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Osmia cornuta Outperforms Osmia bicornis as a Managed Pollinator in Cherry and Apple Orchards

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ABSTRACT

Reliance on traditional pollinators like the honeybee Apis mellifera and the bumblebee Bombus terrestris carries inherent risks, can disrupt wild pollinator populations, and does not always produce optimal fruit pollination. Mason bees, particularly Osmia cornuta and Osmia bicornis, are increasingly considered as managed alternatives, yet their effectiveness for fruit trees remains poorly characterized. In this study, we compared the performance of these two species in two cherry orchards and four apple orchards. Bees were introduced at the beginning of the flowering period, and we tracked their emergence timing, nesting success, population abundance through transect surveys, frequency of flower visits over 20-minute intervals, and pollen carried on their bodies. O. cornuta emerged earlier by an average of 4 ± 2 days and demonstrated at least five times higher nesting activity than O. bicornis across all orchards. Transect data revealed that O. cornuta was far more prevalent than O. bicornis (21.2% ± 10.1% versus 1.3% ± 1.8% of observed pollinators) and consistently visited more flowers (53 versus 5 visits). Pollen analysis indicated that O. cornuta predominantly collected Rosaceae pollen (95%), likely from apples and cherries, while O. bicornis carried only 30%, suggesting it foraged largely outside the orchards. These findings highlight that O. cornuta outperforms O. bicornis as a managed pollinator for early-flowering crops like cherry and apple under the cool, rainy conditions characteristic of this study period.

Keywords: Emergence rate, Flower visitation, Mason bees, Nesting rate, Pollen collection, Pollinators

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Introduction

Insect pollination is essential for the production of many fruits and vegetables, contributing an estimated €153 billion to global agriculture [1]. Approximately one-third of all crops rely on animal pollinators, with about 15% requiring pollination specifically for seed formation [2]. Historically, wild pollinators fulfilled these roles, but widespread declines in their populations, coupled with the expansion of pollination-dependent crops [3–5], have created a growing reliance on managed pollinator species [6–8]. Among these, the honeybee Apis mellifera and the bumblebee Bombus terrestris dominate commercial pollination practices [9, 10]. However, dependence on these two species can be problematic, as their pollination efficiency varies across crop types [11–13], and they can negatively affect wild pollinators through competition for floral resources, disease transmission, and genetic mixing [14–21]. Furthermore, pests and pathogens such as American foulbrood or the small hive beetle threaten the sustainability of managed honeybee and bumblebee colonies [8]. These challenges highlight the urgent need to diversify the species used for crop pollination.

Solitary bees offer a promising solution to reduce reliance on a limited number of managed pollinators. Bees of the genus Osmia (Hymenoptera: Apidae) are emerging as efficient alternatives and have been applied on small scales in North America, East Asia, and Europe [22]. In Europe, Osmia cornuta (Latreille, 1805) and Osmia bicornis (Linnaeus, 1758) (Hymenoptera: Megachilidae) are already employed in managed pollination programs in countries such as Switzerland, France, Italy, and Germany [23, 24]. These species emerge early in spring and are capable of foraging at lower temperatures and under adverse weather, making them valuable for pollination when traditional species like honeybees are inactive [25, 26]. Their pollen-gathering behavior—storing dry pollen on the ventral abdomen—enhances pollination efficiency. For example, in almonds, a visit by O. cornuta results in a 21.8%–38.1% chance of successful pollination, whereas honeybee visits have a success rate of only 16.7%–25.9% [27]. With a short foraging range (50–150 m) and high fidelity to particular plant species, Osmia bees provide targeted pollination [25, 28, 29]. Their gregarious nesting in artificial cavities also allows easy breeding, transport, and release into orchards [30]. Compared to honeybees and bumblebees, Osmia bees are less likely to negatively affect wild pollinators because of their floral specificity, limited foraging distance, shorter adult lifespan, and controlled environmental requirements [31]. These characteristics make them ideal candidates for pollinating early-flowering, high-value crops such as cherries, almonds, and apples.

Although previous research has addressed the biology and management of O. cornuta and O. bicornis separately, comparative evaluations of their suitability for early-flowering fruit crops remain scarce. O. bicornis typically requires warmer temperatures to emerge than O. cornuta [32]. For instance, in Spain and Serbia, O. cornuta foraged under rainy, windy conditions at 10–12°C, while O. bicornis required temperatures above 15°C [26, 33]. Although both species are considered generalists, their host plant preferences differ: O. cornuta favors Sorbus species [34], whereas O. bicornis prefers Salix and Acer [35]. In this study, we assessed the performance of these two species in Swiss cherry and apple orchards by examining emergence timing, nesting activity, orchard abundance, flower visitation rates, and pollen composition, providing insights for growers to select appropriate mason bee species for effective crop pollination.

Materials and Methods

Study area

This study was performed in six orchards located in north-eastern Switzerland, including two cherry and four apple orchards **(Table 1)**. In Waldkirch (Saint-Gall), a single cherry orchard was provided with nesting units for both Osmia cornuta and Osmia bicornis, spaced 85 meters apart. The second cherry site, near Wädenswil (Zürich), consisted of two small, adjacent orchards labeled 1A and 1B; O. cornuta nests were placed in 1A and O. bicornis in 1B **(Table 1)**. For the four apple orchards situated around Berg (Thurgau) and Wädenswil, each orchard received one nesting unit per species, positioned at a minimum distance of 100 meters to prevent overlap. Nesting unit placement was randomized within each orchard. No other bee nesting structures were present, resulting in a total of twelve nesting units across all sites—six for O. cornuta and six for O. bicornis **(Table 1)**. To assess surrounding land cover, the area within 500 meters of each orchard was analyzed using satellite imagery **(Table 1)**.

Bees

Cocoons of O. cornuta and O. bicornis were sourced from Wildbiene + Partner AG (Zürich, Switzerland). These bees had been reared in northern Swiss orchards during the spring and summer of 2018. Following autumn collection from their nesting materials, the cocoons were stored over the winter at 0°C ± 3°C. To ensure that bee emergence coincided with orchard bloom, diapause was artificially broken according to standard commercial protocols [36]. This procedure involved exposing the cocoons to 10°C ± 3°C until the first male emerged—approximately thirty days for O. bicornis and four days for O. cornuta—after which they were returned to 0°C until the orchards began flowering **(Table 1)**.

Table 1. Characteristics of the Six Orchards Studied in North-Eastern Switzerland

Crop	Location	Site	Introduced Mason Bee Species	Surrounding Land (500 m radius)	Management Type	Additional Managed Pollinators	Bloom Start
Cherry	Wädenswil	1A	*O. cornuta*	70% agricultural, 20% residential, 10% forest	Conventional	*A. mellifera*	01 Apr 2019

Cherry	Wädenswil	1B	*O. bicornis*	80% residential, 10% agricultural, 10% forest	Conventional	*A. mellifera*	01 Apr 2019
Cherry	Waldkirch	2	*O. cornuta* & *O. bicornis*	60% forest, 40% agricultural	Conventional	*A. mellifera*	10 Apr 2019
Apple	Wädenswil	3	*O. cornuta* & *O. bicornis*	60% agricultural, 40% residential	Conventional	*A. mellifera*	15 Apr 2019
Apple	Wädenswil	4	*O. cornuta* & *O. bicornis*	70% agricultural, 20% residential, 10% forest	Conventional	*A. mellifera*	15 Apr 2019
Apple	Berg	5	*O. cornuta* & *O. bicornis*	70% agricultural, 20% residential, 10% forest	Organic	*A. mellifera* & *B. terrestris*	18 Apr 2019
Apple	Berg	6	*O. cornuta* & *O. bicornis*	70% agricultural, 20% forest, 10% residential	Organic	*A. mellifera* & *B. terrestris*	18 Apr 2019

Nesting sites

At each orchard, one or two wooden nesting boxes **(Table 1)** were installed at 1.5 m above ground level, filled with 500–700 pieces of Arundo donax stalks, each about 20 cm long, to provide nesting substrates. Consistent with Gruber *et al*. (2011), the boxes were positioned in the orchard center, maintaining at least an 80 m distance from orchard edges [37]. At the start of flowering, 500 bee cocoons were placed in open containers within each nesting unit, reflecting standard orchard management practices [38].

Evaluation of osmia species as orchard pollinators

The behavior of the two Osmia species was tracked across several parameters, including emergence timing, nesting activity, flower visitation rates, and pollen collection. Monitoring spanned 22 days in cherry orchards and 18 days in apple orchards, with timing adjusted according to bloom phenology and local weather conditions.

Emergence monitoring

Emergence of Osmia bees was recorded directly in the field and compared with a control group maintained under ambient indoor temperatures. Field assessments were conducted every two days, recording the number of empty and still-occupied cocoons, with empty cocoons discarded. After 18 days for apples and 21 days for cherries, remaining closed cocoons were dissected to detect parasitoids. Since bloom onset varied among sites **(Table 1)**, emergence tracking was not synchronized across locations.

The control group included four sets of three batches of 50 cocoons per species, exposed indoors on four separate dates to account for seasonal acceleration of emergence (i.e., faster emergence later in April). Dates were 1 April 2019 (cherry bloom, Wädenswil), 10 April (cherry bloom, Waldkirch), 15 April (apple bloom, Wädenswil), and 18 April (apple bloom, Berg). Cocoons were checked daily, empty ones removed, and after at least 18 days, remaining cocoons were dissected to examine for parasitoids.

Nesting activity

Alongside emergence observations, bee establishment in the nesting units was recorded. Eight observation sessions were conducted at two-day intervals, beginning two days after bee release and spanning 18 days. Each session involved 20 minutes of observation per unit, during which nesting females were counted. Individual females were identified based on the reed tubes used for nest construction, as Osmia females rarely switch nesting sites once they begin a nest. Each tube was marked with a pen to avoid double-counting, with a different color used for each observation session, enabling precise monitoring of nest occupancy and bee activity within the units.

Pollen analysis

The pollen collection behavior of O. cornuta and O. bicornis was analyzed to determine their floral host range. Pollen was sampled from females in front of their nests, from emergence until bloom ended, by removing pollen from their abdominal brushes with a toothpick. This yielded 40 samples for O. cornuta and 8 for O. bicornis in cherry orchards, and 78 samples for O. cornuta and 41 for O. bicornis in apple orchards. Samples were sent to CREAF (Centre for Ecological and Forestry Applications Research, Spain) for microscopic identification. Pollen grains were classified to family or genus level and counted. Pollen from the Rosaceae family served as a proxy for cherry and apple flower visitation, as few other Rosaceae species were flowering nearby during the study period.

Flower visitation

Pollinator activity in the orchards was monitored by focusing on individual fruit trees positioned approximately 10 meters south of each nesting unit. Observations were conducted at three distinct flowering stages: when roughly 20% of flowers had opened, at full bloom, and when only 20% of flowers remained. Each session lasted 20 minutes, during which the frequency and duration of visits were recorded for the pollinators A. mellifera, B. terrestris, O. cornuta, and O. bicornis.

Pollinator survey

The diversity and abundance of orchard pollinators were evaluated through 30-meter transect walks conducted every two days after placing the cocoons, with a total of 12 rounds in cherry orchards and 9 in apple orchards. Transects were laid along the row of fruit trees south of each nesting unit. During each 3-minute walk, all pollinators observed on the left-hand row were identified and logged as A. mellifera, B. terrestris, male or female O. cornuta, male or female O. bicornis, hoverflies, butterflies, or other pollinator types.

Data analysis

Cocoon emergence timing under field and indoor conditions was analyzed using a Kaplan–Meier survival estimator, assuming a constant hazard rate and accounting for censoring, since not all bees emerged during the observation period. Parametric analyses were carried out with the survreg function in the R survival package, using either bee species or environmental condition (field vs. control) as explanatory variables to allow pairwise comparisons. Emergence and parasitism rates for O. cornuta and O. bicornis were compared with Fisher's exact test for count data.

Nesting activity was expressed as the cumulative number of tubes occupied at each observation. Because repeated-measures ANOVA assumptions were not met, a Wilcoxon rank-sum test with continuity correction was used to compare the number of occupied tubes per day between the two Osmia species.

For pollen analysis, each sample was assigned a dominant pollen type if more than 80% of grains originated from a single plant group, classified as Salix, Ranunculaceae, Quercus, Rosaceae, or other. Samples lacking a dominant pollen type (14 in total, <10%) were excluded, corresponding to 10% of O. bicornis and 7% of O. cornuta samples. Differences in plant-family visitation between bee species were tested using Pearson's chi-squared test, with a Fisher exact test applied specifically for Rosaceae visits. Graphical summaries were created with the ggstatplot R package [39].

The time bees spent per flower and the number of flowers visited were analyzed separately for each managed pollinator species (A. mellifera, B. terrestris, O. bicornis, O. cornuta) using Kruskal–Wallis one-way ANOVA. Where significant differences were detected, pairwise comparisons were conducted using Wilcoxon rank-sum tests with Bonferroni correction. All analyses were performed in R i386 3.6.0 and RStudio Version 1.2.1335. Results throughout are presented as mean ± SEM.

Results and Discussion

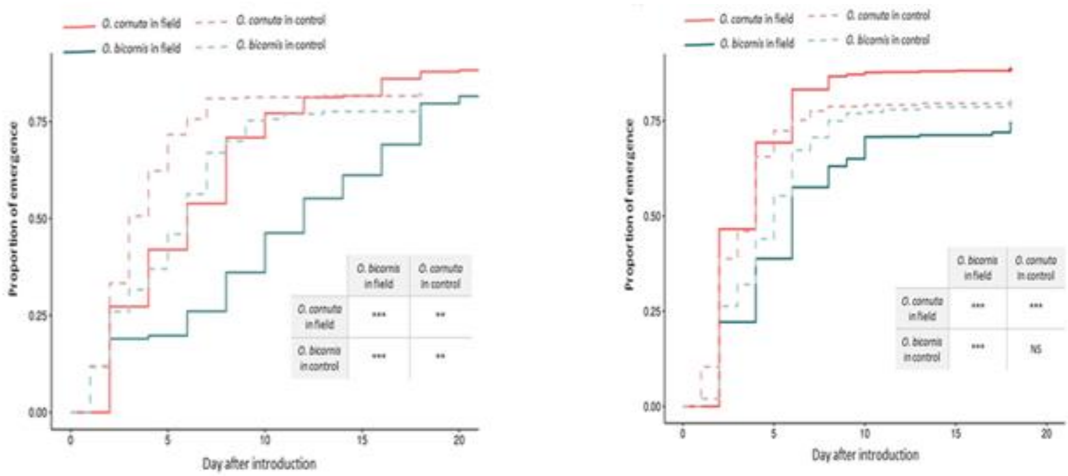
Experimental conditions

In 2019, the onset of cherry flowering varied among orchards, beginning on 1 April in Wädenswil and Dietikon and on 10 April in Waldkirch. Early April was marked by unfavorable weather for bee activity, as only five days featured temperatures above 10°C without strong winds or heavy rainfall. Apple trees bloomed later, starting on 15 April in Wädenswil and 18 April in Berg. Weather conditions during the second half of April were generally more favorable, allowing bees to emerge and forage on 13 suitable days. However, a cold spell in early May temporarily reduced bee activity across all sites.

Emergence patterns of O. cornuta and O. bicornis

In both cherry and apple orchards, O. cornuta consistently emerged faster than O. bicornis **(Figure 1)** ($p < 0.001$). In cherries, over half of O. cornuta individuals had emerged within six days of release (7 April in Wädenswil; 16 April in Waldkirch), while achieving the same threshold for O. bicornis required 12 days in Wädenswil and 16 days in Waldkirch (17 and 22 April, respectively). In apple orchards, 50% of O. cornuta emerged within four days (19 April in Wädenswil; 23 April in Berg), whereas O. bicornis required six days (21 April in Wädenswil; 25 April in Berg).

When incubated indoors under ambient temperatures, O. cornuta still demonstrated faster emergence than O. bicornis during the cherry bloom period (1 and 10 April; $p < 0.01$). No significant difference between species was observed under indoor conditions for apple bloom (15 and 18 April). Across both species and orchard types, emergence was slower in field conditions compared with room conditions. Overall, O. bicornis reached a lower emergence proportion than O. cornuta (76.6% vs. 87.3%; $p < 0.001$). Parasitism rates were low and similar for both species, affecting 1.5% of cocoons ($p = 0.21$).



a) b)

Figure 1. Temporal proportion of O. cornuta and O. bicornis cocoons emerging following introduction at the onset of the blooming period in cherry orchards (a) and apple orchards (b). Solid lines represent field conditions, while dashed lines indicate controlled conditions. O. cornuta emergence is depicted in red, and O. bicornis in blue. Tables present the significance levels from Kaplan–Meier parametric analyses for pairwise comparisons. ***$p < 0.001$, **$p < 0.01$, NS = not significant.

Nesting rate of O. cornuta and O. bicornis

In apple orchards, O. bicornis exhibited lower nesting activity compared to O. cornuta **(Figure 2)**. Between the 2nd and 18th day after cocoon introduction, the number of nesting O. cornuta was consistently higher than that of O. bicornis, with significant differences observed on each day assessed ($p < 0.05$). In cherry orchards, O. bicornis initiated nesting later, with first observations on days 16 and 12 post-introduction in Wädenswil and Waldkirch (17 and 22 April, respectively), whereas O. cornuta began nesting on day 8 at both sites (9 and 18 April, respectively). Due to the very low number of nests, meaningful statistical comparison between the nesting behaviors of O. bicornuta and O. cornuta was not possible.

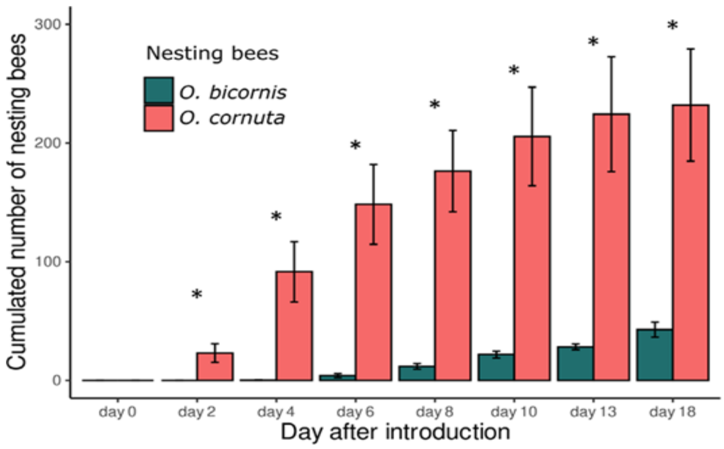


Figure 2. Total number of nesting cavities occupied by O. bicornis and O. cornuta in apple orchard nesting sites across the flowering period. From the 2nd to the 18th day, O. cornuta consistently filled a greater number of cavities than O. bicornis (*$p < 0.05$).

Hostplant range

Pollen carried by O. cornuta and O. bicornis differed notably between orchard types. In cherry orchards, the majority of O. cornuta (80%, n = 40) carried pollen dominated by Rosaceae (>80%), whereas only a small fraction of O. bicornis samples (13%, n = 8) contained Rosaceae pollen. Due to the small sample size of O. bicornis, statistical comparisons were not feasible. In apple orchards, Rosaceae pollen accounted for 95% of O. cornuta (n = 78) pollen samples but only 30% of O. bicornis (n = 37), representing a statistically significant difference ($p < 0.001$) **(Figure 3)**.

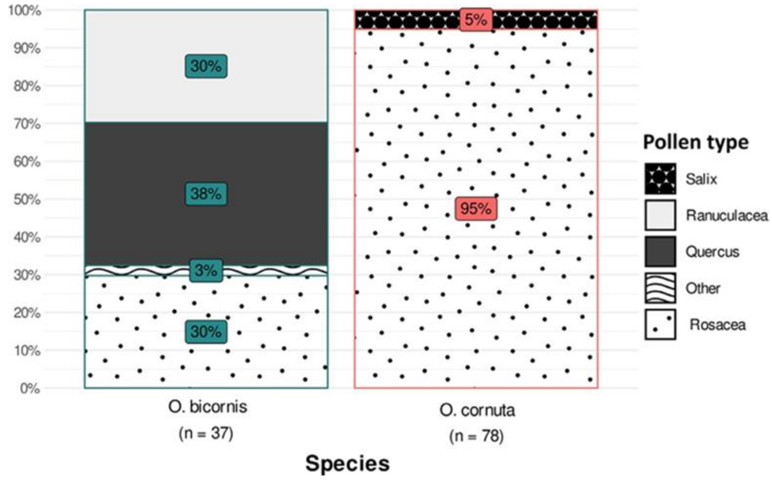


Figure 3. Proportions of plant families or genera visited by O. bicornis and O. cornuta for pollen collection in apple orchards. An individual was classified as visiting a particular plant group if over 80% of its pollen came from that group (Fisher exact test: $p < 0.001$).

Flower visitation and pollinator surveys

During observations in cherry orchards, 69 O. cornuta and 31 A. mellifera were recorded. O. cornuta spent an average of 5.52 ± 2.52 seconds per flower, while A. mellifera lingered significantly longer at 12.29 ± 7.01 seconds ($p < 0.001$). The number of flowers visited per individual did not differ significantly between the two species (O. cornuta: 4.38 ± 0.40 flowers/tree; A. mellifera: 3.97 ± 0.54). No O. bicornis visits were observed in these orchards.
In apple orchards, four pollinator species were observed: A. mellifera (66 individuals), B. terrestris (29), O. bicornis (5), and O. cornuta (53). A. mellifera consistently spent more time on each flower compared with the other species (B. terrestris, $p < 0.001$; O. bicornis, $p = 0.004$; O. cornuta, $p < 0.001$) **(Figure 4)**, though the number of flowers visited per tree was similar across species (A. mellifera: 5.91 ± 0.59; B. terrestris: 6.21 ± 0.95; O. bicornis: 4.00 ± 1.64; O. cornuta: 4.85 ± 0.50 flowers/tree per individual).
Overall, managed species dominated the pollinator community during flowering in both orchard types (n = 945, 91.84% ± 5.86%), with A. mellifera accounting for the majority (62.23% ± 17.84%), followed by O. cornuta (21.18% ± 10.08%), B. terrestris (7.18% ± 7.57%), and O. bicornis (1.25% ± 1.84%).

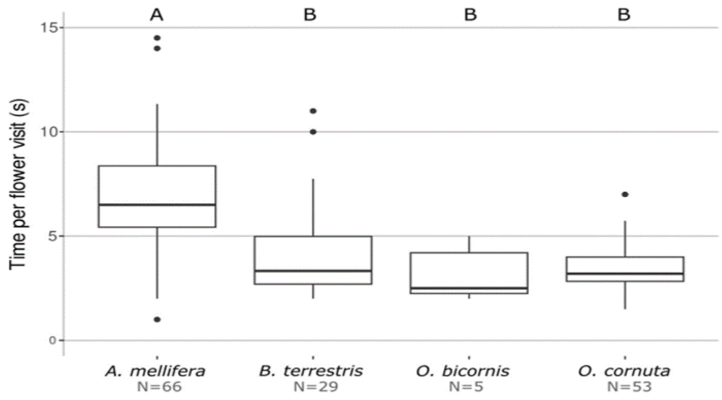


Figure 4. Mean duration of flower visits by four managed pollinator species on apple flowers. 'N' denotes the number of observations per species. Kruskal–Wallis rank-sum test indicated $p < 0.001$, and letters show pairwise differences at $p < 0.01$ based on Wilcoxon rank-sum tests with Bonferroni correction.

Crop pollination largely relies on managed honeybees and bumblebees. Osmia species represent a promising option to diversify managed pollination in fruit orchards, yet the comparative suitability of different Osmia species has been insufficiently documented [27, 40]. This study evaluated the performance of O. cornuta and O. bicornis in cherry and apple orchards across Switzerland. Our results demonstrate that O. cornuta is a more effective pollinator than O. bicornis in both crops, emerging and nesting earlier and in higher numbers. Pollen analyses further indicate that O. bicornis forages on a broader range of plant species, making it less reliable than O. cornuta, which primarily collects pollen from the target orchard crops.

Specifically for cherry trees, O. cornuta displayed traits more favorable for pollination. Cherry presents a particular challenge for Swiss orchards due to its early flowering in late March and early April, when weather conditions may hinder pollinator activity. O. bicornis exhibited low emergence rates and delayed initiation of pollen collection and nest building, starting approximately two weeks after flowering began. Since early flower visits are crucial for optimal fruit set in cherries, this delay could negatively affect production [41]. Conversely, O. cornuta emerged faster, enabling it to begin nesting and pollination during the second week of bloom.

These observations align with prior reports showing that O. bicornis requires higher temperatures for emergence than O. cornuta [32]. Studies of supercooling points indicate that O. cornuta completes diapause more abruptly, while O. bicornis shows a gradual increase, reflecting natural seasonal activity patterns [42]. In Switzerland and southern Germany, O. cornuta is active from mid-March to early May, whereas O. bicornis appears later, from early April to mid-June [25]. O. cornuta becomes active at approximately 9.8°C, slightly lower than the 12.5°C threshold for A. mellifera [43]. O. bicornis has an activity threshold comparable to or lower than A. mellifera, meaning it activates later in the spring compared with O. cornuta. Overall, O. bicornis emerges later and requires warmer temperatures for activity and nesting [44].

During the study, O. cornuta likely outperformed honeybees under the prevailing cool conditions, as A. mellifera's activity threshold exceeds the ambient temperatures for most days [26]. Pollen samples from O. bicornis suggest that it primarily visited Ranunculaceae and Quercus, rarely foraging on cherry trees. Although the small sample size ($n = 8$) warrants caution in interpretation, previous studies similarly show that O. bicornis released in orchards often carries pollen from non-Rosaceae plants such as Quercus, Salix, or Acer [35, 45]. In contrast, most pollen collected by O. cornuta originated from Rosaceae, confirming a strong preference for the target crop, consistent with earlier observations for cherry and almond [46]. Considering these traits collectively, O. cornuta appears to be a more suitable pollinator for cherry orchards than O. bicornis.

In apple orchards, which bloom roughly two weeks after cherries, O. cornuta was again observed to emerge earlier and commence nesting and pollen collection sooner than O. bicornis. Unlike cherry, apple pollination is generally less time-sensitive because weather conditions are typically more favorable, and growers perform fruit thinning to ensure optimal fruit size and prevent alternate bearing [47, 48]. Despite these favorable conditions, clear differences between the two Osmia species were evident. Fewer O. bicornis females were seen near nesting sites compared with O. cornuta, suggesting that O. bicornis may disperse more readily. Mason bees are known to disperse following disturbances or when nesting conditions are suboptimal, and a certain level of dispersal is normal [37, 43]. Since alternative nesting sites were scarce in our orchards, it appears that O. bicornis left the area to nest elsewhere. However, in the absence of comparative studies on dispersal between Osmia species, other explanations—such as higher female mortality—cannot be ruled out.

The relatively high nesting activity of O. cornuta likely produced a sufficient population to ensure effective apple pollination, even though we did not directly measure pollination success, whereas O. bicornis populations were insufficient. Early emergence and nesting of O. cornuta have been documented in Spain and Serbia, but this phenomenon has not previously been reported in central Europe [42, 49].

Analysis of pollen loads revealed that 95% of O. cornuta samples were dominated by Rosaceae pollen, highlighting a strong preference for apple flowers. In contrast, only 30% of O. bicornis pollen loads consisted of Rosaceae, while Quercus pollen was prominent (38% of samples). It is well documented that O. bicornis prefers non-crop plants over orchard crops [35, 45, 46], whereas O. cornuta favors fruit trees [38, 46]. The observed preference of O. bicornis for Quercus may relate to its role in accelerating early-season nest construction and enhancing reproductive success, although the underlying reasons remain unclear [50–52]. These findings indicate that O. cornuta's foraging behavior is more targeted and suitable for apple and cherry pollination compared with the broader plant range utilized by O. bicornis.

Across 80 transect surveys in both cherry and apple orchards, only 76 wild pollinators were recorded, demonstrating that crop pollination relies heavily on managed species, including mason bees, honeybees, and bumblebees. Given the early bloom and unpredictable weather, unmanaged pollinators alone are unlikely to provide adequate pollination for commercial orchards [53]. In our observations, honeybees dominated the pollinator community, likely due to the high density of hives surrounding the orchards **(Table 1)**. Nevertheless, honeybee visitation rates were low—only 2.5 visits per tree per 20 minutes—far below the recommended 20 visits per tree per minute [54]. These results emphasize the value of supplementing honeybees with other managed pollinators, particularly O. cornuta.

Although O. cornuta and O. bicornis showed clear differences in emergence during cherry bloom under both field and controlled conditions, the pattern was less distinct during apple bloom. Under laboratory conditions, the two species exhibited similar emergence rates, but in the field, O. cornuta still emerged considerably faster, suggesting that field temperatures were not sufficient to trigger rapid emergence in O. bicornis.

The delayed emergence of O. bicornis in orchards is likely driven by physiological factors, including overwintering conditions and a higher temperature requirement to break diapause. Overall, O. cornuta achieved roughly 10% higher emergence than O. bicornis, which could be due to higher winter mortality in O. bicornis [23] or undetected pathogens, although both species experienced similar parasitoid rates (1.5%). Numerous studies have highlighted that winter mortality in Osmia bees is largely influenced by suboptimal temperatures during and prior to diapause, with both excessively long and short cold exposure causing high mortality due to increased consumption of energy reserves [22, 55, 56].

In controlled conditions, O. bicornis emerged faster and in greater numbers than in orchards, whereas O. cornuta showed slightly lower emergence at room temperature than in field conditions. Although the European ranges of O. bicornis and O. cornuta overlap substantially, O. bicornis also inhabits northern Europe and may require higher temperatures to terminate diapause, preventing premature emergence that could be detrimental under fluctuating spring conditions.

Several limitations should be considered when interpreting our study. First, it was conducted over a single year, during a cold and wet spring. Early April offered only five favorable days for bee emergence (temperature >10°C, low wind, no heavy rain), improving to 13 suitable days in late April. A climatic depression in early May brought frequent rain and low temperatures, reducing bee foraging and slowing metabolism. Such harsh spring conditions are most common in northern and eastern Europe, so our findings may not reflect performance under milder southern European conditions, where O. bicornis may fare better [57]. Nevertheless, the suitability of O. bicornis for northern Europe remains inconclusive. In Denmark, it is considered less effective than A. mellifera due to its preference for non-crop plants [35], while in the UK and Germany, it is regarded as a viable orchard pollinator [37, 58]. These contrasting outcomes suggest that local populations may adapt differently, affecting their efficacy as orchard pollinators.

Second, due to poor weather, only a limited number of O. bicornis observations were made in cherry orchards, preventing a full assessment of their nesting and pollination behavior. Third, in the pollen analysis, Rosaceae pollen could not be identified to the species level, so differentiation between cherry, apple, and other Rosaceae was not possible. However, given that most blooming Rosaceae near the orchards were fruit trees and very few Prunus spinosa were present, it is reasonable to assume that collected pollen came from cherry or apple. Considering that the foraging range of both species is only 50–150 m, it is likely that Rosaceae pollen was almost exclusively from orchard trees [28].

Despite these limitations, the study provides strong evidence that O. cornuta has clear advantages over O. bicornis for fruit orchard pollination under continental European climates.

Conclusion

Our findings highlight the scarcity of wild pollinators in Swiss cherry and pear orchards, emphasizing the essential role of managed pollinators in securing effective fruit pollination. O. cornuta demonstrated faster emergence, initiated nesting earlier, and achieved higher nest numbers compared with O. bicornis. These differences were particularly pronounced in cherry orchards but were also evident in apple orchards. In addition, O. cornuta predominantly foraged on cherry and apple trees, while O. bicornis frequently collected pollen from a wider variety of plants. These results suggest that O. cornuta offers greater potential as a commercial pollinator for cherry and apple orchards in central Europe. Nonetheless, O. bicornis may still be a viable option in northern regions where O. cornuta is absent, such as the UK. Overall, our study supports the use of managed O. cornuta in Swiss fruit orchards to ensure reliable and sustainable pollination, even under challenging weather conditions.

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Ethics Statement: None

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