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Bee community and trophic resources in Joinville, Santa Catarina

Comunidade de abelhas e recursos tróficos em Joinville, Santa Catarina

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ABSTRACT
Aiming to verify the relationships between native bees and floral resources in an urban area, their interactions were observed in Joinville, state of Santa Catarina, southern Brazil. Observations were established, lasting 8 hours daily, during different periods from 2009 to 2015. Bees and plants, after preparation, were identified and registered in a database. We sampled 3,073 bees, all of which 1042 were wild native species. The collected bees are included in 34 species and 44 morphospecies (Halictinae-35, Megachilinae-17, Apinae non corbiculate-15, Apinae corbiculate- 10, Andreninae-1). With the exception of *Apis mellifera*, the most abundant bee *taxa* sampled were *Trigona spinipes* (330 individuals), *Xylocopa brasilianorum* (92) and *Pseudaugochlora graminea* (92). Euglossini females and species poorly sampled in inventories such as *Leiopodus lacertinus, Thygater (Thygater) armandoi, Anthodioctes megachiloides* and *Coelioxys aculeaticeps* were captured. The bees were sampled over 83 botanical species of 38 families. The most visited botanical families were Lamiaceae and Asteraceae. The richness of the studied area is lower than those of other nearby compared places, indicating probably a decrease of the apifauna. The found diversity previews the place as a possible refuge.
Keywords: apifauna; urban bees; urban fauna.

RESUMO
Visando verificar as relações entre abelhas nativas e recursos florestais em área urbana, suas interações foram averiguadas em Joinville, estado de Santa Catarina, sul do Brasil. Realizaram-se observações com duração de 8 horas diárias, em diferentes períodos de 2009 a 2015. As abelhas e plantas, após a preparação, foram identificadas e registradas em banco de dados. Amostraram-se 3.073 abelhas, das quais 1.042 são espécies nativas silvestres. As abelhas coletadas estão incluídas em 34 espécies e 44 morfoespécies (Halictinae – 35, Megachilinae – 17, Apinae não corbiculados – 15, Apinae corbiculados – 10, Andreninae – 1). Com exceção de *Apis mellifera*, os táxons de abelhas mais abundantes foram *Trigona spinipes* (330 indivíduos), *Xylocopa brasilianorum* (92) e *Pseudaugochlora graminea* (92). Fêmeas de Euglossini e espécies pouco amostradas em inventários, tais como *Leiopodus lacertinus*, *Thygater (Thygater) armandoi*, *Anthodioctes megachiloides* e *Coelioxys aculeaticeps*, foram coletadas. As abelhas foram amostradas sobre 83 espécies botânicas de 38 famílias. As famílias botânicas mais visitadas foram Lamiaceae e Asteraceae. A riqueza da área estudada é menor do que a de outros locais próximos, indicando provavelmente uma diminuição da apifauna. A diversidade encontrada antecipa o local como um possível refúgio.
Palavras-chave: apifauna; abelhas urbanas; fauna urbana.

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INTRODUCTION

Cities, in terms of the their natural areas that may offer spaces as parks and various green areas, may be considered as islands and refuges in the surrounding agricultural and industrial areas, despite human intervention. This can be attributed, beside other factors, to the absence of pesticide application in the cities and higher temperatures than those that prevail in countryside environments (FORTEL *et al.*, 2014). Questions arose as to whether species have migrated to cities or have adapted to the change of environmental matrix of an area they have already occupied. Some studies showed that populations of non-domesticated species progressively occupy urban areas, turning them into havens for wildlife, an effect due to the fact that natural areas are shrinking worldwide in view of human intervention in the environment and animal species migrate to urban areas, in a way to survive (KNOLL *et al.*, 1994).

Although urbanization has a negative effect on insect fauna, wild bees are found in urban environments (EREMEEVA & SUSHCHEV, 2005). This is because urban areas offer numerous possibilities of nesting cavities and the presence of florid, often conspicuous and concentrated plants (FRANKIE & EHLER, 1978). Unincorporated areas of cities include gardens, orchards, squares, parks, sports fields, clubs, vacant areas etc. where there is blooming of ruderal and ornamental plants, fruit trees, vegetables, weeds and others species, with a variety of sizes and habits (GRISSELL, 2001). Despite the negative effect of urban areas for many species of fauna, it is possible to find in this type of environment the rearing of stingless bees (Meliponini) or the intentional provision of cavities for the nesting of solitary bees, besides those already occurring naturally.

The richness of the bee species in cities has been the subject of studies in several parts of the world (MATTESON *et al*., 2008). In Brazil, some studies on urban apifauna were carried out (LAROCA *et al.*, 1982; TAURA, 1990; TAURA & LAROCA, 1991; AGOSTINI & SAZIMA, 2003). In Santa Catarina state, no studies have been carried out related to this theme. In view of the advances in anthropization, a survey of the apifauna and its floral resources was done in the city of Joinville, SC, Brazil, to verify the bees' richness in an urban area.

MATERIAL AND METHODS

STUDY AREA

The work was carried out on the campus of the UNIVILLE-University of the Region of Joinville (figure 1), located in the city of Joinville (26° 18' 16" S 48° 50" 44" W), which has an average elevation of 20 m, flat relief, original vegetation cover of lowland rain forest (named *mata atlantica*), Koeppen Cfa subtropical climate (humid mesothermal, with hot summer), annual average temperature 20ºC, mean annual precipitation between 1,700 to 1,900 mm and relative humidity of 84 to 86% (EPAGRI, 2003).

The Univille campus has been installed in the same place since 1975. The area where it is settled presently was originally *mata atlantica*. The total area of the Univille campus is 163.802.30 m^2, of which 110.717, 96 m^2 consists of unoccupied areas, which mainly include landscaped parts and extensions with native vegetation cover in different stages of regeneration.

SAMPLING

The bees were searched on flowering plants, during sampling periods of eight hours on sunny days, during the periods: Mar. 2009 to Mar. 2010; Feb. 2011 to Jan. 2012 and Jul.2015 to Sep.2015.

The total time of sampling was 432 hours. The transects included gardens, medicinal gardens and edges of forest fragments.

The bees were captured with entomological nets (SAKAGAMI *et al*., 1967 adapted), preserved in plastic pots, registered, and prepared for identification (MICHENER *et al*., 1994). Specimens of *Apis mellifera* Linnaeus 1758 were not collected but recorded by quantitative estimate. The no sampling of this species implies in possible recounting of the same individuals. Bees were prepared and identified with taxonomic keys (SILVEIRA *et al.,* 2002 and others) and comparison with the reference collection of bees (CRABEU) of Univille Bees Laboratory (LABEL) as well by experts' consultation. The classification followed Melo & Gonçalves (2005).

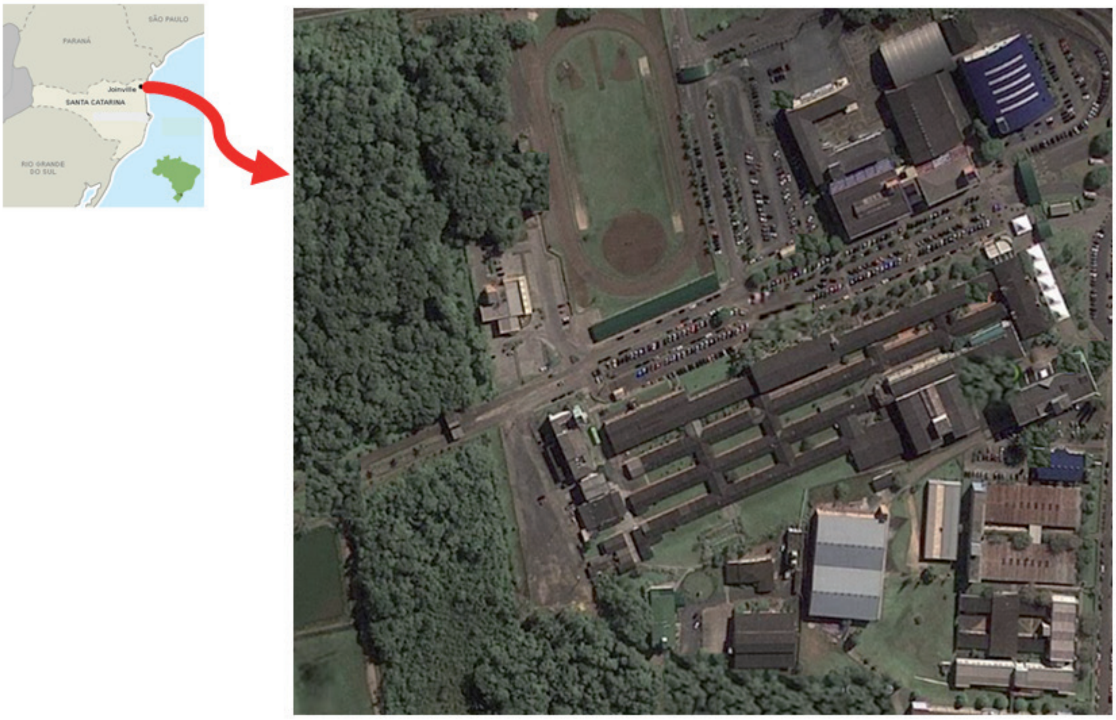

Figure 1 – Representation and photograph of the *campus* of Univille in Joinville, SC, Brazil.

The plants on which the bees were sampled were annotated, photographed, collected and prepared for identification. Plant vouchers were arranged as herbarium specimens and identified by experts (Herbarium of the Municipal Botanical Museum of Curitiba) or by comparison with material from the Herbarium Joinvillea of UNIVILLE. The classification of plants followed APG III and Flora (2017). All materials are kept in LABEL.

Data was analyzed qualitatively and quantitatively. Ecological indices were computed for bees: diversity of Shannon-Wiener (KREBS, 1989), dominance (SIMPSON, 1949), evenness (PIELOU, 1977) and richness estimators jackknife 1 and jackknife 2 (PALMER, 1991). In order to make comparisons of data from this study with other surveys performed in nearby environments, Sørensen Similarity Quotient (QS or SI) was calculated (SOUTHWOOD, 1971). These calculations were done with Windows Excel 2010.

RESULTS

BEES

A total of 3,073 individuals were sampled, of which 2,031 were *Apis mellifera*. A total of 34 species of bees and 44 morphospecies (table 1) were recognized from four subfamilies. Specimens of Colletinae were not found. The decreasing sequence of species richness by subfamily is: Halictinae (35)> Megachilinae (17)> Apinae non-corbiculate (15)> Apinae corbiculate (10)> Andreninae (1). The decreasing sequence of number of individuals (except *A. mellifera*) by subfamily are: Apinae corbiculate (453)> Halictinae (320)> Apinae non-corbiculate (203)> Megachilinae (65)> Andreninae (1).

In terms of the major *taxa* in the subfamilies, the species more predominant were *A. mellifera* and *Trigona spinipes* (Fabricius, 1793) (Apinae corbiculate), *Augochlora* spp. and *Augochloropsis* spp. (Halictinae), *Exomalopsis auropilosa* Spinola, 1853 (Apinae non corbiculate), *Xylocopa brasilianorum* (Linnaeus, 1767) (Xylocopini) and *Megachile neoxanthoptera* Cockerell, 1933 (Megachilinae).

Centridini was represented by genera *Centris* and *Epicharis*, the first being represented by only one individual of the species *Centris tarsata* Smith, 1874, collected on the flower of *Stachytarpheta jamaicensis* (L.) Vahl whereas *Epicharis affinis* Smith, 1874 foraged flowers of *Passiflora alata* Curtis, *Passiflora edulis* Sims, *Petiveria alliacea* Linnaeus and *Costus spiralis* (Jacq.) Roscoe.

Females of three species of Euglossini were collected while foraging flowers of three botanical species: *Euglossa annectans* Dressler 1982 visited *Hemerocallis flava* (L.) L. for the collection of nectar while *Euglossa anodorhynchi* Nemesio 2006 and *Eulaema nigrita* Lepeletier 1841, foraged, respectively, flowers of *Dichorisandra thyrsiflora* JC Mikan and *Bixa orellana* L. for the collection of pollen. These two plants are in the campus medical garden. The sampling of females is noticeable due to the fact that, for this group, collection is mainly done with aromatic compounds which attract only males as females are rarely seen.

Table 1 – List of native bee species sampled at the *campus* of Univille, during the period of 2009 to 2015. Legend: c = corbiculate; n c = non corbiculate; N = number of sampled individuals.

	Family	Species	N
1	Andreninae	*Anthrenoides meridionalis* (Schrottky, 1906)	1
2	Apinae c	*Bombus (Fervidobombus) brasiliensis* Lepeletier, 1836	1
3		*Bombus (Fervidobombus) morio* (Swederus, 1787)	33
4		*Euglossa (Euglossa) anodorhynchi* Nemésio, 2006	14
5		*Euglossa* (*Glossura*) *annectans* Dressler, 1982	1
6		*Eulaema* (*Apeulaema*) *nigrita* Lepeletier, 1841	1
7		*Partamona helleri* (Friese, 1900)	1
8		*Plebeia emerina* (Friese, 1900)	8
9		*Tetragonisca angustula* (Latreille, 1811)	13
10		*Trigona braueri* Friese, 1900	51
11		*Trigona spinipes* (Fabricius, 1793)	330
12	Apinae n c	*Centris* (*Hemisiella*) *tarsata* Smith, 1874	1
13		*Epicharis* (*Hoplepicharis*) *affinis* Smith, 1874	11
14		*Thygater* (*Thygater*) *analis* (Lepeletier, 1841)	9
15		*Thygater* (*Thygater*) *armandoi* Urban, 1999	3
16		*Exomalopsis* (*E.*) *auropilosa* Spinola, 1853	44
17		*Exomalopsis* (*Phanomalopsis*) *aureosericea* Friese, 1899	3
18		*Leiopodus lacertinus* Smith, 1854	1
19		*Lophopedia nigrispinis* (Vachal, 1909)	2
20		*Ceratina* (*Crewella*) sp. 1	3
21		*Ceratina* (*Crewella*) sp. 8	6
22		*Ceratina* (*Crewella*) sp. 9	1
23		*Ceratina* (*Crewella*) sp. 10	3
24		*Ceratina* (*Crewella*) sp. 16	3
25		*Xylocopa (Neoxylocopa) brasilianorum* (Linnaeus, 1767)	92
26		*Xylocopa (Neox.) frontalis* (Olivier, 1789)	21

27	Halictinae	*Augochlora* (*A.*) sp. 1	3
28		*Augochlora* (*A.*) sp. 2	1
29		*Augochlora* (*A.*) sp. 3	1
30		*Augochlora* (*A.*) sp. 4	17
31		*Augochlora* (*A.*) sp. 6	2
32		*Augochlora* (*A.*) sp. 7	2
33		*Augochlora* (*A.*) sp. 11	1
34		*Augochlora* (*Oxystoglossella.*) sp. 1	5
35		*Augochlora* (*O.*) sp. 2	15
36		*Augochlora* (*O.*) sp. 4	4
37		*Augochlora* (*O.*) sp. 6	1
38		*Augochlora* (*O.*) sp. 9	2
39		*Augochlora* (*O.*) sp. 10	3
40		*Augochlora* (*O.*) aff. sp. 10	4
41		*Augochlora* (*O.*) sp. 11	1
42		*Augochlora* (*O.*) sp. 12	1
43		*Augochlorella ephyra* (Schrottky, 1910)	2
44		*Augochlorella* sp. 1	1
45		*Augochlorella* sp. 2	1
46		*Augochloropsis* cf. *cupreola* (Cockerell, 1900)	1
47		*Augochloropsis* sp. 1	2
48		*Augochloropsis* sp. 3	82
49		*Augochloropsis* sp. 5	2
50		*Augochloropsis* sp. 6	1
51		*Augochloropsis* sp. 7	7
52		*Augochloropsis* sp. 9	1
53		*Augochloropsis* sp. 10	1
54		*Augochloropsis* sp. 14	2
55		*Paroxystoglossa* sp. 1	1
56		*Pseudaugochlora callaina* Almeida, 2008	5
57		*Pseudaugochlora erythrogaster* Almeida, 2008	1
58		*Pseudaugochlora graminea* (Fabricius, 1804)	92
59		*Pseudaugochlora indistincta* Almeida, 2008	1
60		*Temnosoma* sp.	3
61		*Dialictus* sp.	51
62	Megachilinae	*Anthodioctes megachiloides* Holmberg, 1903	2
63		*Coelioxys (Acrocoelioxys)* sp. 1	3
64		*Coelioxys (Acrocoelioxys) aculeaticeps* Friese, 1921	1
65		*Megachile (Austromegachile) susurrans* Haliday, 1836	3
66		*Megachile (Austromegachile)* sp. 2	1
67		*Megachile (Austromegachile)* sp. 3	2
68		*Megachile (Chrysosarus) affabilis* Mitchell, 1930	11
69		*Megachile (Chrysosarus)* sp. 2	5
70		*Megachile (Chrysosarus)* sp. 3	1
71		*Megachile (Dactylomegachile)* sp. 1	3
72		*Megachile (Leptorachis)* sp. 1	1

73	*Megachile (Moureapis)* sp. 1	3
74	*Megachile* (*Pseudocentron*) sp. 1	1
75	*Megachile (Ptilosaroides) neoxanthoptera* Cockerell, 1933	24
76	*Megachile (Ptilosaroides)* sp. 1	2
77	*Megachile (Ptilosarus)* cf. *bertonii* Schrottky, 1908	1
78	*Megachile (Trichurochile) thygaterella* Schrottky, 1913	1
	TOTAL	1.042

PLANTS

A total of 83 plant species from 38 botanical families were sampled (table 2). Of these, 46 are exotic species that make up the landscaped areas. The most visited botanic families, quantitatively, were Lamiaceae and Asteraceae.

Table 2 – List of visited plants by bees at the campus of Univille, during the period of 2009 to 2015.

	Family	Species
1	Acanthaceae	*Hygrophila costata* Sinning
2	Adoxaceae	*Sambucus nigra* L.
3	Amaranthaceae	*Pfaffia glomerata* (Spreng.) Pedersen
4	Amaryllidaceae	*Agapanthus africanus* (L.) Hoffmanns.
5	Apocynaceae	*Catharanthus roseus* (L.) G. Don.
6	Asclepiadaceae	*Asclepias curassavica* L.
7	Asteraceae	*Baccharis trimera* (Less.) DC
8	Asteraceae	*Achyrocline satureioides* (Lam.) DC.
9	Asteraceae	*Ageratum conyzoides* L.
10	Asteraceae	*Austroeupatorium inulifolium* (Khunth) R. M. King & H. Rob.
11	Asteraceae	*Achillea millefolium* L.
12	Asteraceae	*Cosmos sulphureus* Cav.
13	Asteraceae	*Gazania rigens* (L.) Gaertn.
14	Asteraceae	*Helianthus* sp.
15	Asteraceae	*Tithonia speciosa* Torch.
16	Asteraceae	*Tanacetum vulgare* L.
17	Asteraceae	*Vernonia condensata* Backer
18	Asteraceae	*Vernonanthura montevidensis* (Spreng.) H.Rob.
19	Asteraceae	*Vernonanthura tweediana* (Baker) H.Rob.
20	Asteraceae	*Sphagneticola trilobata* (L.) Pruski
21	Balsaminaceae	*Impatiens balsamina* L.
22	Begoniaceae	*Begonia descoleana* L.B.Sm. & B.G.Schub.
23	Bignoniaceae	*Crescentia cujete* L.
24	Bixaceae	*Bixa orellana L.*
25	Brassicaceae	*Lobularia maritima* (L.) Desv.
26	Caprifoliaceae	*Abelia x grandiflora*
27	Commelinaceae	*Dichorisandra thyrsiflora* J.C. Mikan
28	Commelinaceae	*Tradescantia pallida (Rose)* D.R. Hunt
29	Commelinaceae	*Tripogandra diuretica* (Mart.) Handlos.
30	Costaceae	*Costus spiralis* (Jacq.) Roscoe
31	Crassulaceae	*Kalanchoe blossfeldiana* Poelln.

32	Euphorbiaceae	*Euphorbia pulcherrima* Willd. ex Klot.
33	Euphorbiaceae	*Euphorbia milii* Des Moul.
34	Euphorbiaceae	*Jatropha gossypifolia* L.
35	Euphorbiaceae	*Jatropha multifida* L.
36	Euphorbiaceae	*Jatropha curcas* L.
37	Euphorbiaceae	*Ricinus communis* L.
38	Fabaceae	*Cajanus cajan* (L.) Millsp.
39	Fabaceae	*Crotalaria spctabilis* Roth.
40	Fabaceae	*Mimosa pudica* L.
41	Gesneriaceae	*Streptocarpus saxorum* Engl.
42	Hemerocallidaceae	*Hemerocallis flava* (L.) L.
43	Iridaceae	*Neomarica candida* Sprague
44	Lamiaceae	*Mentha x villosa*
45	Lamiaceae	*Ocimum gratissimum* L.
46	Lamiaceae	*Ocimum basilicum* L.
47	Lamiaceae	*Plectranthus grandis* (Cramer) R. Willemse.
48	Lamiaceae	*Plectranthus neochilus* Schlechter
49	Lamiaceae	*Tetradenia riparia* (Hochst.) Codd
50	Lamiaceae	*Thymus vulgaris* L.
51	Lamiaceae	*Salvia splendens* Sellow ex Schult. in Roem. & Schult.
52	Lamiaceae	*Lavandula officinalis* Mill.
53	Lamiaceae	*Coleus blumei* Benth.
54	Lamiaceae	*Thymus vulgaris* L.
55	Lythraceae	*Cuphea gracilis* Kunth L.
56	Malvaceae	*Hibiscus sabdariffa* L.
57	Malvaceae	*Abutilon megapotamicum* L.
58	Passifloraceae	*Passiflora alata* Curtis
59	Passifloraceae	*Passiflora edulis* Sims
60	Phytolacaceae	*Petiveria alliacea* L.
61	Plantaginaceae	*Plantago major* L.
62	Polygalaceae	*Polygala paniculata* L.
63	Portulacaceae	*Portulaca oleracea* L.
64	Onagraceae	*Ludwigia leptocarpa* (Nutt.) H. Hara
65	Rosaceae	*Rosa chinensis* Jacq.
66	Rosaceae	*Rubus rosifolius* Sm.
67	Scrophulariaceae	*Torenia fournieri* Linden ex E. Fourn.
68	Solanaceae	*Brugmansia suaveolens* (Humboldt & Bonpland ex Willdenow) Bercht. & J.Presl
69	Solanaceae	*Datura metel* L.
70	Solanaceae	*Nicotiana tabacum* L.
71	Solanaceae	*Solanum mauritianum* Scop.
72	Tropaeolaceae	*Tropaeolum majus* L.
73	Verbenaceae	*Lantana camara* L.
74	Verbenaceae	*Verbena litoralis* Kunth
75	Verbenaceae	*Lippia alba* (Mill.) N. E. Brown
76	Verbenaceae	*Stachytarpheta jamaicensis* (L.) Vahl
77	Vitaceae	*Cissus verticillata* (L.) D.H. Nicols. & Jarvis

78	Xanthorrhoeaceae	*Aloe arborescens* Mill.
79	Xanthorrhoeaceae	*Aloe ferox* Mill.
80	Xanthorrhoeaceae	*Aloe vera* (L.) Burm. f.
81	Zingiberaceae	*Alpinia zerumbet* (Pers.) B.L. Burtt & R.M. Sm.
82	Zingiberaceae	*Hedychium coronarium* J. Konig
83	Zingiberaceae	*Zingiber officinale* Roscoe

ECOLOGICAL INDICES

The obtained values for the Shannon-Wiener, Pielou and Simpson's indices are, respectively: H'= 3; J= 0,67; D= 0,14 or 0,76 (1-D). The observed richness (34 species/ 44 morphospecies) was used to calculate the richness estimators jackknife 1 and 2, which indicated values of 90,66 and 91,87 species, respectively, to the site. As parameters, we used species which appeared in only one sampling (singletons) or two (doubletons), which prevents the results from being affected by the high number of individuals of some species (COLWELL & CODDINGTON, 1994). Apoidea surveys conducted in nearby environments were compared by the Sorensen index of similarity (table 3).

Table 3 – Similarity of apifauna (Sorensen index) sampled in this study with others performed in nearby environments. The mentioned authors are listed in references. Legend: S.I. Sorensen index; Local: district, municipality, state.

Author	Locality	Geographic coordinates	Altitude (m)	Distance (Km)	Number of considered taxa	S.I.
Mouga et al. (2015b)	Vila da Gloria, São Francisco do Sul, SC	26° 14' 36" S 48° 38' 17" W	9	30	79	0,44
Mouga & Warkentin (2016)	Caieiras, Joinville, SC	26° 18' 05" S 48° 50' 38" W	10	9,5	59	0,41
Lima (2015)	Pirabeiraba, Joinville, SC	26° 10'31 88" S 48° 55'5 79" W	25	10	60	0,45
Dec & Mouga (2014)	Piraí, Joinville, SC	26° 28'84 90" S 48° 84'52 15" W	140	12	48	0,45
This study	Bom Retiro, Joinville, SC	26° 18' 16" S 48° 50' 44" W	20		34	

DISCUSSION

BEES

In spite of the low number of species of Apini and Meliponini, often attributed to their social behavior (ALVES-DOS-SANTOS *et al.*, 2012), this group, on the campus of Univille, had the greatest abundance, mainly due to the exotic *A. mellifera* and *T. spinipes*, a native stingless bee, of easy adaptation to disturbed environments. A study by Agostini & Sazima (2003), on the campus of UNICAMP-SP, pointed out more abundant species: *T. spinipes*, *A. mellifera* and *Tetragonisca angustula* (Latreille, 1811). The latter is a species of stingless bee, abundant in urban areas and occurring in Santa Catarina, capable of nesting even in artificial structures such as wall openings but which, in the present study, was poorly sampled. Its low abundance, when compared to *A. mellifera* and *T. spinipes*, may be due to the latter two being generalist species whereas *T. angustula* is a more sensitive and selective species in relation to the floral resources visited (NOGUEIRA-NETO, 1997). Other eusocial species sampled, such as *Partamona helleri* (Friese, 1900) and *Plebeia emerina* (Friese, 1900) were also poorly represented. *P. emerina* is a common species in southern Brazil, present in urban areas (SILVA & PAZ, 2012) and shows general behavior in flower foraging (CORTOPASSI-LAURINO & NOGUEIRA-NETO, 2016). *P. helleri* nests in areas without anthropic influence and its geographic distribution in the south of Brazil is limited to the north of Santa Catarina (CAMARGO & PEDRO, 2003), so its absence on campus is expected.

Euglossini species are more associated with conserved forest environments, with few species adapted to the anthropic impact (POWELL & POWELL, 1987). The foraging behavior of some species of this *taxon* in cultivated plants such as *B. orellana*, *D. thyrsiflora* and *H. flava* has already been reported by Dodson (1966) and Rocha-Filho *et al*. (2012). Orchid bees are rarely collected in flowers (NEMESIO & SILVEIRA, 2007) and are considered as a bioindicator group of environmental quality (PARRA-H & NATES-PARRA, 2007). These interactions recorded on campus increase the importance of gardened areas in urban environments, as they contribute significantly to the maintenance of these floral visitors.

Centridini is a group composed of solitary species, whose females collect oils from different botanical families, which are used for larval feeding and the building of their nests, excavated in the soil, gullies or in pre-existing wooden cavities (MICHENER & LANGE, 1958; COVILLE *et al*., 1983). Its presence on *campus*, especially *Epicharis affinis*, may be justified by the range of food resources available or the ease of finding nesting sites, however, this data was not evaluated.

The richness of Halictinae (six species and 29 morphospecies) may be due to the fact that it is a *taxon* which thrives in degraded areas, according to Harter (1999). Complementarily, Michener (2000, 2007) states that Halictinae presents species that vary from a solitary to primitive eusocial and succeed in urbanized areas due to the low food supply they need and the ease to find places for nesting behavior. Taura & Laroca (2001) found similar numbers (32 species), in a study carried out in the *Passeio Publico* park, central area of Curitiba, state of Paraná. In Criciuma, southern state of Santa Catarina, Bez (2009) obtained greater richness for the Halictinae in a forest fragment within the urban perimeter (ten species and 14 morphospecies). Harter (1999) also found a high diversity of Halictinae (39 species and 32 morphospecies) in the city of São Francisco de Paula (RS).

Bees of the genus *Xylocopa*, which have predominantly solitary behavior (SILVEIRA *et al*., 2002), totaled 113 individuals sampled. Chaves-Alves *et al*. (2011) verified the abundance of this *genus* in the campus of the Federal University of Uberlandia, MG, concluding that tree species of the *genus Ficus* are important for the nesting of these bees. Several individuals of *Ficus benjamina* Linnaeus occur on the campus of Univille and this may be an explanatory factor for the numbers of individuals of the *Xylocopa.* In addition to the nesting sites, some species of plants were extensively foraged by *X. brasilianorum* and *X. frontalis* (Olivier, 1789) such as *Agapanthus africanus* (L.) Hoffmanns.and different varieties of *Hemerocallis*, both widely used in the ornamentation of the campus. Therefore, the food resource was also abundant, favoring these populations. Another botanical species in which a high number of these bees found was *Hedychium coronarium* J. Konig, an invasive plant that occurs on the forest edges on campus.

The campus environment includes areas with native vegetation at various stages of regeneration and constructions in a low density pattern. According to Frankie *et al.* (2009), bee species observable in cities represent the native apifauna resilient to urbanization in the area since urban bees are those that lived in an area prior to urbanization and were able to adapt to anthropogenic alterations to the environment besides the exotic species that have become naturalized in there. In this way, the found species seemingly have adapted to the change of environmental matrix of an area they already occupied. On the other hand, according to Mendonça & Anjos (2005), anthropic intervention of vegetation in urban areas creates a fragmented mosaic, altering the structure of the original cover, offering distinct conditions and resources to be explored by the fauna, already resident or foreign.

Thus, the study of the richness and abundance of bees in human agglomerations can be analyzed in order to verify the reductional effect of urbanization on the biota or the green areas in cities can also be seen as fragments that allow connectivity with surrounding non-urban areas and constitute possible areas for migration. The study of the species richness and abundance of these green urban areas report to the theory of island biogeography and can help in the understanding of the population dynamics facing the size and isolation of the fragments of vegetation and the consequences of reduced groups in fragments.

PLANTS

Urban environments in terms of plant diversity can be considered from two points of view. They tend to have a diversity of native plants smaller than non anthropized environments due to deforestation that gives rise to the buildings and there is also a greater amount of exotic plant species, depending on the ornamental choices of the inhabitants, which are not so often of primary choice of the apifauna. In addition, it is observed that the exotic vegetation many times presents low density, not being enough to supply the needs of its floral visitors (ALVES-DOS-SANTOS *et al*., 2012), causing a consequent loss in the community of bees, that need the flowers as a source of food, and the fact that elimination of native vegetation also implies a reduction of nesting sites for bees.

On the other hand, in this case, it is possible to consider the area a transition from the forest to a degraded environment, being likely to find species which transit, adapted to the two environments and thus increase the richness. In urban environments, botanical species with different flowering periods are usually used in gardening and, consequently, the supply of resources is maintained throughout the seasons, eventually by the use of intensive watering, pruning and replanting (MOUGA *et al.*, 2015b).

ECOLOGIC INDICES

The richness found at the Univille campus by the Shannon index (H' = 3.00) was higher than those found in studies of nearby areas conducted in forest formations. Dec & Mouga (2014) obtained H' = 2.87 in submontane rain forest environment, however, the sampling period of the latter was only 12 months. Mouga *et al*. (2015a) obtained H' = 2.31 after two years of lowland rain forest sampling in the Vila da Gloria region, while Mouga & Warkentin (2016), in a study carried out in a transition area between mangrove, *restinga* and rain forest in the estuarine region of Joinville, obtained H = 2.64 in 12 months of sampling. Lima (2015), after one year of sampling, presented the value of H = 2.37. The lower diversity indices found in the cited studies may have been due to the shorter sampling time compared to the present study, since all had more conserved environments, therefore with a probable greater diversity of bees. Another factor to be considered in relation to the values found in the Shannon indices is the overvaluation of the most abundant species since the number of individuals directly affects the index result (MAGURRAN, 2004).

The obtained values of similarity are relatively high. The species of bees sampled in the present study showed a greater similarity with the works of Dec & Mouga (2014) and Lima (2015), both carried out in forest environments near the campus (less than 15 km), sharing 29 and 28 species, respectively, demonstrating that the campus is slightly more similar to *Serra do Mar* hillside forests where the cited studies were carried out, than with the estuarine transition vegetation where studies by Mouga & Warkentin (2016) and Mouga *et al*. (2015a) were performed.

The richness of the studied area (taking into account the number of considered taxa for Sorensen index) is lower than that of the other nearby places compared. This indicates probably a decrease of the apifauna of the studied area as the morphospecies that could elevate the richness belong mainly to Halictinae, a group that is reported to be abundant in degraded areas (HARTER, 1999, among other studies). As there is still an intensely forested matrix around the studied area, we consider that the *campus* of the Univille is not yet a shelter place but rather an impoverished one if compared to the others that are approximately close. Nevertheless, the found diversity of species (some rare and poorly sampled elsewhere) anticipates that the spot could become a haven in the future, as urbanization continues on the same pace than presently. In view of the large size of urban grounds nowadays and the intensive use of the natural lands around the cities for industrial and agricultural purposes, urban green surfaces represent increasingly important refuges for biodiversity.

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