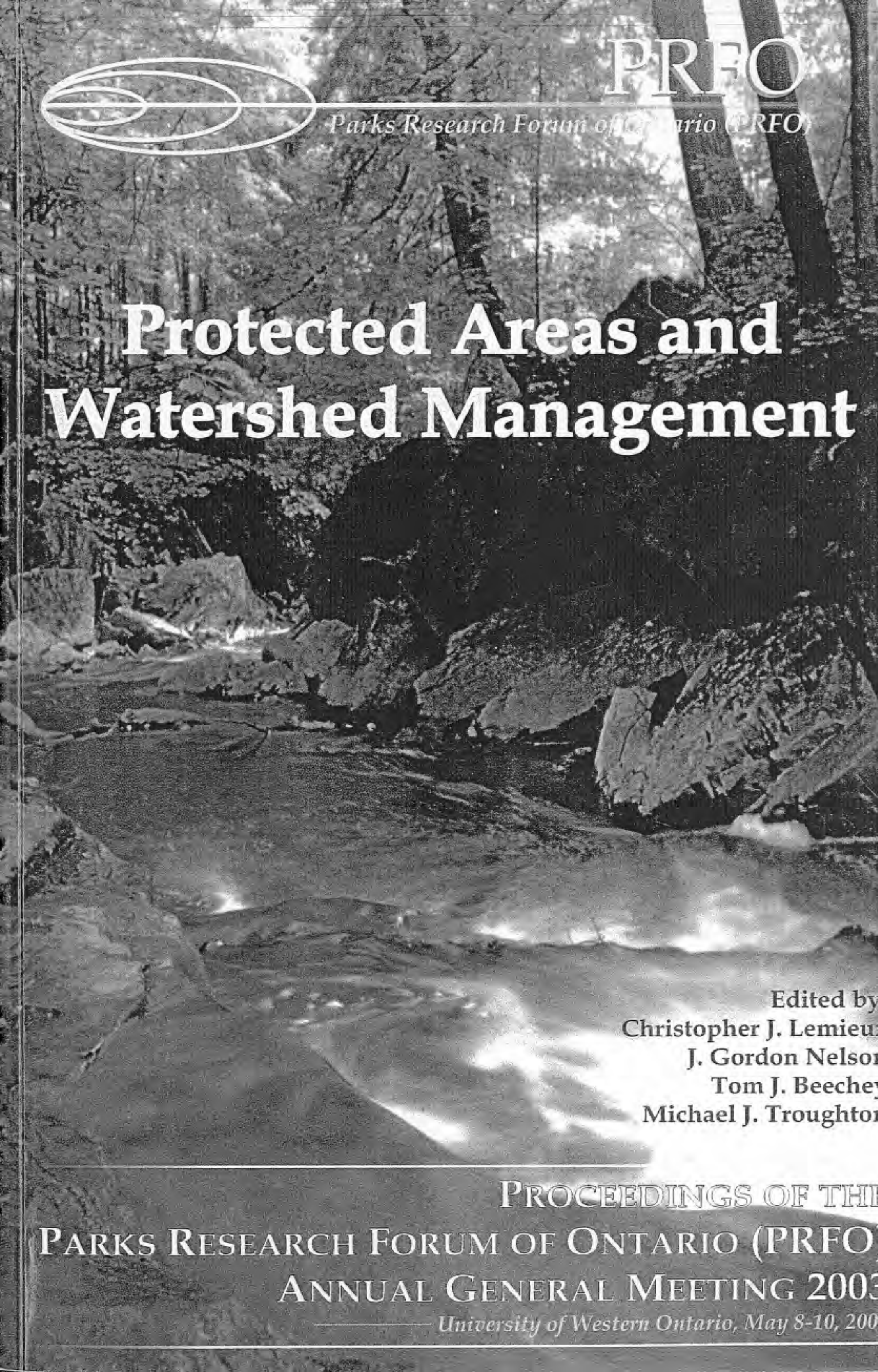

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A Bee Diversity Survey in Oak Savannah Habitats in Rondeau Provincial Park, Ontario

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Abstract

A survey of bee diversity was conducted in two oak savannah habitats - Oak Savannah 3 (O3) and South Point (SP) - in Rondeau Provincial Park in Southern Ontario, Canada. The bee community composition of O3 and SP were similar in both sites according to a Detrended Correspondence Analysis (DCA) and Sorensen's coefficient of community similarity. However, bees appeared to prefer the SP habitat over O3 as determined by the greater bee species abundance, richness, Shannon diversity, and evenness values found in SP. This is possibly due to the larger habitat area and greater plant species richness and abundance of SP compared to O3. The decline in bee species richness and abundance toward the end of the summer correlated with the decline in plant richness and abundance because bees rely on the nectar and pollen in plants that are flowering as sources of food.

Introduction

Bees (*Hymenoptera: Apoidea*) are a diverse group of flower visiting insects, playing a big role in ecosystem functioning (Paxton, 1995). They are important pollinators of angiosperms (LaSalle and Gauld, 1993; Michener, 2000), and agricultural crops (Kevan, 1999; Cane and Tepedino, 2001; Kevan and Phillips, 2001). Given the importance of bees in the plant-pollinator mutualistic relationship, if there is a loss in bee pollinators, a loss in flowering plant species may follow (LaSalle and Gauld, 1993). The purpose of this research was to study of bee diversity in relation to plant diversity in oak savannah habitats in Rondeau Provincial Park.

Rondeau Provincial Park was chosen for this study for three reasons: 1) bees have never before been surveyed in this park; 2) vegetation has been studied in oak savannah sites in this park; and, 3) oak savannah is one of the most threatened ecosystems in North America (Nuzzo, 1986). Because bees are important in ecosystem functioning, they can support continued reproduction and survival of plants that other organisms rely upon, thus maintaining the oak savannah ecosystems.

Objectives of the Study

Bees were collected in two oak savannah sites in Rondeau Provincial Park: Oak Savannah 3 (O3) and South Point (SP). The following objectives were investigated:

1. The bee and plant community composition and diversity between the two oak savannah sites; and,
2. The relationship between changes in diversity of plants that are flowering and changes in bee diversity from early summer to late summer at each site.

Materials and Methods

Bee Sampling and Vegetation Data

Bees were collected using the method of pan trapping. At each site, 30 pan traps were laid out 3m apart in a linear transect. White pans (plastic Solo™ party bowls) were spray-painted either yellow, or blue, or left as white. At each site, 10 blue pans, 10 white pans, and 10 yellow pans were used, which were laid out on top of the ground in alternating colours. Each pan was half-filled with water mixed with a few drops of clear unscented liquid dishwashing detergent (Southwood, 1978). Insects are attracted to the colour of the pans and drown once they land on the water because the detergent breaks the water surface tension (Cane *et al.*, 2000).

Bee sampling took place between 1st June and 18th August of 2002. Bees were collected every 2-3 days (weather permitting) and preserved in 70% ethanol. Once they were brought back to Toronto at the end of August, they were pinned and identified down to species level by Lily Mac, Dr. Terry Griswold, and Dr. Laurence Packer, the latter of whom verified all identifications.

Plant characteristics of O3 and SP sites were available from a previously recorded vegetation survey (by Dr. Dawn Bazely), that included the 1) maximum frequency abundance values, and 2) frequency abundance values (early summer, and late summer) of each plant species present at each site.

O3 and SP Bee and Plant Composition Analyses

Species composition relationship (bees and flowering plants) was inferred through the multivariate ordination technique, detrended correspondence analysis (DCA), which arranges plots (pans and quadrats) and species in two-dimensional space (two axes) on the basis of species composition data (Jongman *et al.*, 1995; ter Braak and Prentice, 1988). The axes are hypothetical environmental gradients that best describe the variation in species composition between sites, and are in units of standard deviation (S.D.) (Hill and Gauch, 1980). Points (plots) in the diagram that are within 4 S.D. are samples that are significantly similar in species composition (Jongman *et al.*, 1995). DCAs were generated for the bee community using species occurrence and abundance of bees found in pans, and for the plant community using occurrence and frequency cover data of plants found in quadrats. The computer programme, CANOCO 4.0 was used to generate the DCAs. The analysis, Sorensen's coefficient of community similarity (CC), was calculated to see how the bee and plant communities are similar between the two oak savannah sites.

O3 and SP Bee Diversity Analyses

Diversity variables were calculated for bees collected in each site for between site comparisons: 1) Shannon Wiener Index of diversity (H'); 2) species richness; 3) species abundance; and, 4) evenness (E) (Magurran, 1988; Pielou, 1975). These variables were all analyzed with Mann Whitney non-parametric test (Watt, 1993; Zar, 1999). All statistical tests were done using the computer statistical programme, SPSS 11.5 for Windows.

Results

Bee Species and Abundance

Pan trap sampling yielded a collective abundance of 422 bee specimens, and 42 species (Appendix 1). Individually by site, pans in O3 yielded 85 bees and 26 species, and pans in SP yielded 337 bees and 33 species. The percentage of species that were found only in O3 and SP was 21.43% and 38.10% respectively. Species that were common in both sites comprised of 40.48%. Throughout the summer, higher bee abundance and richness were found in SP than O3, both variables of which dropped in numbers by late summer (Figure 1a and 1b).

Figure 1a. Bee abundance by month in O3 and SP.

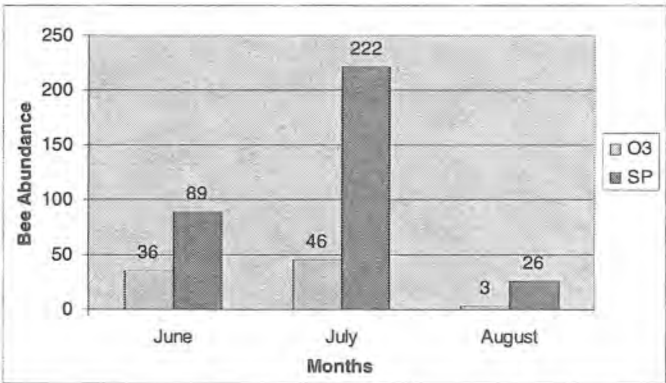
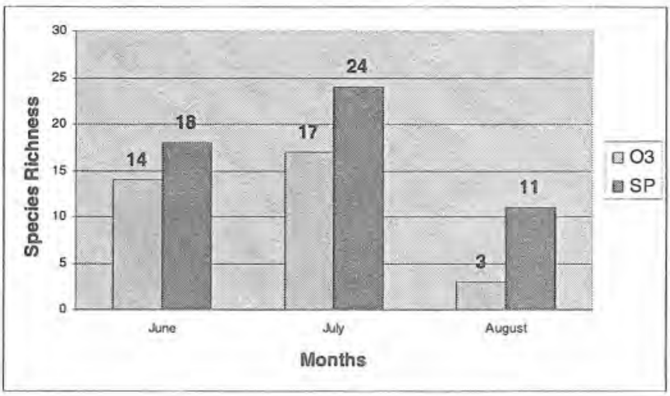


Figure 1b. Bee species richness by month in O3 and SP.



O3 and SP Bee and Plant Composition Analyses

DCA for the bee communities show that the plots (pans) from O3 and SP overlap. This suggests that the bee community composition between the two sites was similar overall, but in O3 the bees varied much more across the site (Figure 2a).

DCA for the vegetation communities show that the plots (quadrats) in O3 and SP are spatially apart but plots between the two sites overlap. This suggests that the plant community composition is more variable than the bee community composition (Figure 2b).

There was a change in plant species composition in O3 and SP from early summer to late summer as illustrated by Figures 3a and 3b respectively. The DCAs show two points connected by a line of permanent plots sampled at different times - one in early summer and one in late summer. Their different positions imply that there has been a change in species composition in that plot from early to late summer plant species. There were more plant species and in greater abundance in SP than O3 in both early summer and late summer. Overall plant species richness and abundance dropped in both SP and O3 from early summer through to late summer. Sorensen's coefficient of community similarity was calculated for bee and plant species which gave values of 0.58 and 0.27 respectively, suggesting that the bee community is more similar than the plant community.

Figure 2a. DCA diagram showing the distribution of plots (pans) in O3 and SP.

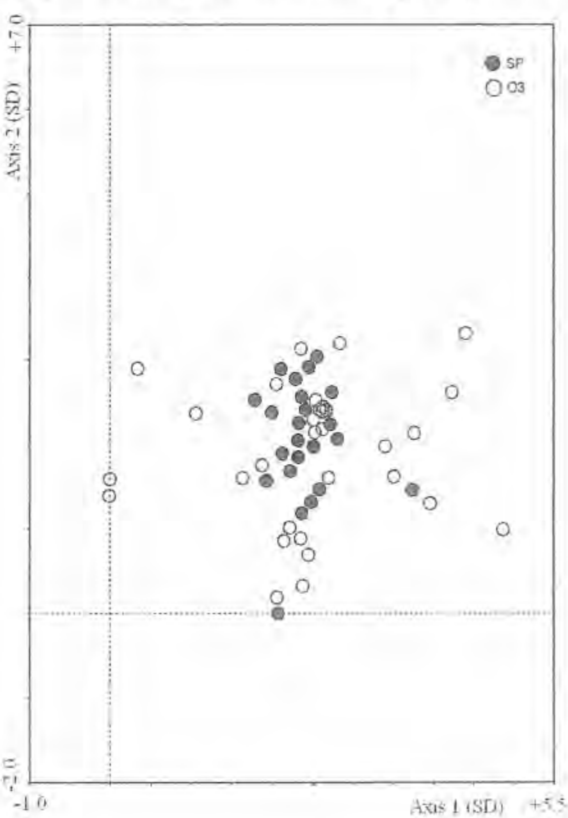


Figure 2b. *DCA diagram showing the distribution of plots (quadrats) in O3 and SP.*

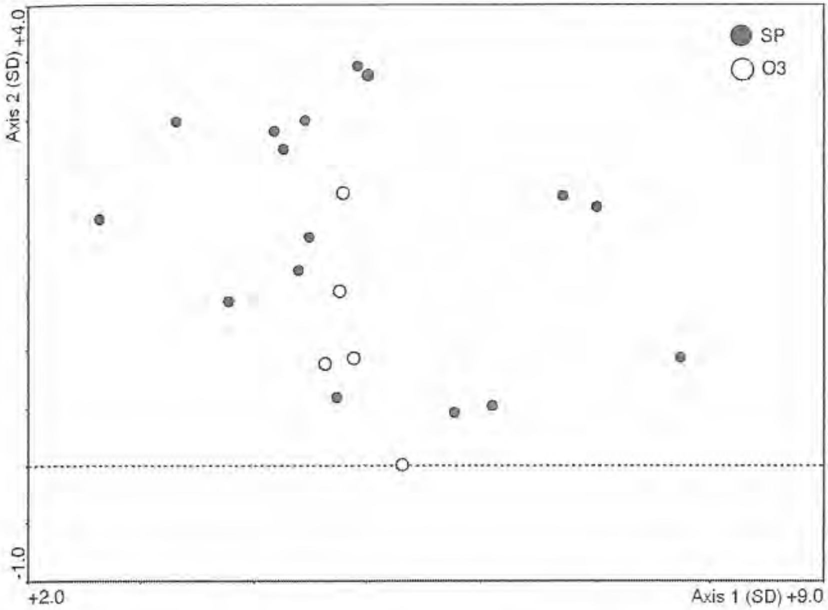


Figure 3a. *DCA showing early summer and late summer plant community distribution in O3.*

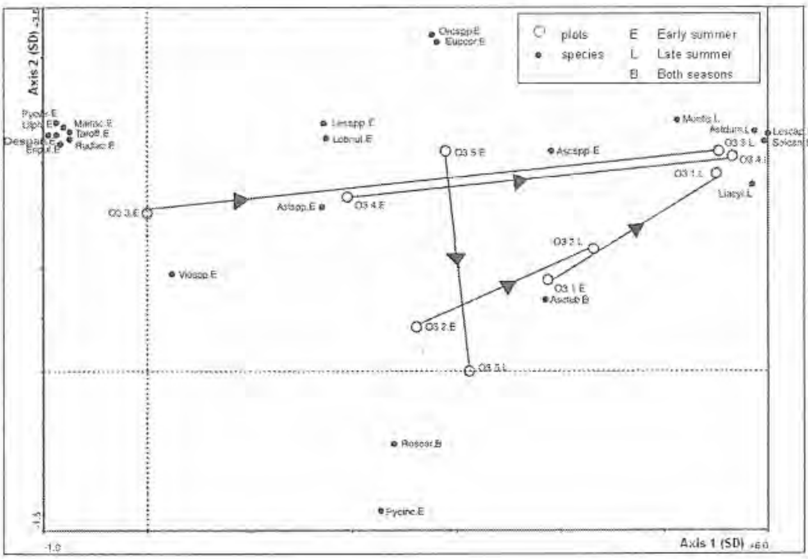
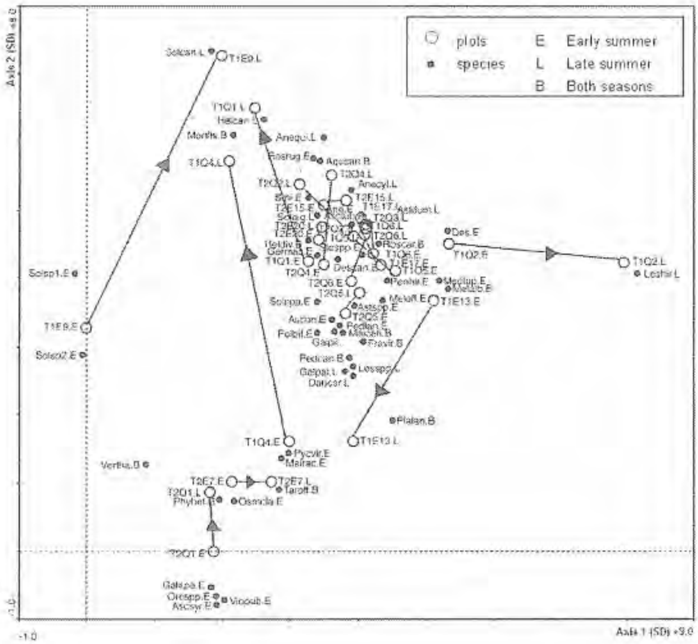


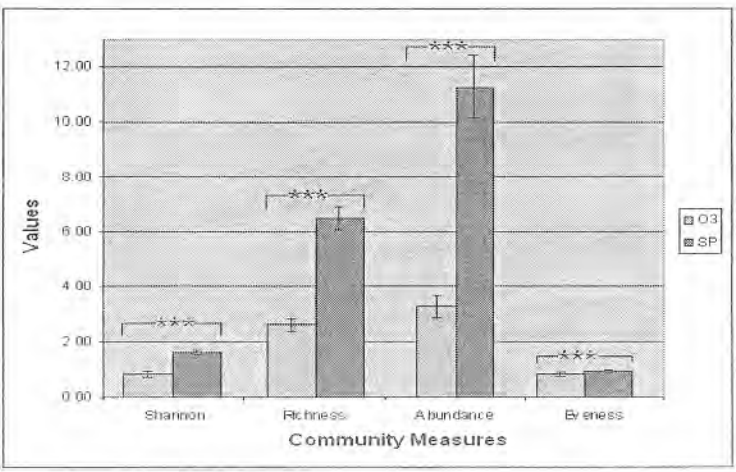
Figure 3b. DCA showing early summer and late summer plant community distribution in SP.



O3 and SP Bee Diversity Analyses

Mean values of Shannon diversity, species richness, abundance, and evenness were significantly higher in SP than O3 (Fig. 4), indicating a greater diversity of bees at SP than O3.

Figure 4. Mean Shannon diversity, richness, abundance, and evenness values for O3 and SP sites.



Discussion

Analyses (DCAs and Sorensen's coefficient) suggest that the bee communities between the two oak savannah sites are more similar than the plant communities. Bees are mobile organisms, and therefore similar species would be present in both sites due to their ability to fly long distances to reach these sites. It is known that medium bodied bees can fly up to distances of 1–2 km (Cane, 2001), and the distance between the O3 and SP sites is about 2–3km (Bazely, 2002).

However, there was greater bee diversity in SP than O3 since it had significantly greater species richness, abundance, evenness, and Shannon diversity values than O3 (Figure 4). Thus, although the same bee species were visiting both sites (i.e., sites are similar in bee composition), bees generally favoured SP over O3 (since SP had greater bee diversity). Greater bee diversity in SP was expected since it is a larger and more open habitat than O3 (which is a small fragment in the middle of a forest) and thus, might be able to provide habitat for many more species of bees. The greater species richness and abundance of bees collected from SP is consistent with findings that more species are discovered in larger areas (Williams *et al.*, 2001). Plant diversity and abundance have also been shown to positively affect bee communities (Heithaus, 1974; Carvell, 2002). Changes in plant community, species richness and abundance correlated with the decline in bee species and abundance towards the end of summer. This was expected as many of the flowering species that bees depend on for food were replaced by the fewer late summer flowering plants and the predominance of tall grasses.

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Appendix 1 *– Total bee abundance and bee species for individual sites [Oak savannah 3 (O3) and South Point (SP)] and pooled.*

TAXA	O3	SP	TOTAL
ANDRENIDAE			
Andrena erythronii	0	1	1
COLLETIDAE			
Colletes americanus	0	1	1
Hylaeus affinis	0	30	30
Hylaeus stevensi	1	15	16
HALICTIDAE			
Agapostemon sericeus	0	1	1
Agapostemon splendens	6	23	29
Agapostemon virescens	1	0	1
Augochlorella striata	12	83	95
Halictus confusus	1	27	28
Halictus ligatus	2	7	9
Lasioglossum (Dialictus) cressonii	0	4	4
Lasioglossum (Dialictus) perpunctatus	4	0	4
Lasioglossum (Dialictus) pilosus	1	17	18
Lasioglossum (Dialictus) pruinosus	1	0	1
Lasioglossum (Dialictus) tegularis	0	2	2
Lasioglossum (Evylaeus) pectoralis	4	7	11
Lasioglossum (Lasioglossum) coriaceum	0	2	2
Lasioglossum (Lasioglossum) fuscipenne	2	0	2
Lasioglossum (Lasioglossum) leucozonium	2	1	3
Lasioglossum (Lasioglossum) zonulum	3	2	5
Pseudoaugochloropsis metallica	0	1	1
Sphecodes persimilis	0	2	2
Sphecodes stygius	1	3	4
Anthophora furcata	0	1	1
APIDAE			
Apis mellifera	4	0	4
Bombus bimaculatus	1	2	3
Melissodes apicata	0	1	1
Psithyrus citrinus	1	0	1
Epeolus lectoides	5	0	5
Nomada articulata	1	0	1
Nomada maculata	1	0	1
Nomada pygmaea	1	2	3
Ceratina calcarata	5	29	34
Ceratina dupla dupla	0	1	1
Ceratina metallica	2	27	29
MEGACHILIDAE			
Anthidium maculata	0	1	1
Megachile addenda	0	3	3
Megachile frigida frigida	0	2	2
Megachile rotundata	2	4	6
Osmia caerulessens	2	3	5
Osmia collinseae	0	1	1
Osmia pumila	19	31	50
Abundance	**85**	**337**	**422**
Species richness	**26**	**33**	**42**