig, ihre Entwicklung im Herbst zu beenden und sie überwinterten als lebende Larve oder Vorpuppe. Der Prozentsatz solcher Individuen war sehr hoch (21,75%), wenn die Larven bei 20–25°C aufgezogen wurden, aber er fiel deutlich auf 3,93%, als die Aufzuchttemperatur 22–30°C betrug.

***Osmia cornuta* / Bionomie / Nistmaterial / Management / Mandel / Bestäubung**

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