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# The native bee fauna of the Palouse Prairie (Hymenoptera: Apoidea)

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**Abstract.** While synoptic collections provide data on the range and general composition of the North American bee fauna, bee communities associated with specific habitats are largely uncharacterized. This report describes the community of native bees currently found in remnant fragments of the Palouse Prairie of northern Idaho and southeastern Washington State. Native bees were collected using standardized collection techniques including blue vane traps, colored pan traps and aerial netting. More than 13,000 individuals were collected, representing at least 174 species and 36 morphospecies in 29 genera. These data provide the most thorough characterization of the bee fauna of this vulnerable ecosystem, as well as community level information on bee species of unknown conservation status. These results are relevant to regional conservation efforts and, more broadly, are representative of conditions in fragmented grasslands surrounded by intense agriculture, a common global land use pattern of conservation concern.

## INTRODUCTION

By 2005, cultivated systems covered one quarter of Earth's terrestrial surface (Sarukhan *et al*., 2005). This habitat loss is responsible for worldwide reductions in species richness and diversity of many taxa including bees (Foley *et al*., 2005; Brown & Paxton, 2009; Senapathi *et al*., 2015). Temperate grasslands, such as the Palouse Prairie, are greatly impacted by anthropogenic land use change, with more than half of all temperate grassland, shrubland or savannah converted to agricultural or urban use

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(White *et al*., 2000). Habitat loss is associated with pollinator declines (Vanbergen, 2013) and can exacerbate reductions in bee species richness and abundance caused by pesticides (Park *et al*., 2015). Additionally, fragmentation caused by habitat loss can impact remaining isolated populations through inbreeding (Zayed, 2004; Zayed & Packer, 2005; Darvill *et al*., 2006; Ellis *et al*., 2006); inability of small habitat fragments to support populations (Lennartsson, 2002); and through degradation of the remaining habitat, where depauperate bee communities inadequately pollinate necessary forage plants (Fontaine *et al*., 2005).

Habitat loss and fragmentation functions in conjunction with disease, invasive plant spread, and pesticide use to cause bee declines (Brown *et al*., 2002; Vanbergen, 2013; Goulson *et al*., 2015, but see Winfree *et al*., 2007). However, the extent and magnitude of native bee decline in North America remains unclear (NRC, 2007) despite the important role native bee pollinators play in agricultural production and ecosystem health (Ashman *et al*., 2004; Klein *et al*., 2007). The degree of bee species decline can be difficult to resolve because baseline data necessary to identify species of concern is lacking in many cases and the conservation status of most native bee species remains unknown (Meffe *et al*., 1998; NRC, 2007; Goulson *et al*., 2008). Yet, reductions in bee species' range and abundance have been documented throughout the world (Biesmeijer *et al*., 2006; Fitzpatrick *et al*., 2007; Potts *et al*., 2010; Cameron *et al*., 2011). While there have been some efforts to quantify bee species decline using museum specimens (Bartomeus *et al*., 2013; Scheper *et al*., 2014), systematic surveys of bee fauna presence and abundance are lacking in most parts of the world, including in the Palouse Prairie in northern Idaho and adjacent eastern Washington.

The Palouse Prairie is a discrete component of the Pacific Northwest bunchgrass biome, differentiated by its distinctive soils and topography (Tisdale, 1982). It is considered a subsection within Bailey's ecoregions (Bailey, 1995), a subregion in Omernik's ecoregions (1987), and a unit in Ertter and Moseley's floristic regions of Idaho (1992). It is bounded by the arid channeled scablands of central Washington to the west, the canyon grasslands adjacent to the Snake and Clearwater Rivers to south and southeast, and the forests of the Selkirk and Bitterroot Mountains to the north and east. The Palouse Prairie was continuous habitat across this region until the late 1800s when agricultural conversion began. Now approximately 1% of the Palouse Prairie remains (Black *et al*., 1998), and so the ecosystem could be considered 'Critically Endangered' using the criteria of Keith *et al*. (2013). The remaining fragments are small (most less than 2 ha) with high perimeter-to-area ratios, located disproportionately along streams or on land too rocky or steep to farm (Looney & Eigenbrode, 2012). Although fragmented and surrounded by intensive agriculture, the Palouse Prairie still supports a species rich community of vascular plants, including rare and threatened plant species like *Silene spaldingii* S. Watson, *Symphyotrichum jessicae* (Piper) G.L. Nesom, *Astragalus arrectus* A. Gray, and *Calochortus nitidus* Douglas (Daubenmire, 1942; Lichthardt & Moseley, 1997; Hanson *et al*., 2008; Davis, 2015). The native earthworm *Driloleirus americanus* Smith still persists in the Palouse (Sánchez-de León & Johnson-Maynard, 2008). Weevils (20 species), darkling beetles (five species), and scarab beetles (six species) present in Palouse Prairie fragments and adjacent agricultural fields have been characterized (Hatten *et al*., 2004, 2007), and all eight regional species of carrion beetles are found in Palouse Prairie fragments (Looney *et al*., 2004). However, native bee communities on the Palouse remain uncharacterized, a situation common throughout North America (NRC, 2007).

A compilation of historical records lists 257 bee species present in the Palouse ecoregion (Bailey, 1995), among the highest of all ecoregions in the Columbia Basin (Tepedino & Griswold, 1995). However, these data were compiled from many different sources using a variety of collection methods, so the relative abundance of species in this assemblage is unknown. The objectives of this study were to: 1) provide a comprehensive species list of bee fauna of the Palouse Prairie, 2) assess the relative abundance of bee species, and 3) identify range expansions or new state records for bee species.

## MATERIAL AND METHODS

Bee collection occurred at 32 sites on 29 fragments of the Palouse Prairie (Fig. 1) between May and July in 2012 and 2013. We chose to constrain sampling to these months to coincide with the period of highest species richness of plants in flower and the greatest abundance of active bees. The great majority (73%) of bee specimens recorded in the Global Biodiversity Information Facility (hereafter, GBIF) from the Palouse region were collected between May and July (GBIF, 2015). Only seven species recorded in GBIF have records of occurrence in the Palouse that do not overlap these three months. Of these seven species, five are represented by a single specimen in the GBIF database (GBIF, 2015). So, while this sampling scheme may miss some of the early spring and late summer species this was the most efficient use of collector time. Each site was sampled four times in each year, at sampling intervals of approximately three weeks. Sampling location within the fragment was determined by generating a random point within each prairie fragment at least 10 meters from the fragment edge, when possible, using the Create Random Points tool in ArcMap 10.0 (ESRI, Redlands, CA). If the sampling location fell within a thicket of shrubs or small trees, which would inhibit trap placement, the sampling location was moved 5 meters beyond the nearest edge of the thicket. Multiple methods of bee sampling were employed to maximize detection of the existing fauna: pan traps, blue vane traps, and aerial netting. Pan traps have been extensively used in standardized bee sampling regimes, but are known to have bias in bee capture, recovering Halictinae and *Perdita* Smith at greater rates than the genera *Anthidium* Fabricius, *Colletes* Latreille, and *Epeolus* Latreille, as compared with netting in the same locations (Wilson *et al*., 2008). Blue vane traps were used so we could better compare results with the only other systematic bee collection effort in Pacific Northwest bunchgrass prairie, which was performed using only blue vane traps (Kimoto *et al*., 2012). Blue vane traps filled with soapy water (Springstar Inc., Woodinville, WA) (Stephen & Rao, 2007) were hung about one meter off the ground on a bamboo tripod at the randomly determined sampling location. Three colored pan traps (3.25 oz. soufflé cups, Solo model #p325w-0007) filled with soapy water, one each of fluorescent yellow, fluorescent blue, and white, were set three meters apart in a transect leading away from the blue vane trap on a random heading. Pan trap colors were randomized within each transect. Traps were left open for 24 hours. Finally, an aerial net was used to collect bees from flowers within 50 meters of the random point for 5 minutes at the time of trap placement and again at removal for a total of 80 minutes of net collection at each site over the 2 years of sampling.

Sampling was only initiated on mostly sunny days with highs above 16°C, but quickly changing weather during the spring and early summer in this region meant some light rain fell during the 24 hours traps were left open. The average high temperature for sampling days was 22.7°C in 2012 and 27°C in 2013; the average low temperature was 5.4°C in 2012 and 6.2°C in 2013; 1.16 cm of precipitation fell over four

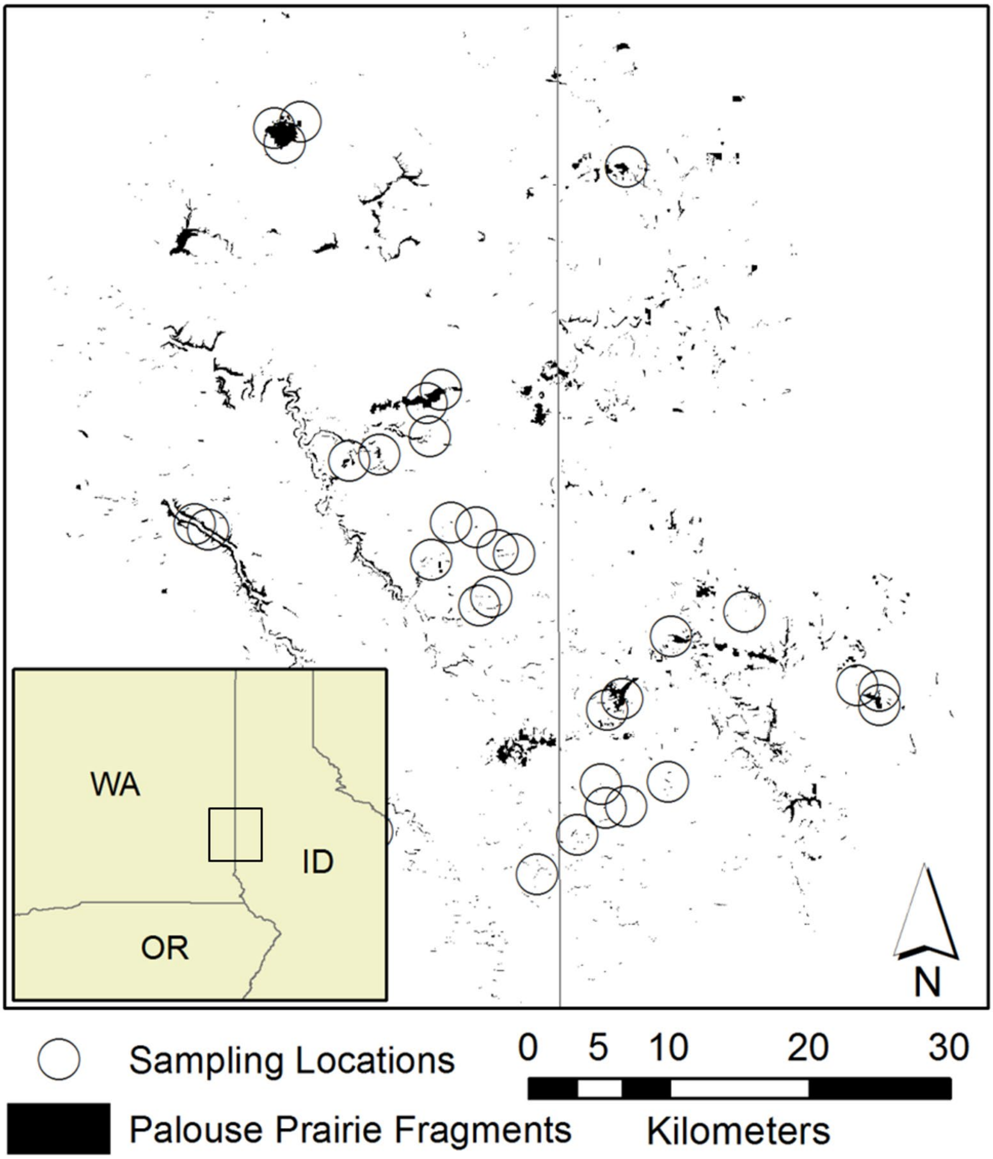


**Figure 1.** Map of sampling locations and Palouse Prairie fragments.

sampling days in 2012 and 0.15 cm fell over two days in 2013; the largest daily rainfall total on a sampling day was 0.71 cm in 2012 and 0.1 cm in 2013.

Netted bees were kept frozen before processing. Bees collected in blue vane traps or pan traps were rinsed in ethanol and then placed in a Whirl-Pak bag (Nasco, Fort Atkinson, WI) and covered with ethanol for temporary storage. Bees stored in ethanol were then washed and dried before further processing (methods adapted from Droege, 2009). All bees were pinned in the first year of collection. In the second year, very common and easily identifiable species including *Agapostemon angelicus* Cockerell, *A. virescens* (Fabricius), *A. femoratus* Crawford, and *Halictus tripartitus* Cockerell were identified without pinning to save time and resources. Additionally, because species-level identification of *Lasioglossum* Curtis belonging to the *Hemihalictus* series (Michener, 2007) was not possible, they were counted then stored without pinning. Individuals in other genera not identified to species were damaged or, rarely, males. Voucher specimens reside in the William F. Barr Insect Museum at the University of Idaho and the U.S. National Pollinating Insects Collection, USDA Bee Biology and Systematics Laboratory, housed on the campus of Utah State University.

To determine historical records of bee occurrence in the Palouse region, data from GBIF were downloaded and used in conjunction with raw data used in a report on the bees of the Upper Columbia River basin (Tepedino & Griswold, 1995), obtained from the authors. Only records falling within the Palouse ecoregion (Omernik, 1987) were used.

The taxonomy of *Bombus* Latreille is relatively stable presently and historically, so good information on bumble bee community composition is readily available where similar information for other genera is not. There are four instances where *Bombus* community data can be compared to the Palouse: 1) A 2003 survey of *Bombus* was performed in the Palouse Prairie, reflecting recent community composition (Hatten *et al*., 2013); and 2) a GBIF-derived dataset with 1675 records of *Bombus* occurrence when limited to pre-2000 records (1805–1999) within the Palouse, reflecting historical community composition [the preponderance of post-1999 records in the GBIF database were from the Hatten *et al*. (2013) study]; 3) a recent survey of native bees on the Zumwalt prairie (Kimoto *et al*., 2012); and 4) *Bombus* community data extracted from a bee study of the nearby Okanogan National Forest (Wilson *et al*., 2010). Bray-Curtis dissimilarity was calculated using the vegan package in R (Oksanen *et al*., 2015; R Core Development Team, 2015), among these four datasets to evaluate: 1) the similarity of the Palouse *Bombus* community through time, and 2) the similarity of the contemporary Palouse *Bombus* community to nearby habitats. All community data were normalized to account for differing sampling regimes.

Incidence-based rarefaction without replacement was performed using EstimateS (Colwell *et al*., 2012) to evaluate the number of non-*Hemihalictus* bee species that remain undetected in the study area. *Hemihalictus* Cockerell were excluded because of the large number of unidentified individuals in this group. Estimated species richness was extrapolated to twice the total number of collected non-*Hemihalictus* individuals.

## RESULTS

Over two years of sampling, 13,293 bees were collected, comprising 174 species and 36 morphospecies in five families and 29 genera (Appendix). Rarefaction analysis indicates the total number of trappable, non-*Hemihalictus* bees was 253 ±22 species (Fig. 2).

The Halictidae were the most abundant family, comprising more than 64% of all collected bees (Appendix), followed by the Apidae (16%) and Megachilidae (11%). The most abundant species also belonged to Halictidae: *H. tripartitus* made up 10.2% of total collected bees, *A. virescens* (6.5%), *A. angelicus* (4.6%), and *L. sisymbrii* (Cockerell) (4.0%). The most abundant genus was the halictid *Lasioglossum*, comprising 37% of all collected bees, with the *Hemihalictus* series making up nearly 75% of collected *Lasioglossum*. *Halictus* Latreille (15%), *Agapostemon* Guérin-Méneville (11%), the megachilid genus *Osmia* Panzer (8%), and the andrenid genus *Andrena* Fabricius (7%) were also abundant (Appendix).

The most speciose families were Megachilidae (64 species, 2 morphospecies) and

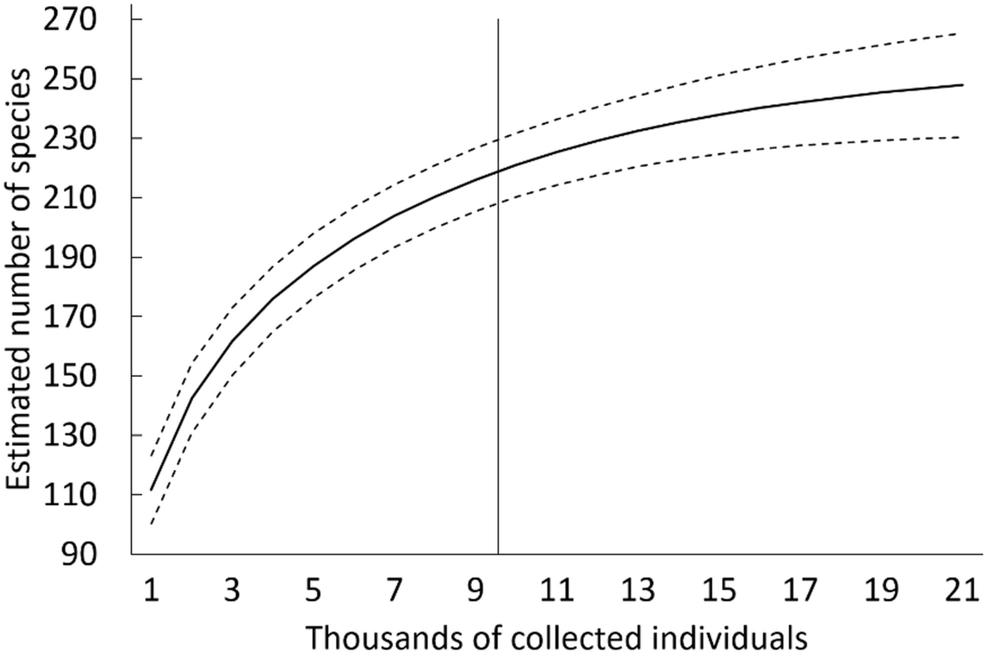


**Figure 2.** Extrapolated rarefaction curve with 95% confidence intervals based on all collected non-*Hemihalictus* bees. Vertical line indicates the actual number of collected non-*Hemihalictus* bees.

Apidae (52 species, 21 morphospecies), followed by Andrenidae (28 species) and Halictidae (23 species, 13 morphospecies) (Appendix). It is important to note that the *Hemihalictus* series, with 28% of collected individuals, were not identified to species. A similar study in a nearby Pacific Northwest bunchgrass system (Kimoto *et al*., 2012), detected as many as 38 morphospecies within the *Hemihalictus* series. If species richness within the *Hemihalictus* series is comparable in the Palouse Prairie, it would nearly make the Halictidae the most speciose family. Colletidae were poorly represented (8 species) and Melittidae were absent. The most speciose genera include *Osmia* (Megachilidae, 33 species), *Andrena* (Andrenidae, 26 species), *Nomada* Scopoli (Apidae, 2 species and 17 morphospecies), *Bombus* (Apidae, 16 species), and *Lasioglossum* (14+ species) (Appendix).

## DISCUSSION

This is the first thorough examination of the wild bee fauna in the Palouse Prairie. We noted several first records and range expansions. These data provide a baseline of presence and abundance of prairie-inhabiting bee species which will be useful in evaluating declines or range contractions of wild bees in the western United States. As Kimoto *et al*. (2012) noted, the Pacific Northwest bunchgrass ecosystem supports a rich community of wild bees. By utilizing a more diverse array of trapping methods and by identifying more individuals to species rather than morphospecies, we were able to more fully characterize the community of bees inhabiting bunchgrass prairie.

Remarkably, bee richness in the Palouse is greater than recorded for most studies in the extensive tallgrass prairie (Table 1). This may be due in part to sampling effort,

**Table 1.** Studies of prairie or grassland inhabiting bees.

| Habitat | Years Collecting | Specimens Collected | Species Detected | Sampling Method | Sampling Period | Citation |
|---|---|---|---|---|---|---|
| Iowa tallgrass prairie | 2 | 3566 | 86 | pan trap | May–August | Davis *et al*., 2008 |
| grasslands near Boulder, CO | 5 | 5207 | 104 | pan trap & net | May–August | Kearns & Oliveras, 2009 |
| Minnesota tallgrass prairie | 3 | 3702 | 127 | net | May–September | Reed, 1995 |
| Illinois tallgrass prairie | 1 | 4622 | 111 | malaise trap, pan trap, & vane trap | June–October | Geroff *et al*., 2014 |
| Iowa tallgrass prairie | 1 | 1149 | 73 | pan trap & net | June–August | Hendrix *et al*., 2010 |
| Iowa tallgrass prairie & ruderal areas | 1 | 582 | 56 | pan traps & nets | June–August | Kwaiser & Hendrix, 2008 |
| Wyoming shortgrass prairie | 2 | — | 200 | net | May–August | Tepedino & Stanton, 1981 |
| Zumwalt bunchgrass prairie | 2 | 9158 | 211 | blue vane trap | June–August | Kimoto *et al*., 2012 |
| Palouse bunchgrass prairie | 2 | 13,241 | 210 | vane trap, pan trap, & net | May–July | this report |

since a larger number of collected individuals will yield more detected species. Additionally, a wider variety of collection methods could have increased the bee fauna sampled, as trap type can affect the taxa detected (Geroff *et al*., 2014). Finally, the Palouse and Zumwalt regions both have a more diverse array of habitats nearby. The Palouse Prairie is surrounded by forest, sagebrush steppe, and arid grasslands. Many detected taxa could be adapted to more mesic or arid environments, only marginally present on the Palouse.

Historic records from GBIF and Tepedino & Griswold (1995) list 273 positively identified species (*i.e.*, not morphospecies or generic-level determinations) of native bees in the Palouse region. Of the 174 positively identified species we collected, 117 species were previously noted as denizens of the Palouse and 57 species were not formerly observed in the region. Species previously unknown to the area are primarily in *Osmia* (12 species), *Andrena* (7 species), *Megachile* Latreille (5 species), and *Eucera* Scopoli (5 species). Discrepancies between the list of species historically present and the list of species observed in our study are stark. We observed less than half of historically present species and nearly a third of the species we identified were not previously observed in the Palouse region. This highlights the difficulty of fully characterizing the composition of bee communities which tend to be dominated by rare species.

Indeed, despite insect collection data stretching back more than a century, eleven

**Table 2.** New state records or range expansions for bee species collected in Palouse Prairie fragments.

| Species | New record | | Previously documented range |
|---|---|---|---|
| | ID | WA | |
| *Andrena fuscicauda* | X | | Within and coastward of Sierra Nevada and Cascade mountains. Rarely found in central OR and NV. |
| *Andrena semipunctata* | X | | Arid southwestern US and within and coastward of Sierra Nevada and Cascade mountains. Rarely found in eastern WA. |
| *Andrena shoshoni* | | X | Very rare. Observed in SD and WY. |
| *Andrena aff. waldmerei* | X | X | Southern CA, more rarely found in northern CA. |
| *Anthophora affabilis* | | X | Arid southwestern US, north to OR and ID. |
| *Melissodes plumosa* | X | | Within and coastward of Sierra Nevada and Cascade mountains. One specimen observed in ND. |
| *Hylaeus granulatus* | X | X | CA to CO, north to OR. |
| *Osmia aglaia* | | X | CA and OR. |
| *Osmia thysanisca* | | X | OR, WY, and CA. |
| *Osmia trifoliama* | X | | Within and coastward of Sierra Nevada and Cascade mountains. |
| *Stelis interrupta* | X | | Southwest US, Cascade mountains in OR. |
| *Megachile snowi* | | | TX to CA. North to southern ID. |
| *Osmia raritatis* | | | CA to CO. North to Cascade mountains and southern ID. |

species were recovered that are new records for Washington, Idaho, or both (Table 2), and range expansions were noted for two species, including *Megachile snowi* Mitchell (Table 2). However, *M. snowi* was recently elevated to the rank of species, being previously regarded as a subspecies of *Megachile mendica* Cresson (Bzdyk, 2012), for which there are records in the Palouse region, so it is not clear if this species has been previously observed in the Palouse region or not.

Since historic data for non-*Bombus* bee species are sparse, it is difficult to determine if once common species have disappeared from the region. However, *Osmia lignaria* Say was consistently found in the Palouse region by various collectors between 1905 and 1991 (GBIF, 2015), and was the most commonly detected species of *Osmia* during this period. While we did not recover this species in 2012 or 2013, *O. lignaria* is active very early in the spring and the preponderance (60%) of records in GBIF were collected in March or April, before sampling commenced in the present study. So, our failure to detect this species may be because we began sampling too late in the year. While we did fail to detect other species previously found on the Palouse, the paucity of historical data makes it impossible to say if this was due to our times of sampling, the rarity of these species, or their actual absence.

Unlike other bee taxa, data on bumble bee species is complete enough to make statements about alterations to the community over time and space. Despite differing trapping methods, Bray-Curtis dissimilarity analysis shows the three *Bombus* datasets from the Palouse Prairie (historic net collections, 2002 and 2003 pitfall traps, contemporary mixed methods) to be more similar to one another than to the Zumwalt Prairie

**Table 3.** Bray-Curtis dissimilarity matrix for *Bombus* community data from the Palouse Prairie (this report), Okanogan National Forest (Wilson *et al*., 2010), the Zumwalt Prairie (Kimoto *et al*., 2012), the Palouse Prairie from 2002 and 2003 (Hatten *et al*., 2013), and Palouse Prairie data collected prior to 2001 (GBIF, 2015).

| | **Current Palouse** | **Okanogan** | **Zumwalt** | **Palouse 2002,2003** |
|---|---|---|---|---|
| **Okanogan** | 72.8 | — | | |
| **Zumwalt** | 63.5 | 43.3 | — | |
| **Palouse 2002,2003** | 55.5 | 87.6 | 78.4 | — |
| **Historic Palouse** | 36.6 | 62.0 | 60.7 | 68.1 |

or the Okanogan National Forest, suggesting the Palouse Prairie has a distinctive *Bombus* community not shared by similar, nearby systems (Table 3). Within the Palouse, a few species of *Bombus* have either declined in abundance or disappeared from the region entirely. *Bombus occidentalis* Greene was once common in the Inland Northwest but is now rare in the region (Stephen, 1957; Rao & Stephen, 2007; Rao *et al*., 2011; Rhoades *et al*., 2016). GBIF data for the Palouse region shows 292 *B. occidentalis* collected between 1888 and 1997, forming about 16% of all pre-2000 *Bombus* occurrences recorded in GBIF for the Palouse region. *Bombus occidentalis* was present in our study, but at lower rates than is evident in the historical data (2.9% of total *Bombus*), mirroring trends found throughout its range (Cameron *et al*., 2011). Additionally, one species of bumble bee listed as vulnerable [*B. morrisoni* Cresson (Hatfield *et al*., 2014)] and one listed as critically endangered [*B. suckleyi* Greene (Hatfield *et al*., 2015)] were not observed in this survey, despite likely past records of occurrence (GBIF, 2015).

The Palouse Prairie is a unique region that has been heavily impacted through fragmentation and habitat loss caused by conversion to agriculture (Donovan *et al*., 2009). This study adds bees to this list of distinctive and diverse Palouse fauna and contributes to our limited but growing knowledge of the bees of the inland Northwest.

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**Appendix.** List of all collected bee species and their abundance in each month in which collection occurred.

| Species | 2012 | | | 2013 | | | Total |
|---|---|---|---|---|---|---|---|
| | May | June | July | May | June | July | |
| **ANDRENIDAE** | 322 | 233 | 48 | 193 | 204 | 26 | 1026 |
| *Andrena angustitarsata* Viereck | 13 | 2 | | 18 | 20 | | 53 |
| *Andrena astragali* Viereck & Cockerell | 2 | | | | | | 2 |
| *Andrena candida* Smith | 4 | 1 | | | | | 5 |
| *Andrena chlorogaster* Viereck | | | | 3 | | | 3 |
| *Andrena cressonii infasciata* Lanham | 6 | 8 | 2 | 4 | 3 | | 23 |
| *Andrena fuscicauda* Viereck[1] | 2 | | | 3 | | | 5 |
| *Andrena hemileuca* Viereck | 12 | | | 3 | | | 15 |
| *Andrena hippotes* Robertson | 4 | | | | | | 4 |
| *Andrena melanochroa* Cockerell | 10 | 20 | 1 | 2 | 15 | 1 | 49 |
| *Andrena merriami* Cockerell | 2 | | | 4 | 3 | | 9 |
| *Andrena microchlora* Cockerell | 39 | 13 | | 16 | 5 | | 73 |
| *Andrena nigrihirta* (Ashmead) | | | | 8 | 25 | | 33 |
| *Andrena nigrocaerulea* Cockerell | 112 | 62 | 3 | 72 | 45 | | 294 |
| *Andrena nivalis* Smith | 13 | 6 | | 12 | 13 | | 44 |
| *Andrena pallidifovea* Viereck | 3 | 22 | 2 | | 18 | | 45 |
| *Andrena piperi* Viereck | | | | 1 | 1 | | 2 |
| *Andrena prunorum* Cockerell | 11 | 42 | 11 | 26 | 18 | 15 | 123 |
| *Andrena semipunctata* Cockerell[1] | | 3 | 1 | | 3 | | 7 |
| *Andrena shoshoni* Ribble[2] | | | | 3 | | | 3 |
| *Andrena sola* Viereck | 6 | 2 | 1 | 2 | 7 | | 18 |
| *Andrena* spp. | 13 | | | | | | 13 |
| *Andrena subtilis* Smith | 3 | 8 | 2 | 2 | 2 | | 17 |
| *Andrena thaspii* Graenicher | | 1 | 1 | 2 | 3 | 2 | 9 |
| *Andrena topazana* Cockerell | | 2 | 2 | | | | 4 |
| *Andrena trevoris* Cockerell | | | 3 | | | 5 | 8 |
| *Andrena vierecki* Cockerell | 1 | 1 | 1 | | | 1 | 4 |
| *Andrena aff. waldmerei* LaBerge & Bouseman[1,2] | 1 | 1 | | 2 | | | 4 |
| *Panurginus atriceps* (Cresson) | 61 | 37 | 16 | 10 | 23 | 2 | 149 |
| *Panurginus* spp. | 4 | 1 | | | | | 5 |
| *Perdita* sp. | | 1 | | | | | 1 |
| *Perdita wyomingensis* Cockerell | | | 2 | | | | 2 |
| **APIDAE** | 450 | 366 | 195 | 305 | 378 | 606 | 2281 |
| *Anthophora affabilis* Cresson[2] | | | | | 1 | | 1 |
| *Anthophora bomboides* Kirby | 1 | | 5 | | 5 | 1 | 12 |
| *Anthophora edwardsii* Cresson | 1 | | | 1 | | | 2 |

**Appendix.** Continued.

| Species | 2012 | | | 2013 | | | Total |
|---|---|---|---|---|---|---|---|
| | May | June | July | May | June | July | |
| *Anthophora occidentalis* Cresson | | | | | | 1 | 1 |
| *Anthophora pacifica* Cresson | | | | 8 | | | 8 |
| *Anthophora porterae* Cockerell | | | | 1 | | | 1 |
| *Anthophora terminalis* Cresson | | | | | 2 | 1 | 3 |
| *Anthophora urbana* Cresson | | | 1 | | 2 | 17 | 20 |
| *Anthophora ursina* Cresson | 2 | 1 | 1 | 3 | 4 | | 11 |
| *Apis mellifera* Linnaeus | 21 | 36 | 23 | 3 | 13 | 9 | 105 |
| *Bombus appositus* Cresson | 13 | 4 | 3 | 4 | 13 | 12 | 49 |
| *Bombus bifarius* Cresson | 69 | 18 | 4 | 2 | 1 | 1 | 95 |
| *Bombus californicus* Smith | 1 | 2 | 2 | 2 | 3 | 2 | 12 |
| *Bombus centralis* Cresson | 25 | 4 | 4 | 17 | 7 | 9 | 66 |
| *Bombus fernaldae* (Franklin) | | | | 1 | | | 1 |
| *Bombus fervidus* (Fabricius) | 27 | 9 | 5 | 48 | 17 | 16 | 122 |
| *Bombus flavifrons* Cresson | 2 | | | | | 2 | 4 |
| *Bombus griseocollis* (DeGeer) | | 1 | | | | 7 | 8 |
| *Bombus huntii* Greene | 7 | 2 | | 3 | 1 | 1 | 14 |
| *Bombus insularis* (Smith) | 12 | 5 | 1 | 1 | | | 19 |
| *Bombus melanopygus* Nylander | 1 | | | | | | 1 |
| *Bombus mixtus* Cresson | 12 | | 3 | 1 | | 2 | 18 |
| *Bombus nevadensis* Cresson | 71 | 6 | 8 | 28 | 22 | 25 | 160 |
| *Bombus occidentalis* Greene | 9 | | 1 | 1 | 1 | | 12 |
| *Bombus rufocinctus* Cresson | 41 | 37 | 26 | 18 | 27 | 21 | 170 |
| *Bombus* sp. | | | | | | 1 | 1 |
| *Bombus vagans* Smith | 1 | 1 | 1 | | | | 3 |
| *Ceratina acantha* Provancher | 18 | 45 | 20 | 30 | 22 | 17 | 152 |
| *Ceratina nanula* Cockerell | 71 | 118 | 14 | 78 | 62 | 92 | 435 |
| *Ceratina pacifica* H.S. Smith | 3 | 4 | 34 | 8 | 18 | 82 | 149 |
| *Ceratina* spp. | 5 | | | | | 2 | 7 |
| *Diadasia enavata* (Cressson) | | | | | | 7 | 7 |
| *Diadasia nigrifrons* (Cressson) | | 1 | 2 | | | | 3 |
| *Epeolus minimus* (Robertson) | | | 1 | | | | 1 |
| *Epeolus* sp. | | | | | | 1 | 1 |
| *Eucera actuosa* (Cresson) | 2 | 3 | | | 7 | | 12 |
| *Eucera delphinii* (Timberlake) | 1 | | | 4 | | | 5 |
| *Eucera edwardsii* (Cresson) | | 9 | 4 | 4 | 21 | | 38 |
| *Eucera frater* (Cresson) | 6 | 23 | 16 | 13 | 103 | 50 | 211 |
| *Eucera hurdi* (Timberlake) | 4 | 1 | | 1 | 2 | | 8 |

**Appendix.** Continued.

| Species | 2012 | | | 2013 | | | Total |
|---|---|---|---|---|---|---|---|
| | May | June | July | May | June | July | |
| *Eucera* spp. | | | | | | 3 | 3 |
| *Habropoda cineraria* (Smith) | 1 | | | | | | 1 |
| *Melecta pacifica* Cresson | 2 | 1 | | 1 | 1 | | 5 |
| *Melissodes aff. plumosa* LaBerge | | | | | | 4 | 4 |
| *Melissodes agilis* Cresson | | | 1 | | | | 1 |
| *Melissodes communis* Cresson | | | 1 | | 1 | 29 | 31 |
| *Melissodes lupina* Cresson | | | | | 1 | 90 | 91 |
| *Melissodes menuachus* Cresson | | | 1 | | | | 1 |
| *Melissodes metenua* Cockerell | | | | | | 20 | 20 |
| *Melissodes microsticta* Cockerell | | | 3 | | 5 | 20 | 28 |
| *Melissodes pallidisignata* Cockerell | | | | | | 1 | 1 |
| *Melissodes plumosa* LaBerge[1] | | | | | | 20 | 20 |
| *Melissodes rivalis* Cresson | | | 2 | | 1 | 12 | 15 |
| *Melissodes* spp. | | | | | | 13 | 13 |
| *Melissodes* sp. 1 | | | | | | 3 | 3 |
| *Melissodes* sp. 2 | | | | | | 1 | 1 |
| *Melissodes* sp. 3 | | | | | | 1 | 1 |
| *Melissodes* sp. 4 | | | | | | 1 | 1 |
| *Melissodes verbesinarum* Cockerell | | | 2 | | | 6 | 8 |
| *Nomada edwardsii* Cresson | 1 | 1 | | | | | 2 |
| *Nomada hemphilli* Cockerell | | | | 2 | | | 2 |
| *Nomada* spp. | 5 | 7 | | 7 | 2 | 1 | 22 |
| *Nomada* sp. 1 | 1 | 1 | | 3 | | | 5 |
| *Nomada* sp. 2 | 1 | 3 | | 4 | 3 | | 11 |
| *Nomada* sp. 3 | 1 | 1 | | | | | 2 |
| *Nomada* sp. 4 | 1 | | | 3 | | | 4 |
| *Nomada* sp. 5 | | 5 | | | | | 5 |
| *Nomada* sp. 6 | | | | | 2 | | 2 |
| *Nomada* sp. 7 | 3 | | | | | | 3 |
| *Nomada* sp. 8 | | | | | 1 | | 1 |
| *Nomada* sp. 9 | | | | | 1 | | 1 |
| *Nomada* sp. 10 | | | | 1 | | | 1 |
| *Nomada* sp. 11 | 2 | | | | 1 | | 3 |
| *Nomada* sp. 12 | 5 | 3 | | 2 | 3 | | 13 |
| *Nomada* sp. 13 | | | | | 1 | | 1 |
| *Nomada* sp. 14 | 1 | | | | | | 1 |
| *Nomada* sp. 15 | | 1 | | | | | 1 |

**Appendix.** Continued.

| **Species** | **2012** | | | **2013** | | | **Total** |
|---|---|---|---|---|---|---|---|
| | **May** | **June** | **July** | **May** | **June** | **July** | |
| *Nomada* sp. 16 | | | | 1 | 1 | | 2 |
| *Nomada* sp. 17 | | | | 1 | | | 1 |
| *Triepeolus heterurus* (Cockerell & Sandhouse) | | | | | | 2 | 2 |
| **Colletidae** | 0 | 13 | 6 | 1 | 16 | 3 | 36 |
| *Colletes fulgidus* Swenk | | 1 | | | 2 | | |
| *Hylaeus affinis* (Smith) | | 2 | 1 | | 1 | 1 | 5 |
| *Hylaeus conspicuus* (Metz) | | | | | 1 | | 1 |
| *Hylaeus granulatus* (Metz)[1,2] | | 10 | 2 | 1 | 8 | 1 | 22 |
| *Hylaeus modestus* Say | | | | | 1 | 1 | 2 |
| *Hylaeus* spp. | | | 2 | | 1 | | 3 |
| *Hylaeus verticalis* (Cresson) | | | 1 | | | | 1 |
| *Hylaeus wootoni* (Cockerell) | | | | | 2 | | 2 |
| **Halictidae** | 1635 | 1721 | 1030 | 1365 | 1722 | 975 | 8448 |
| *Agapostemon angelicus* Cockerell | 50 | 145 | 88 | 24 | 192 | 98 | 597 |
| *Agapostemon coloradinus* (Vachal) | 3 | | | | 1 | 3 | 7 |
| *Agapostemon femoratus* Crawford | | | | 7 | 11 | 4 | 22 |
| *Agapostemon virescens* (Fabricius) | 35 | 136 | 219 | 25 | 219 | 225 | 859 |
| *Halictus confusus* Smith | 4 | 16 | | | | | 20 |
| *Halictus farinosus* Smith | 11 | 9 | 11 | 19 | 17 | 3 | 70 |
| *Halictus ligatus* Smith | 46 | 21 | 6 | 13 | 29 | 10 | 125 |
| *Halictus rubicundus* (Christ) | 45 | 51 | 22 | 170 | 78 | 7 | 373 |
| *Halictus* spp. | 12 | 1 | | 11 | 1 | | 25 |
| *Halictus tripartitus* Cockerell | 259 | 213 | 113 | 324 | 276 | 172 | 1357 |
| *Lasioglossum anhypops* McGinley | 1 | 2 | | | | | 3 |
| *Lasioglossum athabascense* (Sandhouse) | 4 | | 2 | | 1 | 1 | 8 |
| *Lasioglossum colatum* (Vachal) | 3 | 16 | 14 | 5 | 14 | 1 | 53 |
| *Lasioglossum Hemihalictus* series | 815 | 661 | 365 | 694 | 652 | 328 | 3515 |
| *Lasioglossum egregium* (Vachal) | 16 | 90 | 45 | 3 | 51 | 41 | 246 |
| *Lasioglossum mellipes* (Crawford) | | | | 2 | 7 | | 9 |
| *Lasioglossum olympiae* (Cockerell) | 16 | 29 | 4 | 2 | 5 | | 56 |
| *Lasioglossum ovaliceps* (Cockerell) | | 1 | | | 1 | | 2 |
| *Lasioglossum pacificum* (Cockerell) | | 4 | 7 | 8 | 6 | 5 | 30 |
| *Lasioglossum paraforbesii* McGinley | | | | | | 2 | 2 |
| *Lasioglossum sisymbrii* (Cockerell) | 64 | 238 | 81 | 27 | 91 | 24 | 525 |
| *Lasioglossum* spp. | 172 | 4 | 1 | | | | 177 |
| *Lasioglossum titusi* (Crawford) | 50 | 54 | 27 | 13 | 18 | 40 | 202 |

**Appendix.** Continued.

| Species | 2012 | | | 2013 | | | Total |
|---|---|---|---|---|---|---|---|
| | May | June | July | May | June | July | |
| *Lasioglossum trizonatum* (Cresson) | 3 | 3 | 1 | 4 | 30 | 2 | 43 |
| *Lasioglossum zonulum* (Smith) | | 5 | 12 | 8 | 4 | | 29 |
| *Sphecodes* spp. | | | 1 | | | 7 | 8 |
| *Sphecodes* sp. 1 | 2 | 1 | | | 1 | | 4 |
| *Sphecodes* sp. 2 | 3 | 1 | 1 | 2 | | | 7 |
| *Sphecodes* sp. 3 | 2 | 1 | | | | | 3 |
| *Sphecodes* sp. 4 | | 1 | 1 | | 1 | | 3 |
| *Sphecodes* sp. 5 | | 1 | 1 | | | | 2 |
| *Sphecodes* sp. 6 | | | | | | 1 | 1 |
| *Sphecodes* sp. 7 | | | | | 1 | | 1 |
| *Sphecodes* sp. 8 | | | 2 | | | | 2 |
| *Sphecodes* sp. 9 | | 1 | | | | | 1 |
| *Sphecodes* sp. 10 | 1 | 4 | 1 | 1 | 6 | | 13 |
| *Sphecodes* sp. 11 | 8 | 11 | 5 | 3 | 8 | 1 | 36 |
| *Sphecodes* sp. 12 | | | | | 1 | | 1 |
| *Sphecodes* sp. 13 | | 1 | | | | | 1 |
| **Megachilidae** | 215 | 385 | 198 | 180 | 287 | 234 | 1510 |
| *Anthidium manicatum* (Linnaeus)[3] | | | | | | 1 | 1 |
| *Anthidium utahense* Swenk | | | 1 | | 1 | 1 | 3 |
| *Atoposmia copelandica* (Cockerell) | | | | | 1 | | 1 |
| *Dianthidium curvatum* (Smith) | | | | | | 3 | 3 |
| *Dianthidium subparvum* Swenk | | | 2 | | 2 | 4 | 8 |
| *Heriades carinatus* Cresson | | | 1 | | | 5 | 6 |
| *Hoplitis albifrons argentifrons* (Cresson) | | 3 | 3 | | 1 | 4 | 11 |
| *Hoplitis fulgida* (Cresson) | | 8 | 4 | 3 | 13 | | 28 |
| *Hoplitis grinnelli* (Cockerell) | 1 | 6 | 2 | | 3 | 1 | 13 |
| *Hoplitis hypocrita* (Cockerell) | 3 | 3 | 1 | 7 | 6 | | 20 |
| *Hoplitis producta* (Cresson) | 1 | 29 | 37 | 5 | 26 | 15 | 113 |
| *Hoplitis sambuci* Titus | | | 1 | | 1 | 4 | 6 |
| *Megachile apicalis* Spinola[3] | | | | | | 2 | 2 |
| *Megachile brevis* Say | | | | 1 | 2 | 4 | 7 |
| *Megachile gemula* Cresson | | 1 | | | | | 1 |
| *Megachile gentilis* Cresson | | | | | 2 | 6 | 8 |
| *Megachile lippiae* Cockerell | | | | | | 1 | 1 |
| *Megachile* sp. | | | | | | 1 | 1 |
| *Megachile melanophaea* Smith | | | | | | 2 | 2 |
| *Megachile mellitarsis* Cresson | 1 | | | | | | 1 |

**Appendix.** Continued.

| Species | 2012 | | | 2013 | | | Total |
|---|---|---|---|---|---|---|---|
| | May | June | July | May | June | July | |
| *Megachile montivaga* Cresson | | 12 | 12 | | 9 | 24 | 57 |
| *Megachile parallela* Smith | | | | | | 2 | 2 |
| *Megachile perihirta* Cockerell | | 3 | 9 | | 13 | 65 | 90 |
| *Megachile relativa* Cresson | | | | | | 1 | 1 |
| *Megachile rotundata* (Fabricius)[3] | | | | | | 4 | 4 |
| *Megachile snowi* Mitchell | | | | | | 1 | 1 |
| *Osmia* spp. | 22 | | 1 | | | | 34 |
| *Osmia aglaia* Sandhouse[2] | 1 | | | | | | 1 |
| *Osmia albolateralis* Cockerell | 3 | 2 | 2 | 5 | 26 | 15 | 53 |
| *Osmia atrocyanea* Cockerell | 20 | 19 | 3 | 15 | 22 | 4 | 83 |
| *Osmia bakeri* Sandhouse | 1 | | | 1 | | | 2 |
| *Osmia brevis* Cresson | 2 | 10 | | | | | 12 |
| *Osmia bruneri* Cockerell | 8 | 5 | | | 7 | 2 | 22 |
| *Osmia caerulescens* (Linnaeus)[3] | | 8 | 12 | | 8 | 1 | 29 |
| *Osmia californica* Cresson | 3 | | 1 | 1 | 1 | | 6 |
| *Osmia calla* Cockerell | | | 4 | 1 | 5 | 4 | 14 |
| *Osmia cobaltina* Cresson | 1 | 1 | | | | | 2 |
| *Osmia coloradensis* Cresson | 3 | 3 | | 8 | | 1 | 15 |
| *Osmia densa* Cresson | 6 | 5 | | 25 | 9 | 1 | 46 |
| *Osmia dolerosa* Sandhouse | | | | | 2 | | 2 |
| *Osmia giliarum* Cockerell | 6 | 10 | 2 | 1 | | 1 | 20 |
| *Osmia grindeliae* Cockerell | | | | | 1 | | 1 |
| *Osmia integra* Cresson | | | | | 1 | | 1 |
| *Osmia iridis* Cockerell & Titus | 1 | 3 | | 5 | | | 9 |
| *Osmia kincaidii* Cockerell | 10 | 16 | 5 | 7 | 7 | 3 | 48 |
| *Osmia marginipennis* Cresson | | | 1 | | | | 1 |
| *Osmia nemoris* Sandhouse | | | 1 | 4 | 2 | | 7 |
| *Osmia nigrifrons* Cresson | | 1 | | 1 | | | 2 |
| *Osmia paradisica* Sandhouse | | | 1 | | 2 | 3 | 6 |
| *Osmia proxima* Cresson | 4 | 11 | 7 | 3 | 3 | | 28 |
| *Osmia pusilla* Cresson | 30 | 44 | 13 | 2 | 10 | 14 | 113 |
| *Osmia raritatis* Michener | 1 | | | 1 | 1 | | 3 |
| *Osmia simillima* Smith | 5 | 6 | 1 | 1 | 2 | 2 | 17 |
| *Osmia texana* Cresson | | | | | 1 | | 1 |
| *Osmia thysanisca* Michener[2] | 1 | | | | | | 1 |
| *Osmia trevoris* Cockerell | 73 | 167 | 62 | 77 | 81 | 29 | 489 |
| *Osmia trifoliama* Sandhouse[1] | | 4 | | 4 | 3 | 1 | 12 |

**Appendix.** Completed.

| Species | 2012 | | | 2013 | | | Total |
|---|---|---|---|---|---|---|---|
| | May | June | July | May | June | July | |
| *Osmia tristella* Cockerell | | | 2 | | 2 | | 4 |
| *Osmia unca* Michener | 2 | | | | | | 2 |
| *Osmia vandykei* Sandhouse | 1 | | | 2 | | | 3 |
| *Stelis holocyanea* (Cockerell) | | 1 | | | 5 | | 6 |
| *Stelis interrupta* Cresson[1] | | | 3 | | | | 3 |
| *Stelis montana* Cresson | 5 | 3 | 1 | | | | 9 |
| *Stelis monticola* Cresson | | | 1 | | 1 | 1 | 3 |
| *Stelis* sp. | | | | | 1 | | 1 |
| *Stelis* sp. 1 | | 1 | 1 | | | | 2 |
| *Stelis* sp. 2 | | | | | 1 | 1 | 2 |
| *Stelis* sp. 3 | | | 1 | | 1 | | 2 |
| *Stelis subemarginata* Cresson | | | | | 2 | | 2 |

[1] New state record for Idaho.
[2] New state record for Washington.
[3] Exotic.

Journal of Melittology

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The *Journal of Melittology* is an international, open access journal that seeks to rapidly disseminate the results of research conducted on bees (Apoidea: Anthophila) in their broadest sense. Our mission is to promote the understanding and conservation of wild and managed bees and to facilitate communication and collaboration among researchers and the public worldwide. The *Journal* covers all aspects of bee research including but not limited to: anatomy, behavioral ecology, biodiversity, biogeography, chemical ecology, comparative morphology, conservation, cultural aspects, cytogenetics, ecology, ethnobiology, history, identification (keys), invasion ecology, management, melittopalynology, molecular ecology, neurobiology, occurrence data, paleontology, parasitism, phenology, phylogeny, physiology, pollination biology, sociobiology, systematics, and taxonomy.

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