Bee Interaction Database (BID): A project to share biotic interaction and ecological trait data about bees (Hymenoptera: Anthophila)

Katja C. Seltmann, Janice Van Wagner, Rachel Behm, Elaine Tan, Zachary Brown, Kristi Liu

Cheadle Center for Biodiversity and Ecological Restoration
University of California, Santa Barbara
November , 2020; seltmann@ucsb.edu; @irene_moon

2020 ENTOMOLOGY VIRTUAL ANNUAL MEETING

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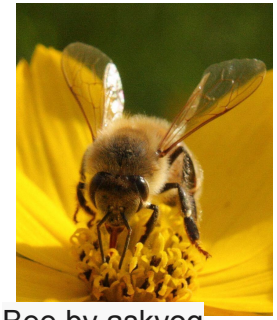
Openly share reusable bee interaction and trait data

IMG_2257 by Klaas de Gelder

Leaf-cutter Bee - Megachile species, Meadowood SRMA, Mason Neck, Virginia by Judy Gallagher



Bee by askyog

20180803-AMS-LSC-0806 by USDAgov

Bees do a lot of things and interact with many organisms

Literature and Reports

Journal of Pollination Ecology, 25(3), 2018, pp 16-23

NATIVE AND NON-NATIVE PLANTS ATTRACT DIVERSE BEES TO URBAN GARDENS IN CALIFORNIA

Gordon Frankie[1], Jaime Pawelek[2], Marissa [illegible] Rizzardi[3], Robbin Thorp[4]

[1]University of California, Berkeley, Department of Environme
[2]University of California, Berkeley, College of Natural Resour
[3]Humboldt State University, Department of Mathematics and S
[4]University of California, Department of Entomology, Davis, C

Abstract—Bees visit native and non-native pla
wildland environments. Results of an extensive sur
2005-2011 were used to examine host-plant recor
non-native bee species; five cities were from north
7,659 bees and their floral host plants were exam
Only four other non-*Apis* species (all in Megachi
402 individuals. These bees have been databased i
Essig Museum of Entomology. We identified 229
in urban areas. Of the 229 species, 71 bee species
non-native host plants; and 106 were collected fr

Flowering plant composition shapes pathogen infection intensity and reproduction in bumble bee colonies

Lynn S. Adler[a,1], Nicholas A. Barber[b], Olivia M. Biller[c], and Rebecca E. Irwin[d]

[a]Department of Biology, University of Massachusetts, Amherst, MA 01003; [b]Ecology Program Area, Department of Biology, San Diego State University, San Diego, CA 92182; [c]Department of Occupational Therapy, Thomas Jefferson University, Philadelphia, PA 19107; and [d]Department of Applied Ecology, North Carolina State University, Raleigh, NC 27695

Edited by Nils Chr. Stenseth, University of Oslo, Oslo, Norway, and approved April 10, 2020 (received for review January 3, 2020)

Pathogens pose significant threats to pollinator health and food security. Pollinators can transmit diseases during foraging, but the consequences of plant species composition for infection is unknown. In agroecosystems, flowering strips or hedgerows are

the number of trees and shrubs was positively correlated with phorid fly parasitism in both honey and bumble bees (18). In another study, the prevalence of deformed wing virus and black queen cell virus was higher in bumble bees and on flowers near honey bee apiaries, suggesting that flowers are the site of virus transmission from commercial honey bees to wild bumble bees (19). All of these studies suggest that floral resources can increase both bee abundance and risks of pathogen or parasite infection, but we do not yet know whether plant species composition plays significant roles in shaping bee pathogen infection.

Variation in floral traits within and among plant species can change the likelihood of vectoring or transmitting pathogens or parasitic mites (14, 15, 20, 21), and such variation can have consequences for disease transmission dynamics (22). In particular, a recent study found fourfold variation across 14 plant species in transmission of the gut pathogen *Crithidia bombi* to foraging bumble bees (*Bombus impatiens*) (20), and defecation on flowers by infected bees varied with plant species (23). However, we do not know whether these individual dynamics scale up to plant community consequences for bumble bee colony-level pathogen infection and reproduction.

The role of plant species in shaping infection intensity could be influenced by bee behavior. If infected bees increase visitation

Significance

Pollinator decline affects food security, and pollinators are threatened by stressors including pathogens and insufficient food resources. Flowering strips are increasingly planted to increase pollinator abundance and diversity in agricultural settings, but flowers can also be disease transmission sites between pollinators. However, the effect of plant species composition on bee disease is unknown. We compared the effect of flowering strips with high- or low-infection plant species, or no flowering strips, on bee infection and reproduction in tents. Using high-infection flowering strips doubled bee infection intensity compared to low-infection flowering strips. However, bee reproduction was higher with any flowering strips. Thus, floral resources in flowering strips benefited bees, but certain plants also come with a risk of increased pathogen infection intensity.

Author contributions: L.S.A. and R.E.I. designed research; L.S.A. and O.M.B. performed research; N.A.B. analyzed data; and L.S.A. wrote the paper.

The authors declare no competing interest.

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Data deposition: All data and R scripts are deposited in Dryad (https://doi.org/10.5061/dryad.p2ng1vn1).

[1]To whom correspondence may be addressed. Email: ladler@umass.edu.

This article contains supporting information online at https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.2000074117/-/DCSupplemental.

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Kansas Entomological Society

Vol. 48 July, 1975 Number 3

THE BIOLOGY OF PERDITA NUDA AND DESCRIPTIONS OF ITS IMMATURE FORMS AND THOSE OF ITS SPHECODES PARASITE (HYMENOPTERA: APOIDEA)

PHILIP F. TORCHIO
Bee Biology and Systematics Laboratory, Agr. Res. Serv., USDA
Logan, Utah 84322

ABSTRACT

The biology of *Perdita nuda* Ckll. is described in detail and compared with biologies of other known *Perdita* species. The parasitic halictine bee, *Sphecodes* *Sphecodes* sp. [(near *fragariae* Ckll.)], is associated with *Perdita nuda*, and its biology is described. Important findings include: (1) host and parasite larvae can remain in diapause for 35 months; (2) not all *P. nuda* larvae pupate during any particular year; (3) *Sphecodes* larvae mimic the host larvae in feeding and overwintering positions; (4) *Sphecodes* larvae diapause as predetermined forms. Also, movement of the *Perdita* egg during embryogenesis is explained.

The larvae and pupae of *P. nuda* and *Sphecodes* sp. are described and compared with known forms. Species of known *Perdita* larvae are nearly indistinguishable, but those of *Sphecodes* spp. are easily separated. However, species of both taxa are distinguishable on the basis of pupal characteristics.

NESTING HABITAT

Perdita nuda Ckll. was found nesting on a low hill adjacent to Bear River, 3 miles northwest of Preston, Franklin County, Idaho, in August 1970. This particular hill was formed by sedimentation of the river and was composed mostly of river bottom gravel that was interrupted periodically by narrow veins of coarse-to-fine-grained sand. One pocket of sand (9 m wide, 22 m long, and at least 2.5 m deep) situated on the crest of the hill was completely devoid of plants, but it supported two disjunct nesting populations of *P. nuda*. Site A (a gregarious nesting site 2 m² restricted to the southern edge of the sandy niche) was established on a 30° inclined surface that had an easterly exposure. Nests were closely congregated (2 nests/10 cm²) on a surface composed of numerous gravel particles mixed with sand. Site B (a nesting site restricted to the northern edge of the area) was established on a horizontal surface composed of sand only. It was approximately one-third the size of site A, and nests were less congregated (0.7 nests/10 cm²).

Received for publication October 29, 1974.

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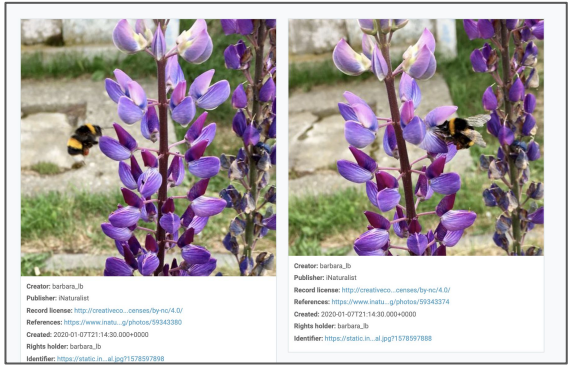
Human Observations



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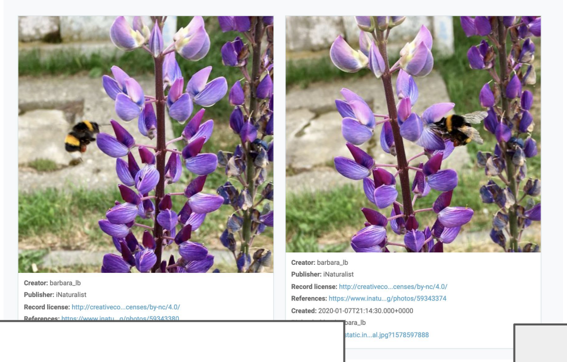
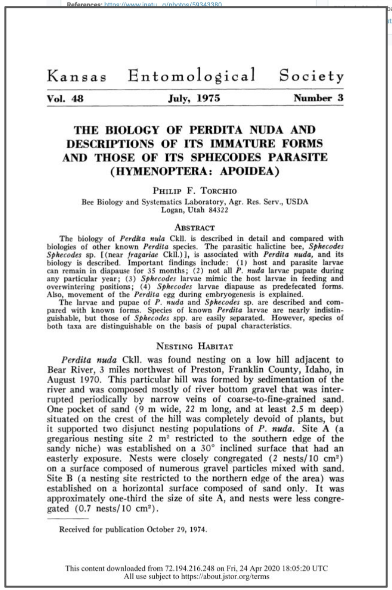
https://www.gbif.org/occurrence/2550024372

Natural History Specimens

Unstructured data





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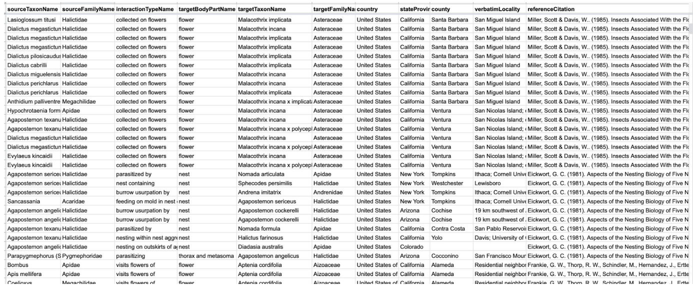
Reusable/structured interaction data



sourceTaxonName	sourceFamilyName	interactionTypeName	targetBodyPartName	targetTaxonName	targetFamilyNa	country	stateProvir	county	verbatimLocality	referenceCitation
Lasioglossum titusi	Halictidae	collected on flowers	flower	Malacothrix implicata	Asteraceae	United States	California	Santa Barbara	San Miguel Island	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Dialictus megastictun	Halictidae	collected on flowers	flower	Malacothrix incana	Asteraceae	United States	California	Santa Barbara	San Miguel Island	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Dialictus megastictun	Halictidae	collected on flowers	flower	Malacothrix implicata	Asteraceae	United States	California	Santa Barbara	San Miguel Island	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Dialictus megastictun	Halictidae	collected on flowers	flower	Malacothrix implicata	Asteraceae	United States	California	Santa Barbara	San Miguel Island	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Dialictus pilosicaudus	Halictidae	collected on flowers	flower	Malacothrix implicata	Asteraceae	United States	California	Santa Barbara	San Miguel Island	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Dialictus cabrilli	Halictidae	collected on flowers	flower	Malacothrix implicata	Asteraceae	United States	California	Santa Barbara	San Miguel Island	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Dialictus miguelensis	Halictidae	collected on flowers	flower	Malacothrix incana	Asteraceae	United States	California	Santa Barbara	San Miguel Island	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Dialictus perichlarus	Halictidae	collected on flowers	flower	Malacothrix incana	Asteraceae	United States	California	Santa Barbara	San Miguel Island	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Dialictus perichlarus	Halictidae	collected on flowers	flower	Malacothrix implicata	Asteraceae	United States	California	Santa Barbara	San Miguel Island	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Anthidium palliventre	Megachilidae	collected on flowers	flower	Malacothrix incana x implicat	Asteraceae	United States	California	Santa Barbara	San Miguel Island	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Hypochrotaenia form	Apidae	collected on flowers	flower	Malacothrix incana	Asteraceae	United States	California	Ventura	San Nicolas Island;	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Agapostemon texanu	Halictidae	collected on flowers	flower	Malacothrix incana	Asteraceae	United States	California	Ventura	San Nicolas Island;	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Agapostemon texanu	Halictidae	collected on flowers	flower	Malacothrix incana x polycepl	Asteraceae	United States	California	Ventura	San Nicolas Island;	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Dialictus megastictun	Halictidae	collected on flowers	flower	Malacothrix incana	Asteraceae	United States	California	Ventura	San Nicolas Island;	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Dialictus megastictun	Halictidae	collected on flowers	flower	Malacothrix incana x polycepl	Asteraceae	United States	California	Ventura	San Nicolas Island;	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Evylaeus kincaidii	Halictidae	collected on flowers	flower	Malacothrix incana	Asteraceae	United States	California	Ventura	San Nicolas Island;	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Evylaeus kincaidii	Halictidae	collected on flowers	flower	Malacothrix incana x polycepl	Asteraceae	United States	California	Ventura	San Nicolas Island;	Miller, Scott & Davis, W.. (1985). Insects Associated With the Flo
Agapostemon sericeu	Halictidae	parasitized by	nest	Nomada articulata	Apidae	United States	New York	Tompkins	Ithaca; Cornell Unive	Eickwort, G. C. (1981). Aspects of the Nesting Biology of Five N
Agapostemon sericeu	Halictidae	nest containing	nest	Sphecodes persimilis	Halictidae	United States	New York	Westchester	Lewisboro	Eickwort, G. C. (1981). Aspects of the Nesting Biology of Five N
Agapostemon sericeu	Halictidae	burrow usurpation by	nest	Andrena imitatrix	Andrenidae	United States	New York	Tompkins	Ithaca; Cornell Unive	Eickwort, G. C. (1981). Aspects of the Nesting Biology of Five N
Sancassania	Acaridae	feeding on mold in nest	nest	Agapostemon sericeus	Halictidae	United States	New York	Tompkins	Ithaca; Cornell Unive	Eickwort, G. C. (1981). Aspects of the Nesting Biology of Five N
Agapostemon angeli	Halictidae	burrow usurpation by	nest	Agapostemon cockerelli	Halictidae	United States	Arizona	Cochise	19 km southwest of	Eickwort, G. C. (1981). Aspects of the Nesting Biology of Five N
Agapostemon angeli	Halictidae	burrow usurpation by	nest	Agapostemon cockerelli	Halictidae	United States	Arizona	Cochise	19 km southwest of	Eickwort, G. C. (1981). Aspects of the Nesting Biology of Five N
Agapostemon texanu	Halictidae	parasitized by	nest	Nomada formula	Apidae	United States	California	Contra Costa	San Pablo Reservoi	Eickwort, G. C. (1981). Aspects of the Nesting Biology of Five N
Agapostemon texanu	Halictidae	nesting within nest aggre	nest	Halictus farinosus	Halictidae	United States	California	Yolo	Davis; University of	Eickwort, G. C. (1981). Aspects of the Nesting Biology of Five N
Agapostemon angeli	Halictidae	nesting on outskirts of a	nest	Diadasia australis	Apidae	United States	Colorado			Eickwort, G. C. (1981). Aspects of the Nesting Biology of Five N
Parapygmephorus (S	Pygmephoridae	parasitizing	thorax and metasoma	Agapostemon angelicus	Halictidae	United States	Arizona	Cocconino	San Francisco Mour	Eickwort, G. C. (1981). Aspects of the Nesting Biology of Five N
Bombus	Apidae	visits flowers of	flower	Aptenia cordifolia	Aizoaceae	United States of	California	Alameda	Residential neighbor	Frankie, G. W., Thorp, R. W., Schindler, M., Hernandez, J., Ertte
Apis mellifera	Apidae	visits flowers of	flower	Aptenia cordifolia	Aizoaceae	United States of	California	Alameda	Residential neighbor	Frankie, G. W., Thorp, R. W., Schindler, M., Hernandez, J., Ertte
Coelioxys	Megachilidae	visits flowers of	flower	Aptenia cordifolia	Aizoaceae	United States of	California	Alameda	Residential neighbor	Frankie, G. W., Thorp, R. W., Schindler, M., Hernandez, J., Ertte

Understandable by people and computers

GloBI

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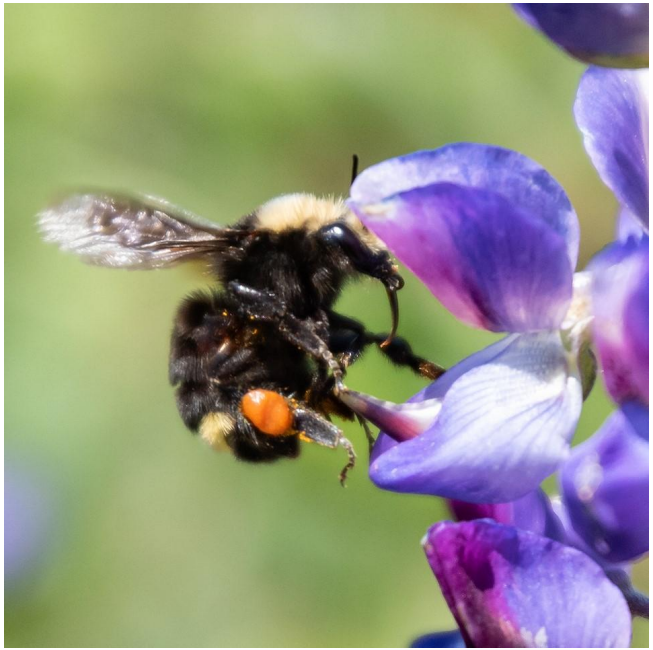


A biotic interaction

Source → Relationship → *Target*

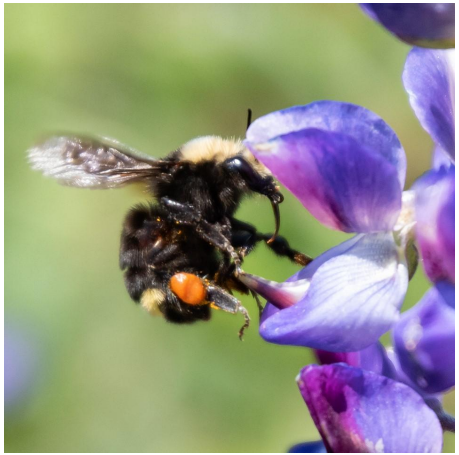
Bombus vosnesenskii → *Lupinus succulentus*

Examples of floral visitation as found in the literature

“collected from flowers of”
“carries pollen from”
“pollinates”
“visits”
“floral visit”

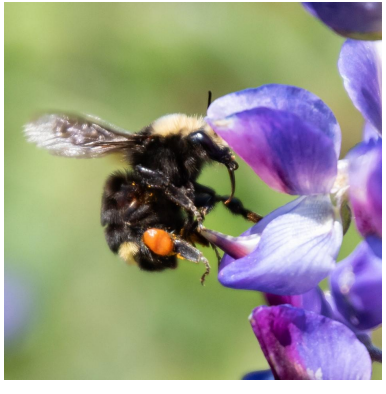
Source → Relationship → *Target*

But I want to ask what plants does *Bombus vosnesenskii* visit?!?!



What we have..

visits flowers of
“collected on
flowers of”
carries pollen from
pollinates



What we want is a graph of Bombus vosnesenskii interactions

We do this with GloBI?

- Global Biotic Interactions (GloBI) is a data integration tool that **indexes existing species interaction datasets**, literature, and specimen records from collections, including BID
- Results are a giant graph showing instances of support for that interaction between two taxa, including links to specimen records in natural history collections or literature citations
- Specimen citations contain links to full specimen occurrence records available online

https://www.globalbioticinteractions.org

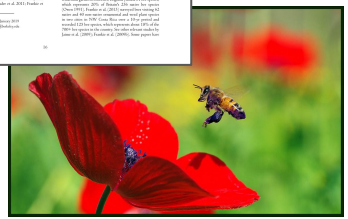
Manually extracting data from literature

START HERE

Scientific Literature Assessment

Read & review papers looking for specific biotic interactions and trait data about bees

NATIVE AND NON-NATIVE PLANTS ATTRACT DIVERSE BEES TO URBAN GARDENS IN CALIFORNIA



Hard working honey bee. By Ziva_Amir

Get feedback from Global Biotic Interactions

Adding to Dataset/ Literature Transcription

Using the guidelines provided at the BID GitHub repository, assign each interaction a line in the dataset.

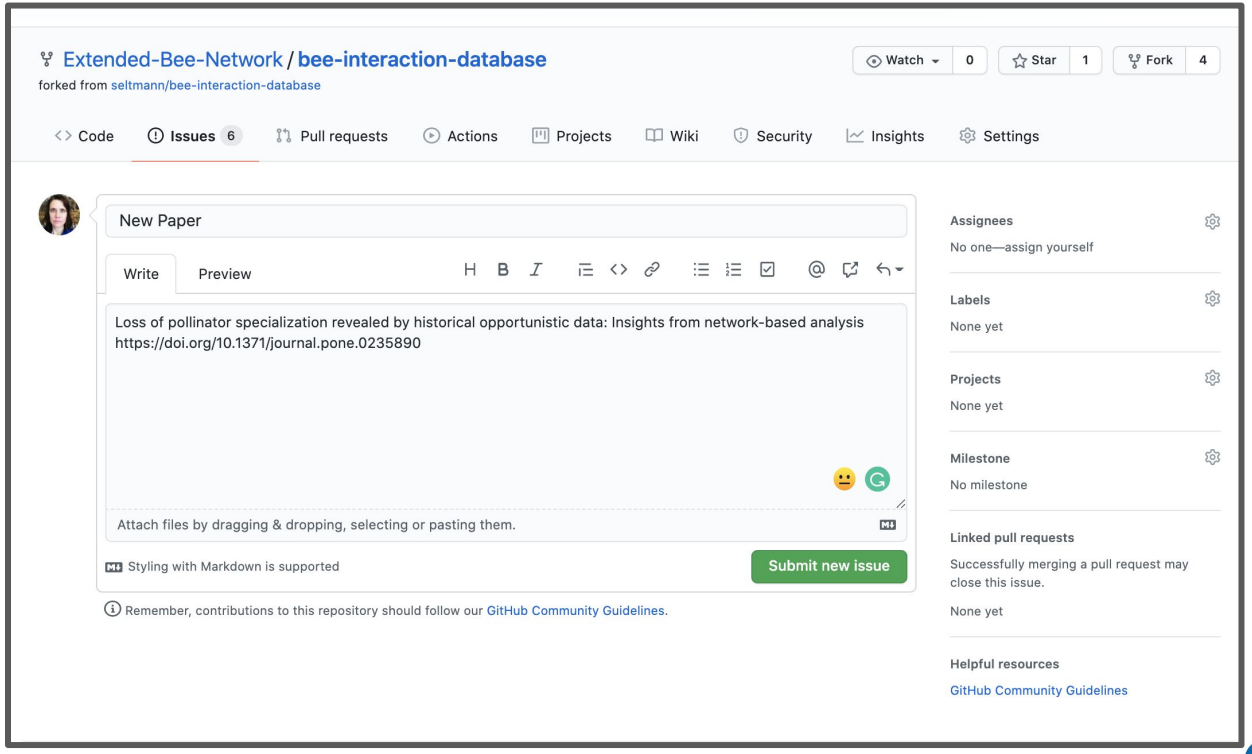
Extracting all available details about the interaction, map the data according interaction type, taxa, trait, location, etc. using both a controlled vocabulary and computer readable web links.

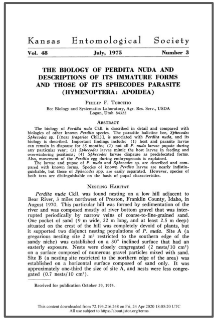
Verbatim fields are also provided, as is a field for citations.

Index to Global Biotic Interactions

(Indexed nightly)

What is BID? A GitHub repository for people to work together to get interactions out of the literature





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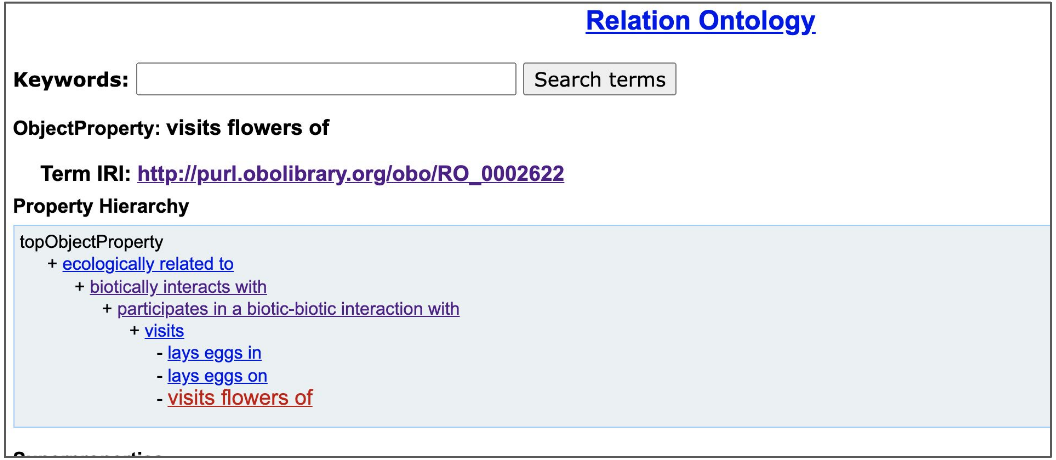
"In field trial, *Bombus vosnesenskii* observed visiting blooming *Lupinus succulentus*."

sourceTaxonId	sourceTaxonName	interactionId	interactionName	targetTaxonId	targetTaxonName
https://www.gbif.org/species/1340436	*Bombus vosnesenskii*	http://purl.obolibrary.org/obo/RO_0002622	"visiting blooming"	https://www.gbif.org/species/2964314	*Lupinus succulentus*



As of September 2020...

- 302,926 bee floral associations
- 8423 unique plants
- 25,992 interactions with non-arthropod parasites
- 6277 arthropod parasites

Future Directions

Get in touch and share your data!

Inclusion of custom ontology for bee interaction and functional traits

Encourage born open datasets or use of semantic publications.

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GloBI: https://www.globalbioticinteractions.org

Bee Interaction Database:
https://github.com/Extended-Bee-Network/bee-interaction-database

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seltmann@ucsb.edu