The human touch: a meta-analysis of anthropogenic effects on plant-pollinator interaction networks (#95435)

First submission

Guidance from your Editor

Please submit by **16 Feb 2024** for the benefit of the authors (and your token reward) .

Structure and Criteria
Please read the 'Structure and Criteria' page for general guidance.

Custom checks
Make sure you include the custom checks shown below, in your review.

Raw data check
Review the raw data.

Image check
Check that figures and images have not been inappropriately manipulated.

If this article is published your review will be made public. You can choose whether to sign your review. If uploading a PDF please remove any identifiable information (if you want to remain anonymous).

Files

Download and review all files from the materials page.

3 Figure file(s)
2 Table file(s)
1 Raw data file(s)

Custom checks

Systematic review or meta analysis

- Have you checked our policies?
- Is the topic of the study relevant and meaningful?
- Are the results robust and believable?

Structure and Criteria

Structure your review

The review form is divided into 5 sections. Please consider these when composing your review:

1. **BASIC REPORTING**
2. **EXPERIMENTAL DESIGN**
3. **VALIDITY OF THE FINDINGS**
4. General comments
5. Confidential notes to the editor

You can also annotate this PDF and upload it as part of your review

When ready submit online.

Editorial Criteria

Use these criteria points to structure your review. The full detailed editorial criteria is on your guidance page.

BASIC REPORTING

- Clear, unambiguous, professional English language used throughout.
- Intro & background to show context. Literature well referenced & relevant.
- Structure conforms to PeerJ standards, discipline norm, or improved for clarity.
- Figures are relevant, high quality, well labelled & described.
- Raw data supplied (see PeerJ policy).

EXPERIMENTAL DESIGN

- Original primary research within Scope of the journal.
- Research question well defined, relevant & meaningful. It is stated how the research fills an identified knowledge gap.
- Rigorous investigation performed to a high technical & ethical standard.
- Methods described with sufficient detail & information to replicate.

VALIDITY OF THE FINDINGS

- Impact and novelty not assessed. *Meaningful* replication encouraged where rationale & benefit to literature is clearly stated.
- All underlying data have been provided; they are robust, statistically sound, & controlled.
- Conclusions are well stated, linked to original research question & limited to supporting results.

Standout reviewing tips

The best reviewers use these techniques

Tip	*Example*
Support criticisms with evidence from the text or from other sources	*Smith et al (J of Methodology, 2005, V3, pp 123) have shown that the analysis you use in Lines 241-250 is not the most appropriate for this situation. Please explain why you used this method.*
Give specific suggestions on how to improve the manuscript	*Your introduction needs more detail. I suggest that you improve the description at lines 57- 86 to provide more justification for your study (specifically, you should expand upon the knowledge gap being filled).*
Comment on language and grammar issues	*The English language should be improved to ensure that an international audience can clearly understand your text. Some examples where the language could be improved include lines 23, 77, 121, 128 – the current phrasing makes comprehension difficult. I suggest you have a colleague who is proficient in English and familiar with the subject matter review your manuscript, or contact a professional editing service.*
Organize by importance of the issues, and number your points	*1. Your most important issue* *2. The next most important item* *3. …* *4. The least important points*
Please provide constructive criticism, and avoid personal opinions	*I thank you for providing the raw data, however your supplemental files need more descriptive metadata identifiers to be useful to future readers. Although your results are compelling, the data analysis should be improved in the following ways: AA, BB, CC*
Comment on strengths (as well as weaknesses) of the manuscript	*I commend the authors for their extensive data set, compiled over many years of detailed fieldwork. In addition, the manuscript is clearly written in professional, unambiguous language. If there is a weakness, it is in the statistical analysis (as I have noted above) which should be improved upon before Acceptance.*

The human touch: a meta-analysis of anthropogenic effects on plant-pollinator interaction networks

Karla López-Vázquez [1] , **Carlos Lara** [Corresp., 2] , **Pablo Corcuera** [3] , **Citlalli Castillo-Guevara** [2] , **Mariana Cuautle** [2]

[1] Doctorado en Ciencias Biológicas y de la Salud, Universidad Autónoma Metropolitana, Iztapalapa, Ciudad de México, Mexico
[2] Centro de Investigación en Ciencias Biológicas, Universidad Autónoma de Tlaxcala, San Felipe Ixtacuixtla, Tlaxcala, Mexico
[3] Departamento de Biología, Universidad Autónoma Metropolitana, Iztapalapa, Ciudad de México, Mexico

Corresponding Author: Carlos Lara
Email address: carlos.lara.rodriguez@gmail.com

Background . Anthropogenic activities significantly impact natural ecosystems, leading to alterations in plant and pollinator diversity and abundance. These changes often result in shifts within interacting communities, potentially reshaping the structure of plant-pollinator interaction networks. Given the escalating human footprint on habitats, evaluating the response of these networks to anthropization is critical for devising effective conservation and management strategies.**Methods**. We conducted a comprehensive review of the plant-pollinator network literature to assess the impact of anthropization on network structure. Employing a meta-analytical approach, we examined how anthropization activities, such as land use changes, urbanization, habitat fragmentation, agriculture, and livestock farming, affect both plant and pollinator richness. Additionally, we assessed network metrics such as nestedness (NODF), network specialization (H2), connectance (C), and modularity (Q) to understand structural changes.**Results**. We generated a dataset of 36 effect sizes for various metrics of network structure from 38 papers published between 2010 and 2023. Studies assessing the impact of agriculture and livestock farming were well-represented, with networks involving interacting insects being the most studied taxa. Our meta-analysis suggests that anthropization decreases richness for both plants and pollinators. However, there was high heterogeneity among studies. Similarly, agriculture and fragmentation reduce nestedness and increase specialization in plant-pollinator networks, while modularity and connectance are mostly not affected. We also performed meta-regressions to identify variables accounting for this heterogeneity across studies, and we demonstrate that outcomes may depend on the habitat fragment size where the studies were carried out. **Conclusions**. The analysis of human impacts on plant-pollinator networks showed varied effects worldwide. Activities like agriculture and livestock farming significantly changed ecosystems, reducing species richness in both pollinators and plants, highlighting network vulnerability. Responses differed among network metrics, signaling

nuanced impacts on structure. Regional differences stressed the need for tailored conservation. Despite insights, more research is crucial for a complete understanding of these ecological relationships.

The human touch: a meta-analysis of anthropogenic effects on plant-pollinator interaction networks

Karla López-Vázquez[1], Carlos Lara[2], Pablo Corcuera[3], Citlalli Castillo-Guevara[2], and Mariana Cuautle[2]

[1]Doctorado en Ciencias Biológicas y de la Salud, Universidad Autónoma Metropolitana, Iztapalapa, Ciudad de México, México.

[2]Centro de Investigación en Ciencias Biológicas, Universidad Autónoma de Tlaxcala, San Felipe Ixtacuixtla, Tlaxcala, México.

[3]Departamento de Biología, Universidad Autónoma Metropolitana, Iztapalapa, Ciudad de México, México.

*Corresponding author:
Carlos Lara
Centro de Investigación en Ciencias Biológicas, Universidad Autónoma de Tlaxcala, San Felipe Ixtacuixtla, Tlaxcala, Mexico
Email address: carlos.lara.rodriguez@gmail.com

Abstract

Background. Anthropogenic activities significantly impact natural ecosystems, leading to alterations in plant and pollinator diversity and abundance. These changes often result in shifts within interacting communities, potentially reshaping the structure of plant-pollinator interaction networks. Given the escalating human footprint on habitats, evaluating the response of these networks to anthropization is critical for devising effective conservation and management strategies.

Methods. We conducted a comprehensive review of the plant-pollinator network literature to assess the impact of anthropization on network structure. Employing a meta-analytical approach, we examined how anthropization activities, such as land use changes, urbanization, habitat fragmentation, agriculture, and livestock farming, affect both plant and pollinator richness. Additionally, we assessed network metrics such as nestedness (NODF), network specialization (H2), connectance (C), and modularity (Q) to understand structural changes.

Results. We generated a dataset of 36 effect sizes for various metrics of network structure from 38 papers published between 2010 and 2023. Studies assessing the impact of agriculture and livestock farming were well-represented, with networks involving interacting insects being most studied taxa. Our meta-analysis suggests that anthropization decreases richness for bo plants and pollinators. However, there was high heterogeneity among studies. Similarly, agriculture and fragmentation reduce nestedness and increase specialization in plant-pollin networks, while modularity and connectance are mostly not affected. We also performed n regressions to identify variables accounting for this heterogeneity across studies, and we demonstrate that outcomes may depend on the habitat fragment size where the studies wer carried out.

Conclusions. The analysis of human impacts on plant-pollinator networks showed varied effects worldwide. Activities like agriculture and livestock farming significantly changed ecosystems, reducing species richness in both pollinators and plants, highlighting network vulnerability. Responses differed among network metrics, signaling nuanced impacts on structure. Regional differences stressed the need for tailored conservation. Despite insights, more research is crucial for a complete understanding of these ecological relationships.

This statement is ambiguous. Could you provide a percentage that represents the extent to which studies assessing the impact of agriculture, livestock farming, and insect networks were well-represented?

Introduction

I believe that, in general, the introduction would benefit from additional examples of studies with results supporting the statements. Furthermore, separating the citations would make it easier to consult the papers of interest.

Anthropization is the process by w rm natural environments or ecosystems (*Steffen et al., 2011*). This multifa s a myriad of economic and political factors, including changes in land frastructure development, deforestation, agriculture, mining, and pollution, g the landscapes that sustain life on our planet (*Ellis & Ramankutty, 2008*; *ez, Cárdenas-García, 2017*). Within this context, the intricate relationships heir pollinators face unprecedented challenges and disruptions.

I believe that this statement needs a citation. Perhaps you can refer to this work: https://doi.org/10.3389/fevo.2022.806615. Alternatively, support the statement with other references used in our work

Studies exploring the impacts of ant-pollinator interaction networks h been pivotal in our understanding of how human activities have fundamentally altered thes ecological relationships. The focus of these investigations primarily centers on discerning t shifts in structural patterns within these networks. These changes are driven by an assortme influences, including disturbance gradients, land use modification, urbanization, habitat los fragmentation, which have been studied extensively in recent years (*Marrero, Torreta & M 2014*; *Moreira, Boscolo & Viana, 2015*; *Grass et al., 2018*; *Jauker et al., 2019*; *Newt 2018*; *Della Rocca et al., 2023*). Importantly, these same factors constitute the primar behind the alarming worldwide decline in pollinators (*Adedoja & Kehinde, 2018*).

This seems repetitive with the first paragraph. Please consider restructuring for better coherence and clarity.

The sensitivity of pollinators to habitat alterations is striking, resulting in reduction richness and abundance. Moreover, these alterations provoke shifts in species compo the foraging behavior of pollinators, with far-reaching ecological consequences (*Murcia, 1996; Aizen & Feinsinger, 2003*). Nevertheless, it is not a uniform decline, as anthropized ecosystems affect various species differently. Some species suffer harm, while others might even (*Ewers & Didham 2006*; *Steffan-Dewenter et al., 2007*). Furthermore, the conversion areas into cultivated land significantly modifies the abundance and availability of flo resources, the number of visits by pollinators, and the richness of these crucial specie (*Ricketts et al., 2008*). This transition can also disrupt the spatial and temporal stabili interactions (*Garibaldi et al., 2011a*).

I think it's important to separate the citations to facilitate the reader's access to the specific study of interest. Additionally, consider supporting the statement with more examples, possibly from more recent sources.

This seems to indicate changes in beta-diversity, which is important. Consider providing further explanation and supporting references.

Urbanization, a hallmark of anthropization, is associated w ric abundance of insect pollinator species. This decline is attribu iro pollution (*Morón & Márquez, 2012*), and the extensive use o cid green spaces (*Muratet & Fontaine, 2015*). Intriguingly, there ho differences have been identified in terms of pollinator abundance or diversity between urbanized and less urbanized areas (*Williams & Winfree, 2013*; *Vanbergen et al., 2014*; *Zakardjian et al., 2020*). A nuanced impact emerges when considering specialist and generalist pollinators. Specialists, which rely on a limited number of plant species for sustenance, are more severely affected by anthropization compared to generalists, which have a broader dietary range (*Bronstein, 1994*; *Kunin, 1997*; *Marrero, Torreta & Medan, 2014*; *Marín et al., 2020*).

Animal pollination is crucial for the sexual reproduction of the majority of flowering plants (*Kremen, James & Pitts-Singer, 2008*; *Campbell et al., 2012*; *Cardoza, Harris & Grozinger, 2012*). The efficiency of pollinators in transporting compatible pollen to plant stigmas profoundly influences reproductive success. Consequently, the decline in pollinators can trigger adverse impacts on the life cycle of zoogamous plants and lead to reductions in species populations (*Yao, Holt & Marshall, 1999*; *Lennartsson, 2002*). Habitat fragmentation, a frequent outcome of anthropization, is a known factor in the disruption of pollinator richness, abundance, and composition (*Kearns, Inouye & Waser, 1998*; *Young & Clarke, 2000*). It is often cited as the primary cause of reproductive impairment in fragmented habitats (*Aguilar et al., 2009*). Documented cases emphasize how habitat fragmentation and alterations in pollinatio affect the reproductive success of certain plants. However, the intricate relationship b habitat alteration and pollination is shaped by various factors, including plant-pollina specificity, the quality of fragmented habitat, and resource availability (*Jauker et al.,*

If you mention 'documented cases', it is important to support this with citations for these cases and perhaps explain how they affect pollination.

To truly grasp the impacts of habitat modification on species survival and commun composition, it is imperative to transcend species richness and recognize that all spec intricately interconnected by ecological interactions (*Valiente-Banuet et al., 2015*). P pollinator interactions exist as complex networks, organized into local groups of plants and pollinators (*Biella et al., 2019*). Network analysis emerges as a valuable tool, providing insights into the stability and functionality of plant-pollinator communities in ecosystems. Nonetheless, the influence of land use changes on insect diversity and the structure of their plant-insect interaction networks may be contingent on the intensity of the disturbance (*Escobedo-Kenefi et al., 2022*).

The primary objective of this review was to synthesize the existing body of literature concerning plant-pollinator interaction networks in anthropized environments. Our emphasis was on understanding the impact of human activities on the structural characteristics of these networks. We utilized various indices, including nestedness (NODF), specialization (H2), connectivity (C), and modularity (Q), to conduct our analysis. Additionally, using a meta-analysis, our review aimed to compare species richness of both pollinators and plants in anthropized and conserved environments. We assessed whether the effect size varied depending on factors such as the type of organism (plant or pollinator), the type of disturbance, the continent of study, authorship, and the size of fragmented areas where the revised studies were carried out. These assessments were conducted through a comprehensive meta-analysis, providing a more detailed understanding of the multifaceted impact of anthropization on plant-pollinator interaction networks.

Materials & Methods

Search protocol and data collection

A comprehensive literature search was conducted by KL-V and CL based on studies published from 2010 to 2023 in scientific journals reporting plant-pollinator interaction networks within anthropized environments. Keyword searches and their combinations were used. These included "interaction networks" AND "pollinators" AND "diversity" AND "fragmentation", OR "land use change", OR "habitat loss", along with specific terms such as "bats", "bees", "beetles", "birds", "butterfly", "flies", "hummingbirds" and "moth". Articles were retrieved through an intensive search in the public databases Web of Science and Scopus.

Selection criteria: After conducting the literature search, article titles and abstracts were reviewed to determine whether they met the inclusion criteria for the review. Only studies that assessed the impact of anthropogenic activities on structural patterns of plant-pollinator interaction networks, allowing for comparisons of pollinator and plant species richness within these networks, and studies that considered at least three sampling sites (see Figure 1) were included. Titles and abstracts were carefully examined to determine if the article met inclusion criteria for the review. Subsequently, articles meeting these criteria were re entirety. By adhering to these explicit inclusion and exclusion criteria, potential disag were resolved. In cases where discrepancies persisted, our co-authors were consulted decision was reached through a majority vote.

In order to describe the impact of anthropization on the structure of interaction networks between plants and pollinators, those studies employing network metrics such as nest

this phrase is repeated in this paragraph.

You didn't mention any exclusion criteria, only inclusion criteria

I believe that this part of the method introduces bias to the study because other researchers cannot obtain the same number of

(NODF), network specialization (H2’), connectivity (C), and modularity (Q) were included for our analyses. These network-level parameters allow for a comprehensive understanding of the overall structure of all interactions within the community.

It might be interesting to add another subtitle here related to interaction network metrics. In the next paragraphs, there is no discussion about 'Search protocol and data collection'.

Nestedness (NODF) is an asymmetric pattern of network specialization where specialis species exclusively (or predominantly) interact with generalists, while the generalists als interact with each other (*Jordano, Bascompte & Olesen, 2003*; *Guimarães et al., 2006*). T nestedness pattern holds significant ecological importance as it acts as a kind of insuranc long-term functioning of the ecosystem. It serves as a buffering mechanism against environmental variations (*Thébault & Fontaine, 2010*) and significantly contributes to th stability of such networks (*Bastolla et al., 2009*; *Thébault & Fontaine, 2010*) by promotir greater resilience to extinction for well-connected generalist species (*Aizen, Sabatino & Tylianakis, 2012*).

Connectance (C) is a parameter that measures the proportion of observed interactions relative to all possible interactions within the network and is used to assess the complexity of a network. Citation From a conservation perspective, there is a desire to maintain high levels of connecta provides stability and resilience to the network. Additionally, connectance is closely related to species richness in each community and, therefore, the size of the network. As the network size increases, interactions that do not involve species become more frequent, which decreases the value of connectance (*Jordano, 1987*).

Network specialization (H2’) is a parameter that measures the degree of specialization (or selectivity) of the network, with values ranging from 0 to 1. When values are close to 0, the network consists mainly of generalist species, indicating low specialization. Conversely, values close to 1 indicate that the network is highly specialized, with a predominance of specialist species (*Blüthgen, Menzel & Blüthgen, 2006*). Particularly, specialization in plant-pollinator interactions can be a successful strategy in stable and specific environments, but in areas with anthropogenic activities, it can make species more vulnerable to changes and disturbances in their surroundings. Citation

Modularity (Q) is a parameter that indicates whether there is a group of individuals or species that have more interactions among themselves than with other groups in the network (*Marquitti et al., 2014*). It has been observed that the modularity of networks increases their robustness against disturbances, as specialized interactions are concentrated within the modules and do not affect other species outside of those modules (*Stouffer & Bascompte, 2011*). Additionally, modules can have specific ecological functions, so if one module is negatively affected by a disturbance, other modules can partially compensate for the loss of function, maintaining the overall functional stability of the network (*Montoya, Pimm & Solé, 2006*). However, highly modular networks also inevitably exhibit lower overall connectivity and thus lower overall redundancy, which could reduce resilience to secondary extinctions (*Thébault & Fontaine, 2010*).

Statistical analyses

A synthesis was conducted on the potential impact of anthropization on the structural patterns of plant-pollinator interaction networks, describing the decrease, increase, or lack of effect as reported by the authors (see Table 1). As an initial step in assessing the impact of anthropogenic activities on the structure of plant-pollinator interaction networks, we examined variations in metric values associated with network structural patterns, such as NODF, H2, connectance, and modularity (as response variables), across different anthropogenic activities, including land use change, urbanization, fragmentation, agriculture, and livestock (as a fixed factor), using analysis of variance (ANOVA). To identify specific groups of anthropogenic activities that displayed significant differences in their network metric values, we utilized Tukey post hoc tests. These tests were performed using the R Studio software (*R Core Team, 2020*).

Effect size calculation

To conduct a meta-analysis, it was necessary to determine an effect size that could be summarized across all studies. In this regard, the effect size is defined as a metric that quantifies the relationship between two entities, capturing the direction and magnitude of this relationship (*Harrer et al., 2021*). The effect size was selected using the standardized mean difference (SMD), with the Hedges' g correction for small samples (*Hedges & Vevea, 1996*). This was because the means of plant and pollinator richness between preserved and anthropized environments were the most frequently reported response variables in the collected articles. The calculation of SMD for each study involved subtracting the mean of pollinator or plant richness from the preserved site from the mean of pollinators and plants from the anthropized site in each respective study, and then dividing this difference by the pooled standard deviation (*Harrer et* *al., 2021*). Positive values indicate a higher number of pollinators or plants in the preserved site, while negative values indicate the opposite. A value of 0 represents the absence of an effect size. When means and standard deviations were not reported in an article, other reported statistics that could be converted to SMD, such as correlation coefficients, chi-square (χ^2), one-way ANOVA, and two-sample t-test, along with their corresponding formulas, were used (*Harrer et al., 2021*). In cases where a document did not provide any of these data, it was excluded from the meta-analysis.

Meta-analysis and meta-regressions

The limited number of studies conducted in a semi-arid climate prevented its inclusion as a category in the meta-analysis. Consequently, these were included within the category of studies in tropical climates and analyzed accordingly. Additionally, only one study included in the review examined livestock as an anthropogenic activity; therefore, this activity was not included as a category in the analyses.

For the meta-analysis, a random-effects model was employed. This model assumes that studies do not reflect a single true effect due to differences in populations, interventions, comparators, or outcome assessment methods (*Fernández-Chinguel et al., 2019*). This approach allowed the comparison of results across different studies, even when they did not measure the parame interest in the same way. The maximum likelihood (ML) method was used to obtain tau^2, v measures the variability between the effects of different studies (*Higgins, 2011*), and the Ja method was used to calculate confidence intervals for tau^2 and tau (*Borenstein et al., 2009*) enhance the robustness of our analysis, outlier effect sizes were excluded. Outliers were identified when the confidence intervals fell outside the confidence interval of the summar effect (*Higgins, 2011*). All analyses were conducted using the dmetar, meta, and metafor packages in the R Studio programming environment (*Viechtbauer, 2010*), and the results displayed in forest plots. In these forest plots, when the confidence interval of an effect si not intersect with the null vertical line on the 'effect sizes' axis, it suggests a significant difference in the response variable influenced by the studied factor. Furthermore, if multi confidence intervals do not cross the null line in the same direction, this may indicate consistency in the results and stronger evidence of a significant difference. A *t* test was performed to determine if the size effect was different from the nule value (zero). The *Q*-t

In addition to mentioning the packages, please provide information on the specific functions used for the analysis and cite the authors of these packages.

Previously, you mentioned 'R Studio software,' and now you referred to 'R Studio programming environment.' Please use a consistent definition; I recommend the latter.

used to compare the observed value to the expected value (i.e. residual heterogeneity, *QE*), assuming a chi-squared (χ^2) distribution with degrees of freedom k-1, where k is the number of studies. If the observed value was significantly greater than the expected value, the *p*-value from the test indicated the presence of a real difference in effect sizes among subgroups (*Higgins, 2011*). Also, we calculated the I^2 statistic, which determines the percentage of the total variability in a set of effect sizes due to true heterogeneity, that is, the between-study variance (*Gurevitch & Nakagawa, 2015*).

Additionally, subgroup analysis was performed to determine if the pattern of heterogeneity in effect size was related to the group of organisms evaluated (pollinators and plants), climate, continent, or anthropogenic activity. The model for subgroup analyses is a mixed-effects model, because contains both random effects (within subgroups) and fixed effects (since subgroups are assumed to be fixed). The *Q*-test was used to compare the observed value to the expected value (i.e. residual heterogeneity, QE), assuming a chi-squared (χ^2) distribution with degrees of freedom G-1, where G is the number of groups. If the observed value was significantly greater than the expected value, the *p*-value from the test indicated the presence of a real difference in effect sizes among subgroups (*Higgins, 2011*). Also, we calculated the I^2 statistic for each subgroup.

Furthermore, a meta-regression was conducted to identify specific continuous variables explaining heterogeneity between studies (*Borenstein et al., 2009*; *Koricheva, Gurevitch & Mengersen, 2013*). In this type of analysis, one or more predictor variables can be used to predict real differences in effect sizes, considering mixed-effects models (*Higgins, 2011*). In the following predictor variables were employed: 1) habitat fragment size where the conducted (total coverage in square meters), 2) year of study publication, 3) year of s The model was constructed using a stepwise (forward) approach, where predictor var added one by one. Comparison between the full model and the reduced model was pe using the likelihood ratio test. If the full model proved superior to the reduced model, variable was retained, and the next variable was added. The Knapp-Hartung adjustme to obtain more robust estimators, especially when the number of studies was low (*Hi*

Why are these variables important as predictor variables, and how can you justify the use of the year of publication if you are also using the year of sampling (which seems more appropriate)?

2011). Finally, permutations were used to assess the robustness of the model through resampled data (*Higgins, 2011*). In this analysis, *p*-values were recalculated based on test statistics obtained from all possible permutations or a random selection of permutations from the original dataset. If the test statistic was equal to or greater than the original value in 50 out of 1000 permutations, a *p*-value of 0.05 was established for that predictor.

Results

Network metrics from a total of 38 articles published between 2010 and 2023, were use ANOVAs. This dataset is representative across four continents. The most prominently represented anthropogenic activities included agriculture and livestock farming. Further most well-represented taxon was that of insects (see Figure 2 and Table 1). The nestedn metric showed no effect in nine studies, decreased in fourteen, and increased in two out of the 25 studies reviewed. Concerning H2', ten articles exhibited no effect, seven indicated a decre and nine showed an increase in the 26 studies that used this metric. Regarding connectanc seven publications did not record an increase, while seven indicated an increase, and eight demonstrated a decrease in the 22 studies analyzed. In terms of modularity, eight articles s an increase, three exhibited no effect, and one indicated a decrease out of the 12 studies in this metric was assessed (see Table 1). Our ANOVAs revealed that anthropogenic activiti varying effects on metrics associated with the structure of plant-pollinator interaction networks. NODF values showed significant variation among different anthropogenic activities in the studies we evaluated (F = 16.15, *d.f.* = 2, p = 0.007), with agriculture (p = 0.001) and fragmentation (p = 0.009) being the primary determining factors. A similar significant effect was observed for specialization (H2') (F = 0.02, *d.f.* = 3, p = 0.02), where land use change (p = 0.02) and fragmentation (p = 0.03) contributed to these differences. Conversely, no significant differences were found among anthropogenic activities in their effects on connectance values (F = 0.9, *d.f.* = 3, p = 0.46). Regarding modularity, ANOVA was not applicable due to the limited sample size of the reviewed studies and the lack of variance homogeneity

I believe providing a percentage or a specific number of the articles would enhance understanding of this well-representation and eliminate ambiguity.

If you use the names of the metrics, please do so for all the metrics described. I think standardization is necessary throughout the document.

Meta-analysis

For the meta-analyses, only 16 out of the 38 studies met the inclusion criteria, and for the final dataset used, 36 effect sizes were included (16 for plant species and 20 for pollinator species). The average effect size was 0.52, with a 95% confidence interval ranging from 0.07 to 0.96. The associated *p*-value was significant (t = 2.37, *d.f.*= 35, p=0.02), indicating that anthropogenic disturbance reduces the richness of pollinators and plants (see Figure 3). The value of tau^2 was

This seems more like a discussion than a result.

1.21, while the I^2 value was 83.8%. The test of heterogeneity was significant (Q = 215.75, *d.f.*= 35, $p < 0.0001$), suggesting variability in effect sizes among different studies. The results indicated a statistically significant difference in the richness of pollinator species between conserved and disturbed sites. Both pollinators and plants are more vulnerable in sites with anthropogenic activities, as they exhibit lower species richness. However, there is also significant heterogeneity among the studies. This suggests that the actual effect may vary depending on the type of disturbance or that additional factors, beyond disturbance, may influence species richness of pollinators at different sites (see Table 2, Figure 3).

Subgroup Analysis

A subgroup analysis revealed significant differences in the observed effects within subgroups of pollinators, plants, continents, and anthropogenic activities and climate subgroup (see Table 2).

Pollinators and Plants. The group of 'Pollinators' showed the largest effect size (g = 0.13) compared to 'Plants' (g = 0.79; Table 2). The Tau^2 value for 'Pollinators' (τ^2=0.88) indicates low heterogeneity, meaning that the studies regarding this group are consistent in their findings. On the other hand, the Tau^2 value for 'Plants' (τ^2 = 1.37) indicates a moderate level of heterogeneity, suggesting that there is some variability in the effect sizes reported in the studies concerning this group. This variability may be due to differences in study characteristics, methodologies, or other factors that influence the relationship between 'Pollinators' and the structure of the studied networks.

Anthropogenic Activity. Our results indicate that 'Fragmentation'have the most significant effect (g =2.07, Table 2) on the outcome variable within the anthropogenic activity category. The high SMD value suggest that this activity have a substantial impact on the richness of plant-pollinator networks, and the low Tau^2 value (τ^2 = 0.11, Table 2) indicate that this effect was consistent among the different studies within this subgroup. We can also observe that the other types of antropogenic disturbances had similar negative effects in plant and pollinators richness (Table 2).

Continent. Our results indicate differences in the effect sizes and levels of heterogeneity among continents. 'America' has the largest effect size (g = 0.66, Table 2) observed moderat heterogeneity between-study (τ^2 = 2.64, Table 2). 'Asia' has a low effect size (g = 0.3 moderate heterogeneity (τ^2=1.59 Table 2). 'Africa' and 'Europe' have smaller effect sizes (g =

Isn't this the smaller effect size ?

0.5 and *g*=0.5, respectively) with moderate levels of heterogeneity (τ^2=0.84 and τ^2=0.57 Table 2). The differences in effect sizes and heterogeneity may be attributed to regional variations, such as different environmental factors, study methodologies, or other factors that affect the relationship between anthropogenic activities and plant-pollinator networks richness in these continents.

Climate. Our results indicated a larger effect size in studies conducted in tropical climates (*g*=1.08), with an intermediate level of heterogeneity among these studies (*g*=-0.02) with slightly lower heterogeneity (τ^2=0.77) compared to the former.

Meta-regression

A meta-regression analysis was conducted to identify quantitative variables that could act as sources of heterogeneity and explain differences in effect size between studies. The model used in this analysis exhibited a significant amount of residual heterogeneity that is explained by the fragment size variable (QE = 180.53, $d.f.$ = 33, p = <0.0001). In combining variables that could explain our meta-analysis results, in addition to fragment size, we included the year of sampling (QE = 206.90, $d.f.$ = 34, p = <0.0001) and the year of publication of the studies (QE = 215.17, $d.f.$ = 34, p = <0.001). Their values were found to be significant. Furthermore, after conducting permutations, however there was insufficient evidence to assert a significant relationship between fragment size, year of sampling, and year of publication variables (QE = 178.06, $d.f.$ = 31, p = 0.52).

Discussion

Identifying the structural patterns most susceptible to alterations caused by anthropogenic activities in the plant-pollinator interaction network allows us to anticipate the potential consequences of anthropogenic impacts on biodiversity. Our results showed that the most impactful activities in this research are related to agriculture and fragmentation. These acti[...] are widely practiced worldwide. Some articles have examined how these agricultural activi[...] affect plants and their pollinators. They explain how intensified agriculture can influence t[...] availability of native pollinators for crops, affecting food production. This highlights that g[...] expanses of natural habitats contribute to increased stability and predictability of pollinatio[...] services (*Tscharntke et al., 2005*; *Sardiñas & Kremen, 2014*).

Actually, mutualistic interactions can be more susceptible to anthropogenic changes than single species. I'm not sure about this statement; perhaps you need to be more specific about it.

Citation

Furthermore, it has been observed that agricultural practices can affect pollinator populations such as bees, a widely studied taxonomic group in plant-pollinator interaction networks. It has been noted how monocultures and pesticide use impact not only populations of wild bees but also other pollinators (*Roulston & Goodell, 2011*; *Garibaldi et al., 2011b*). It's worth mentioning that a significant transformation of natural ecosystems into agricultural land is projected to reach 109 million hectares by 2050. This transformation is expected to have substantial implications for the environment, such as increased nitrogen and phosphorus-driven eutrophication and pesticide use (*Tilman et al., 2001*).

Citation

How can this be related to the results in this research?

Although our study did not find significant effects of activities such as livestock farming, urbanization, land-use change, and intentional fires on interaction networks, it's important to consider that these results may be due to the study's limitation in focusing solely on structural patterns of networks. However, other research suggests that these activities also contribute to climate change, which can affect plants through alterations in temperatures, precipitation patterns, and atmospheric carbon dioxide levels, favoring invasive species over native ones (*Dukes & Mooney, 1999*). It has also been examined that when analyzing livestock farming independently from agriculture, how livestock impact pollinator visitation frequency can vary and is further modified by changes in vegetation cover caused by livestock presence (*Tadey, 2008*).

On the other hand, changes in land use can vary in intensity, but in all cases, they cause habitat alterations that affect pollinator populations. This effect is mainly evident through the alteration of floral resources; its impact varies depending on specific characteristics of pollinators, such as specialization, mobility, sociability, nesting sites, and phenology (*Lázaro & Tur, 2018*). Regarding the impact of intentional fires on pollinators, most studies are limited to comparing burned areas with unburned areas (*Carbone et al., 2019*). The overall results of the two analyzed studies indicated a positive effect on pollinator richness. However, a slight impact on Lepidoptera richness was identified (*Peralta et al., 2017*; *Da Silva, 2022*). Regarding the effects of anthropization on the structural patterns of interaction networks, previous research supports our results, concluding that the metrics used (NODF, H2', C, and Q) are particularly sensitive to environmental changes (*Aguilar et al., 2009*; *Ferreira, Boscolo & Viana, 2013*; *Soar... & Lopes, 2017*). However, contrary to our findings, other studies have indicated that data available suggest that nesting is not affected by habitat disturbance. Instead, H2'...

Citation

Could you please specify which studies are being referred to?

show responses similar to those obtained in this study. Furthermore, changes in the roles of species are also described, with oscillations between generalists and specialists in different conditions. This is because in situations of lower environmental quality, specialist species with morphological and behavioral limitations tend to be lost, as observed in previous research (*Ferreira, Boscolo & Viana, 2013*).

The reviewed studies indicate that, although network nesting exhibited different effects on anthropogenic activities, we can infer that the explanation for the fourteen studies where nesting tends to decrease is that authors have observed that any disturbance resulting from anthropogenic activities affects total species richness and the abundance of interactors, which decreases with habitat loss (*Spiesman & Inouye, 2013*). This is because a reduction in species richne the network size, and in turn, the number of interactions (links) by generalist species. related to specialization results (H2’), where an increase was observed in most studies. In some cases, no effect was recorded concerning the different impacts of anthropogenic activities. This can be attributed to the loss of specialist species, the increase in generalist species, and the decrease of pollinators specialized in plants sensitive to environmental changes (*Weiner et al., 2014*). Furthermore, this is confirmed by the analysis of variance, which shows that there are indeed significant differences between anthropogenic activities concerning this metric, as it demonstrates that specialization increases in studies where agricultural activities are present.

Could you please support this with references?

Consequently, these changes can reduce network robustness, which is less robust o susceptible when core species are extinguished due to potential alterations in the spec comprise it, resulting in an imbalance in communities. Furthermore, some articles argue that reduced nesting may be due to the reduction of lower-quality environmental areas (*Burkle, Marlin & Knight, 2013*; *Vanbergen et al., 2014*; *Moreira, Boscolo & Viana, 2015*). An example of this is the observation of a rapid decrease in species diversity over a short period, which primarily affects specialist species and leads to a narrowing of the niche for the remaining generalist species (*Burkle, Marlin & Knight, 2013*; *Moreira, Boscolo & Viana, 2015*). However, in the long term, an even more intense reduction in diversity can be observed, also impacting generalist species (*Burkle & Knight, 2012*). Furthermore, the increase and lack of effect on nesting in the 11 presented studies could be linked to the concentration of interactions by generalist species, both in plants and pollinators (*Jauker et al., 2019*; *Díaz Infante, Lara & Arizmendi, 2020*; *Morrison & Dirzo, 2020*; *Motivans et al., 2021*; *Escobedo-Kenefic, 2022*).

Could you please support this with references?

Regarding network connectance, it did not generally change, although it increased in seven studies and decreased in eight. While we may consider that network connectance is not significantly affected in most studies, it's essential to note that some research has found large, highly connected networks in agricultural areas due to the presence of flowering herbaceous plants and fruit trees (*Aavik et al., 2008*). In this regard, some studies suggest that conservation efforts should focus on preserving highly connected communities, seeking empirical evidence of a relationship between connectance (complexity) and the conservation value of communities at different stages of degradation (*Prendergast & Ollerton, 2021*).

As for modularity, the results showed an increase, likely because interaction networks in fragmented sites tend to exhibit modular patterns. This is due to the high specialization in these sites, given the limited number of interacting species (*Santamaría et al., 2018*; *Morrison & Dirzo, 2020*; *Librán-Embid et al., 2021*). However, this modularity could result from a temporal relationship influenced by species phenology (*Morente-López et al., 2018*; *Lázaro & Gómez-Martínez, 2022*). As a result, the meta-analysis results showed that there is an impact richness of interacting species of both plants and pollinators. While two previous studies have evaluated the impact of these activities, none have focused on describing what happens to species richness within interaction networks. Furthermore, these studies have been limited to the group of bees or insects, where the results have been similar to those obtained in this s contrast, in the meta-analysis, the magnitude of the effects was not as significant.

It has also been shown that the only type of anthropogenic activity that has a negativ agriculture, an activity performed extensively in many parts of the world where there i little natural habitat left (*Winfree et al., 2009*). It has also been demonstrated that as th richness of plants increases in anthropized sites, the species richness of pollinators als As the richness of plant species increases in anthropized areas, there is also an increase pollinator gesting that strategies to enhance plant species diversity promote p *al-O'Brien et al., 2021*). These findings may also relate results obt ression analyses, where we explored the influence of p year, samp nt size on the effect size. While two of these variables (publicatio year) did not yield statistically significant results, they explain wh a declining trend in species richness within interaction networks due to anth In contrast, the fragment size variable did yield significant

Citation

I find it not entirely accurate, as you also mentioned that other kinds of anthropogenic activities result in changes in plant and pollinator diversity. It's important to be cautious when stating 'the only type of anthropogenic activity that has a negative effect is agriculture,' especially considering that agriculture is associated with land-use change, fragmentation, and other anthropogenic activities. Please remember to acknowledge the limitations of your study and consider the context of the analyzed metrics.

Here, it's crucial to exercise caution. An increase in richness is not necessarily a positive outcome. It's essential to consider the complexity of metrics and how changes in the network structure may impact specialist species or key species within the network.

results. In this context, the composition of vegetation cover in the fragments confirms that having a greater number of flowering species can attract more pollinators (*Herrera, 1987*).

Finally, our results indicated a larger effect size in studies conducted in tropical climates compared to those conducted in temperate climates. During our data compilation, we found a higher number of studies carried out in areas with tropical climates. This bias may be related to the fact that the majority of terrestrial biodiversity is found in tropical forests (*Dáttilo & Rico-Gray, 2018*). Therefore, it is in these areas where a greater number of studies regarding plant-pollinator interactions are conducted. This suggests the need for a greater number of studies that delve more deeply into the impacts of anthropization on plant-pollinator interaction networks in temperate climate zones around the world.

Conclusions

An in-depth analysis of patterns in plant-pollinator interaction networks shows a wide range of responses to human activities. The study suggests that intensified agriculture and habitat fragmentation are significant factors harming biodiversity and species interactions. While our results didn't reveal major effects from activities like livestock farming, urbanization, land-use changes, or intentional fires, it's possible these impacts are underestimated because we focused on network structural patterns. Our findings suggest that metrics such as nestedness, H2', connectance, and modularity are useful for assessing how human activities affect these networks. Nestedness often decreases, likely due to habitat loss and a decline in species, affecting overall diversity and interaction abundance. Connectance and modularity show variable responses, but studies emphasize the importance of protecting well-connected communities.

Our study demonstrates that the impact of anthropogenic activities on plant-pollinator networks is complex, context-dependent, and varies across different taxa and regions. The findings underscore the importance of considering these factors when designing conservation strategies and policies aimed at mitigating the negative effects of anthropogenic activities on biodiversity within these networks. Further research may be needed to identify additional variables that contribute to the observed heterogeneity and to develop more targeted conservation approaches.

Acknowledgements

This work constitutes partial fulfillment of Karla María López-Vázquez's doctorate degree requirements at UAM.

References

Adedoja O, Kehinde T. 2018. Changes in interaction network topology and species composition of flower-visiting insects across three land use types. *African Journal of Ecology* **56:** 964–971. DOI: 10.1111/aje.12527.

Aguilar R, Ashworth L, Cagnolo L, Jausoro M, Quesada M, Galetto L. 2009. Dinámica de interacciones mutualistas y antagonistas en ambientes fragmentados. In: *Ecología y evolución de interacciones planta-animal.* Editorial Universitaria, 199–232

Aizen MA, Feinsinger P. 2003. Bees not to be? Responses of insect pollinator faunas and flower pollination to habitat fragmentation. In: Bradshaw G, Marquet P, Moonet, HA, eds. *How landscapes change: human disturbance and ecosystem disruption in the Americas*. New York .: Springer-Verlag.

Aizen MA, Sabatino M, Tylianakis JM. 2012. Specialization and rarity predict nonrandom loss of interactions from mutualist networks. *Science* **335:** 1486–1489. DOI: 10.1126/science.1215320.

Aavik T, Jõgar Ü, Liira J, Tulva I, Zobel M. 2008. Plant diversity in a calcareous wooded meadow - The significance of management continuity. *Journal of Vegetation Science*, **19:** 475–484. DOI: 10.3170/2008-8-18380.

Bastolla U, Fortuna MA, Pascual-García A, Ferrera A, Luque B, Bascompte J. 2009. The architecture of mutualistic networks minimizes competition and increases biodiversity. *Nature* **458:** 1018–1020. DOI: 10.1038/nature07950.

Biella P, Akter A, Ollerton J, Tarrant S, Janeček Š, Jersáková J, Klecka J. 2019. Experimental loss of generalist plants reveals alterations in plant-pollinator interactions and a constrained flexibility of foraging. *Scientific Reports* **9:** 1–13. DOI: 10.1038/s41598-019-43553-4.

Blüthgen N, Menzel F, Blüthgen N. 2006. Measuring specialization in species interaction networks. *BMC Ecology* **6:** 1–12. DOI: 10.1186/1472-6785-6-9.

Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. 2009. Introduction to Meta-Analysis: John Wiley & Sons. 1st Edition, 452 p.

Bronstein JL. 1994. Conditional outcomes in mutualistic interactions. *Trends in Ecology & Evolution* **9:** 214–217. DOI: 10.1016/0169-5347(94)90246-1.

Burkle LA, Knight TM. 2012. Shifts in pollinator composition and behavior cause slow interaction accumulation with area in plant–pollinator networks. *Ecology* **93:** 2329–2335. DOI: 10.1890/12-0367.1.

Burkle LA, Marlin JC, Knight TM. 2013. Plant-pollinator interactions over 120 years: loss of species, co-occurrence, and function. *Science* **339:** 1611–1615. DOI: 10.1126/science.1232728.

Campbell C, Yang S, Shea K, Albert R. 2012. Topology of plant-pollinator networks that are vulnerable to collapse from species extinction. *Physical Review E* **86:** 021924. DOI: 10.1103/PhysRevE.86.021924.

Carbone LM, Tavella JR, Pausas JG, Aguilar R. 2019. Efecto del fuego sobre los polinizadores: Una revisión global. Primera Reunión de la Red de Investigadores en Biología de la Polinización de Argentina. CABA; Argentina

Cardoza YJ, Harris GK, Grozinger CM. 2012. Effects of soil quality enhancement on pollinator-plant interactions. *Psyche Journal of Entomology* **2012:** 1–18. DOI: 10.1155/2012/581458.

Da Silva Goldas C, Podgaiski LR, Veronese Corrêa da Silva C, Abreu Ferreira PM, Vizentin-Bugoni J, De Souza Mendonça M. 2022. Structural resilience and high interaction dissimilarity of plant–pollinator interaction networks in fire-prone grasslands. *Oecologia* **198:** 179–192. DOI: 10.1007/s00442-021-05071-x.

Dáttilo W, Rico-Gray V. 2018. Ecological networks in the tropics an integrative overview of species interactions from some of the most species-rich habitats on earth. Cham, Switzerland: Springer International Publishing.

Della Rocca F, Tagliani A, Milanesi P, Barcella M, Assini SP. 2023. Contrasting response of mountain plant-pollinator network to fragmented semi-natural grasslands. *Land* **12:** 356. DOI: 10.3390/land12020356.

Díaz Infante S, Lara C, Arizmendi MDC. 2020. Land-use change in a Mexican dry forest promotes species turnover and increases nestedness in plant-hummingbird network: are exotic plants taking over. *Tropical Conservation Science* **13:** 1–15. DOI: 10.1177/1940082920978952.

Dukes JS, Mooney HA. 1999. Does global change increase the success of biological invaders? *Trends in Ecology & Evolution* **14:** 135–139. DOI: 10.1016/S0169-5347(98)01554-7.

Ellis EC, Ramankutty N. 2008. Putting people in the map: anthropogenic biomes of the world. *Frontiers in Ecology and the Environment* **68:** 439–447. DOI: 10.1890/070062.

Escobedo-Kenefic N, Casiá-Ajché QB, Cardona E, Escobar-González D, Mejía-Coroy A, Enríquez E, Landaverde-González P. 2022. Landscape or local? Distinct responses of flower visitor diversity and interaction networks to different land use scales in agricultural tropical highlands. *Frontiers in Sustainable Food Systems* **6:** 589. DOI: 10.3389/fsufs.2022.974215.

Ewers RM, Didham RK. 2006. Confounding factors in the detection of species responses to habitat fragmentation. *Biological Reviews* **81:** 117–142. DOI: 10.1017/S1464793105006949.

Fernandez-Chinguel JE, Zafra-Tanaka JH, Goicochea-Lugo S, Peralta CI, Taype-Rondan A. 2019. Aspectos básicos sobre la lectura de revisiones sistemáticas y la interpretación de meta-análisis. *Acta Médica Peruana* **36:** 157–169. DOI: 10.35663/amp.2019.362.818.

Ferreira PA, Boscolo D, Viana BF. 2013. What do we know about the effects of landscape changes on plant–pollinator interaction networks? *Ecological Indicators* **31:** 35–40. DOI: 10.1016/j.ecolind.2012.07.025.

Garibaldi LA, Aizen MA, Klein AM, Cunningham SA, Harder LD. 2011a. Global growth and stability of agricultural yield decrease with pollinator dependence. *Proceedings of the National Academy of Sciences* **108:** 5909–5914. DOI: 10.1073/pnas.1012431108.

Garibaldi LA, Steffan-Dewenter I, Kremen C, Morales JM, Bommarco R, Cunningham SA, Carvalheiro LG, Chacoff NP, Dudenhöffer JH, Greenleaf SS, Holzschuh A, Isaacs R, Krewenka K, Mandelik Y, Mayfield MM, Morandin LA, Potts SG, Ricketts TH, Szentgyörgyi H, Westphal C, Winfree R, Klein AM. 2011b. Stability of pollination services decreases with isolation from natural areas despite honey bee visits. *Ecology Letters* **14:** 1062–1072. DOI: 10.1111/j.1461-0248.2011.01669.x.

Grass I, Jauker B, Steffan-Dewenter I, Tscharntke T, Jauker F. 2018. Past and potential future effects of habitat fragmentation on structure and stability of plant–pollinator and host–

parasitoid networks. *Nature Ecology & Evolution* **2:** 1408–1417. DOI: 10.1038/s41559-018-0631-2.

Guimarães JrPR, Rico-Gray V, Furtado dos Reis S, Thompson JN. 2006. Asymmetries in specialization in ant–plant mutualistic networks. *Proceedings of the Royal Society B: Biological Sciences* **273:** 2041–2047. DOI: 10.1098/rspb.2006.3548.

Gurevitch J, Nakagawa S. 2015. *Research synthesis methods in ecology*. In: Fox G, Negrete-Yankelevich S, Sosa V, eds. Ecological statistics. New York: Oxford University Press, 200–227.

Harrer M, Cuijpers P, Furukawa TA, Ebert DD. 2021. *Doing Meta-Analysis with R: A Hands-On Guide.* Boca Raton, FL and London: Chapman & Hall/CRC Press.

Hedges LV, Vevea JL. 1996. Estimating effect size under publication bias: Small sample properties and robustness of a random effects selection model. *Journal of Educational and Behavioral Statistics* **21:** 299–332. DOI: 10.2307/1165338.

Herrera CM. 1987. Components of pollinator "quality": comparative analysis of a diverse insect assemblage. *Oikos* **50:** 79–90. DOI: 10.2307/3565403.

Higgins JP. 2011. Cochrane handbook for systematic reviews of interventions. Version 5.1. 0 [updated March 2011]. The Cochrane Collaboration. *www. cochrane-handbook. org*.

Jauker F, Jauker B, Grass I, Steffan-Dewenter I, Wolters V. 2019. Partitioning wild bee and hoverfly contributions to plant–pollinator network structure in fragmented habitats. *Ecology* **100:** e02569. DOI: 10.1002/ecy.2569.

Jordano P. 1987. Patterns of mutualistic interactions in pollination and seed dispersal: connectance, dependence asymmetries, and coevolution. *The American Naturalist* **129:** 657–677. DOI: 10.1086/284665.

Jordano P, Bascompte J, Olesen JM. 2003. Invariant properties in coevolutionary networks of plant-animal interactions. *Ecology Letters* **6:** 69–81. DOI: 10.1046/j.1461-0248.2003.00403.x.

Kearns CA, Inouye DW, Waser NM. 1998. Endangered mutualisms: the conservation of plant-pollinator interactions. *Annual Review of Ecology and Systematics* **29:** 83–112. DOI: 10.1146/annurev.ecolsys.29.1.83.

Kleian S, Mogea J, Pitopang R, Schaefer M, Schwarze S, Sporn SG, Steingrebe A, Tjitrosoedirdjo SS, Tjitrosoemito S, Twele A, Weber R, Woltmann L, Zeller M,

Tscharntke, T. 2007. Tradeoffs between income, biodiversity, and ecosystem functioning during tropical rainforest conversion and agroforestry intensification. *Proceedings of the National Academy of Sciences* **104:** 4973–4978. DOI: 10.1073/pnas.0608409104.

Kral-O'Brien KC, O'Brien PL, Hovick TJ, Harmon JP. 2021. Meta-analysis: Higher plant richness supports higher pollinator richness across many land use types. *Annals of the Entomological Society of America* **114:** 267–275. DOI: 10.1093/aesa/saaa061.

Kremen C, James RR, Pitts-Singer T L. 2008. *Crop pollination services from wild bees*. Bee pollination in agricultural ecosystems, Oxford University Press, New York, New York, USA (2008), p. 10–26.

Koricheva J, Gurevitch J, Mengersen K. 2013. *Handbook of meta-analysis in ecology and evolution*. Princeton University Press.

Kunin WE.1997. Population size and density effects in pollination: Pollinator foraging and plant reproductive success in experimental arrays of Brassica kaber. *Journal of Ecology* **85:** 225–234. DOI: 10.2307/2960653.

Lázaro A, Tur C. 2018. Los cambios de uso del suelo como responsables del declive de polinizadores. *Ecosistemas* **27:** 23–33. DOI: 10.7818/ECOS.1378.

Lázaro A, Gómez-Martínez C. 2022. Habitat loss increases seasonal interaction rewiring in plant–pollinator networks. *Functional Ecology* **36:** 2673–2684. DOI: 10.1111/1365-2435.14160.

Lennartsson T. 2002. Extinction thresholds and disrupted plant-pollinator interactions in fragmented plant populations. *Ecology* **83:** 3060–3072. DOI: 10.2307/3071842.

Librán-Embid F, Grass I, Emer C, Ganuza C, Tscharntke T. 2021. A plant–pollinator meta-network along a habitat fragmentation gradient. *Ecology Letters* **24:** 2700–2712. DOI: 10.1111/ele.13892.

Marín L, Martínez-Sánchez ME, Sagot P, Navarrete D, Morales H. 2020. Floral visitors in urban gardens and natural areas: Diversity and interaction networks in a neotropical urban landscape. *Basic and Applied Ecology* **43:** 3–15. DOI: 10.1016/j.baae.2019.10.003.

Marquitti FMD, Guimaraes JrPR, Pires MM, Bittencourt LF. 2014. MODULAR: software for the autonomous computation of modularity in large network sets. *Ecography* **37:** 221–224. DOI: 10.1111/j.1600-0587.2013.00506.x.

Marrero HJ, Torretta JP, Medan D. 2014. Effect of land use intensification on specialization in plant–floral visitor interaction networks in the Pampas of Argentina. *Agriculture, Ecosystems & Environment* **188:** 63–71. DOI: 10.1016/j.agee.2014.02.017.

Mellink E, Riojas-López ME, Cárdenas-García M. 2017. Biodiversity conservation in an anthropized landscape: Trees, not patch size drive, bird community composition in a low-input agro-ecosystem. *PLoS One* **12:** e0179438. DOI: 10.1371/journal.pone.0179438.

Montoya JM, Pimm SL, Solé RV. 2006. Ecological networks and their fragility. *Nature* **442:** 259–264. DOI: 10.1038/nature04927.

Moreira EF, Boscolo D, Viana BF. 2015. Spatial heterogeneity regulates plant-pollinator networks across multiple landscape scales. *PLoS ONE* **10:** e0123628. DOI: 10.1371/journal.pone.0123628.

Morente-López J, Lara-Romero C, Ornosa C, Iriondo JM. 2018. Phenology drives species interactions and modularity in a plant–flower visitor network. *Scientific Reports* **8:** 9386. DOI: 10.1038/s41598-018-27725-2.

Morón MÁ, Márquez J. 2012. Nuevos registros estatales y nacionales de escarabajos (Coleoptera: Scarabaeoidea) y comentarios sobre su distribución. *Revista Mexicana de Biodiversidad* **83:**698–711. DOI: 10.7550/rmb.28386.

Morrison BM, Dirzo R. 2020. Distinct responses of antagonistic and mutualistic networks to agricultural intensification. *Ecology* **101:** e03116. DOI: 10.1002/ecy.3116.

Motivans Švara E, Ştefan V, Sossai E, Feldmann R, Aguilon DJ, Bontsutsnaja A, E-Vojtkó A, Kilian IC, Lang P, Mõtlep M, Prangel E, Viljur ML, Knight TM, Neuenkamp L. 2021. Effects of different types of low-intensity management on plant-pollinator interactions in Estonian grasslands. *Ecology and Evolution* **11:**16909–16926. DOI: 10.1002/ece3.8325.

Muratet A, Fontaine B. 2015. Contrasting impacts of pesticides on butterflies and bumblebees in private gardens in France. *Biological Conservation* **182:** 148–154. DOI: 10.1016/j.biocon.2014.11.045.

Murcia C.1996. *Forest fragmentation and the pollination of Neotropical plants.* In: Schelhas, JRG, eds. Forest patches in tropical landscapes. Island Press, Covelo.

Newton AC, Boscolo D, Ferreira PA, Lopes LE, Evans P. 2018. Impacts of deforestation on plant-pollinator networks assessed using an agent based model. *PLoS ONE* **13:** e0209406. DOI: 10.1371/journal.pone.0209406.

Peralta G, Stevani EL, Chacoff NP, Dorado J, Vázquez DP. 2017. Fire influences the structure of plant–bee networks. *Journal of Animal Ecology* **86:** 1372–1379. DOI: 10.1111/1365-2656.12731.

Prendergast KS, Ollerton J. 2021. Plant-pollinator networks in Australian urban bushland remnants are not structurally equivalent to those in residential gardens. *Urban Ecosystems* **24:** 973–987. DOI: 10.1007/s11252-020-01089-w

RStudio Team. 2020. RStudio: Integrated development environment for R (1.3.959). RStudio, PBC. http://www.rstudio. com/

Ricketts TH., Regetz, J, Steffan-Dewenter I, Cunningham SA, Kremen C, Bogdanski A, Gemmill-Herren B, Greenleaf SS, Klein AM., Mayfield MM, Morandin LA, Ochieng A, Potts SG,Viana FB. 2008. Landscape effects on crop pollination services: are there general patterns? *Ecology Letters* **11:** 499–515. DOI: 10.1111/j.1461-0248.2008.01157.x.

Roulston TAH, Goodell K. 2011. The role of resources and risks in regulating wild bee populations. *Annual Review of Entomology* **56:** 293–312. DOI: 10.1146/annurev-ento-120709-144802.

Santamaría S, Sánchez AM, López-Angulo J, Ornosa C, Mola I, Escudero A. 2018. Landscape effects on pollination networks in Mediterranean gypsum islands. *Plant Biology* **20:** 184–194. DOI: 10.1111/plb.12602.

Sardiñas HS, Kremen C. 2014. Evaluating nesting microhabitat for ground-nesting bees using emergence traps. *Basic and Applied Ecology* **15:**161–168. DOI: 10.1016/j.baae.2014.02.004.

Soares RGS, Ferreira PA, Lopes LE. 2017. Can plant-pollinator network metrics indicate environmental quality? *Ecological Indicators* **78:** 361–370. DOI: 10.1016/j.ecolind.2017.03.037.

Spiesman BJ, Inouye BD. 2013. Habitat loss alters the architecture of plant–pollinator interaction networks. *Ecology* **94:** 2688–2696. DOI: 10.1890/13-0977.1.

Steffan-Dewenter I, Kessler M, Barkmann J, Bos MM, Buchori D, Erasmi S, Faust H,Gerhard G, Glenk K,Gradstein RS, Guhardja E, Harteveld M, Hertel D, Höhn P,

Kappas M, Köhler S, Leuschner C, Maertens M, Marggraf R, Migge-Kleian S, Mogea J,Pitopang R, Schaefer M, Schwarze S, Sporn SG, Steingrebe A, Tjitrosoedirdjo SS, Tjitrosoemito S, Twele A, Weber R, Woltmann L, Zeller M, Tscharntke T. 2007. Tradeoffs between income, biodiversity, and ecosystem functioning during tropical rainforest conversion and agroforestry intensification. *Proceedings of the National Academy of Sciences* **104:** 4973–4978. DOI: 10.1073/pnas.0608409104.

Steffen W, Grinevald J, Crutzen P, McNeill J. 2011. The Anthropocene: conceptual and historical perspectives. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* **369:** 842–867. DOI: 10.1098/rsta.2010.0327.

Stouffer DB, Bascompte J. 2011. Compartmentalization increases food-web persistence. *Proceedings of the National Academy of Sciences* **108:** 3648-3652. DOI: 10.1073/pnas.1014353108.

Tadey M. 2008. Efecto del ganado sobre los niveles de polinización en especies vegetales del monte patagónico. *Ecología Austral* **18:** 89–100.

Thébault E, Fontaine C. 2010. Stability of ecological communities and the architecture of mutualistic and trophic networks. *Science* **329:** 853–856. DOI: 10.1126/science.1188321.

Tilman D, Fargione J, Wolff B, D'Antonio C, Dobson A, Howarth R, Schindler D, Schlesinger WH, Simberloff D, Swackhamer D. 2001. Forecasting agriculturally driven global environmental change. *Science* **292:** 281–284. DOI: 10.1126/science.1057544.

Tscharntke T, Klein AM, Kruess A, Steffan-Dewenter I, Thies C. 2005. Landscape perspectives on agricultural intensification and biodiversity–ecosystem service management. *Ecology Letters* **8:** 857–874. DOI: 10.1111/j.1461-0248.2005.00782.x.

Valiente-Banuet A, Aizen MA, Alcántara JM, Arroyo J, Cocucci A, Galetti M, Zamora R. 2015. Beyond species loss: the extinction of ecological interactions in a changing world. *Functional Ecology* **29:** 299–307. DOI: 10.1111/1365-2435.12356.

Vanbergen AJ, Woodcock BA, Gray A, Grant F, Telford A, Lambdon P, Chapman DS, Pywell RF, Heard MS, Cavers, S. 2014. Grazing alters insect visitation networks and plant mating systems. *Functional Ecology* **28:** 178–189. DOI: 10.1111/1365-2435.12191.

Viechtbauer W. 2010. Conducting Meta-Analyses in R with the metafor Package. *Journal of Statistical Software* **36**: 1–48. DOI: 10.18637/jss.v036.i03

Weiner CN, Werner M, Linsenmair KE, Blüthgen N. 2014. Land-use impacts on plant–pollinator networks: interaction strength and specialization predict pollinator declines. *Ecology* **95:** 466–474. DOI: 10.1890/13-0436.1.

Williams NM, Winfree R. 2013. Local habitat characteristics but not landscape urbanization drive pollinator visitation and native plant pollination in forest remnants. *Biological Conservation* **160:** 10–18. DOI: 10.1016/j.biocon.2012.12.035.

Winfree R, Aguilar R, Vázquez DP, LeBuhn G, Aizen MA. 2009. A meta-analysis of bees' responses to anthropogenic disturbance. *Ecology* **90:** 2068–2076. DOI: 10.1890/08-1245.1.

Yao J, Holt PM, Marshall MS.1999. Woody plant colonization in an experimentally fragmented landscape. *Ecography* **22:**715–728. DOI: 10.1111/j.1600-0587.1999.tb00521.x.

Young AG, Clarke GM. 2000. *Genetics, demography and viability of fragmented populations*. Cambridge University Press

Zakardjian M, Geslin B, Mitran V, Franquet E, Jourdan, H. 2020. Effects of urbanization on plant–pollinator interactions in the tropics: an experimental approach using exotic plants. *Insects* **11:** 773. DOI: 10.3390/insects11110773.

Table 1(on next page)

The dataset comprised 38 studies for the systematic review and 16 studies for the complete set of meta-analyses.

These were utilized to investigate the potential impact of anthropization on the structural patterns of plant-pollinator interaction networks.

Could you please identify the 16 articles used for the meta-analyses ?

Table 1. The dataset comprised 38 studies for the systematic review and 16 studies for the complete set of meta-analyses. These were utilized to investigate the potential impact of anthropization on the structural patterns of plant-pollinator interaction networks.

Metric	Taxonomic group	Climate	Anthropogenic activity	Trend	Reference
Nestedness	Bees	Temperate	Agriculture	No effect	*Hagen & Kraemer, 2010*
			Fragmentation	Decrease	*Newton et al., 2018*
		Tropical	Land use change	Decrease	*Mathiasson & Rehan, 2020*
			Fragmentation	Increase	*Ferreira et al., 2020*
			Urbanización	Decrease	*Traveset et al., 2018*
			Urbanización	Decrease	*Prendergast & Ollerton, 2021*
		Semi-arid	Intentional fires	No effect	*Peralta et al., 2017*
	Bees and others	Tropical	Agriculture	No effect	*Morrison & Dirzo, 2020*
			Land use change	No effect	*Escobedo-Kenefic et al., 2022*
		Semi-arid	Fragmentation	No effect	*Jauker et al., 2019*
			Fragmentation	Decrease	*Grass et al., 2018*
	Insects	Temperate	Agriculture	No effect	*Motivans et al., 2021*
			Agriculture	Decrease	*Vanbergen et al., 2017*
			Agriculture	No effect	*Olsson et al., 2021*
			Fragmentation	Decrease	*Burkle & Knight, 2012*
			Fragmentation	No effect	*Spiesman & Inouye et al., 2013*
			Livestock	Decrease	*Vanbergen et al., 2014*
		Tropical	Agriculture	Decrease	*Moreira, Boscolo & Viana, 2015*
			Land use change	No effect	*Adedoja & Kehinde, 2018*
			Fragmentation	Decrease	*Della Rocca et al., 2023*
		Semi-arid	Fragmentation	Decrease	*Santamaría et al., 2018*
	Butterflies	Tropical	Agriculture	No effect	*Banza, Belo & Evans, 2015*
		Semi-arid	Agriculture	Decrease	*Colom, Traveset & Stefanescu, 2021*
	Hummingbirds	Tropical	Agriculture	Decrease	*Bustamante-Castillo, Hernández Baños & Arizmendi, 2020*

Please standardize the use of names or abbreviations throughout the document.

			Land use change	Increase	*Díaz Infante, Lara & Arizmendi, 2020*
		Tropical	Fragmentation	No effect	*Pinto et al., 2020*
H2		Temperate	Agriculture	No effect	*Hagen & Kraemer, 2010*
		Tropical	Fragmentation	Increase	*Newton et al., 2018*
			Fragmentation	Decrease	*Ferreira et al., 2020*
			Urbanización	Increase	*Traveset et al., 2018*
			Urbanización	Increase	*Mas & Vilagines, 2018*
			Urbanización	No effect	*Prendergast & Ollerton, 2021*
		Semi-arid	Intentional fires	Increase	*Peralta et al., 2017*
	Bees and others	Tropical	Agriculture	No effect	*Fründ, Linsenmair & Blüthgen, 2010*
			Land use change	No effect	*Escobedo-Kenefic et al., 2022*
		Semi-arid	Fragmentation	Increase	*Jauker et al., 2019*
	Insects	Temperate	Agriculture	No effect	*Weiner et al., 2011*
			Agriculture	Increase	*Vanbergen et al., 2017*
			Agriculture	Increase	*Shinohara,Uchida & Yoshida, 2019*
			Agriculture	Decrease	*Motivans et al., 2021*
			Fragmentation	Decrease	*Burkle & Knight, 2012*
			Fragmentation	Decrease	*Marrero, Torretta & Medan, 2014*
			Urbanización	Decrease	*Marín et al., 2020*
		Tropical	Land use change	No effect	*Adedoja & Kehinde, 2018*
			Land use change	Increase	*Sritongchuay et al., 2022*
			Fragmentation	Decrease	*Della Rocca et al., 2023*
			Intentional fires	No effect	*Da Silva et al., 2022*
		Semi-arid	Fragmentation	Increase	*Santamaría et al., 2018*
	Butterflies	Tropical	Agriculture	Decrease	*Banza, Belo & Evans, 2015*
		Semi-arid	Agriculture	No effect	*Colom, Traveset & Stefanescu, 2021*
	Hummingbirds	Tropical	Agriculture	No effect	*Bustamante-Castillo, Hernández Baños & Arizmendi, 2020*
	General	Tropical	Fragmentation	No effect	*Pinto et al., 2020*

Conectance	Bees	Temperate	Fragmentation	Decrease	*Newton et al., 2018*
		Tropical	Land use change	Decrease	*Mathiasson & Rehan, 2020*
			Urbanización	Decrease	*Mas & Vilagines, 2018*
			Urbanización	No effect	*Traveset et al., 2018*
			Urbanización	No effect	*Prendergast & Ollerton, 2021*
		Semi-arid	Intentional fires	Decrease	*Peralta et al., 2017*
	Bees and others	Tropical	Agriculture	Increase	*Morrison & Dirzo, 2020*
			Land use change	No effect	*Escobedo-Kenefic et al., 2022*
		Semi-arid	Fragmentation	Decrease	*Jauker et al., 2019*
	Insects	Temperate	Agriculture	Increase	*Vanbergen et al., 2014*
			Agriculture	Increase	*Shinohara,Uchida & Yoshida, 2019*
			Agriculture	Decrease	*Motivans et al., 2021*
			Agriculture	No effect	*Olsson et al., 2021*
			Fragmentation	Increase	*Spiesman & Inouye et al., 2013*
			Fragmentation	Decrease	*Librán-Embid et al., 2021*
			Livestock	Decrease	*Vanbergen et al., 2017*
		Tropical	Land use change	No effect	*Adedoja & Kehinde, 2018*
			Fragmentation	Increase	*Della Rocca et al., 2023*
		Semi-arid	Fragmentation	Increase	*Santamaría et al., 2018*
	Hummingbirds	Tropical	Agriculture	No effect	*Bustamante-Castillo, Hernández Baños & Arizmendi, 2020*
			Land use change	No effect	*Díaz Infante, Lara & Arizmendi, 2020*
	General	Tropical	Agriculture	Increase	*Sritongchuay et al., 2019*
Modularity	Bees	Semi-arid	Intentional fires	Increase	*Peralta et al., 2017*
	Bees and others	Tropical	Agriculture	Increase	*Morrison & Dirzo, 2020*
			Land use change	No effect	*Escobedo-Kenefic et al., 2022*
		Semi-arid	Fragmentation	Increase	*Grass et al., 2018*
	Insects	Temperate	Agriculture	Increase	*Villa-Galavi et al., 2021*
			Fragmentation	Increase	*Spiesman & Inouye et al., 2013*
			Fragmentation	Increase	*Librán-Embid et al., 2021*

		Tropical	Intentional fires	No effect	*Da Silva et al., 2022*
		Semi-arid	Fragmentation	Increase	*Santamaría et al., 2018*
	Butterflies	Semi-arid	Agriculture	Decrease	*Colom, Traveset & Stefanescu, 2021*
	Hummingbirds	Tropical	Agriculture	No effect	*Bustamante-Castillo, Hernández Baños & Arizmendi, 2020*

Insects: Refers to studies that analyzed taxonomic groups of bees, butterflies, beetles, and flies.

Bees and others: Refers to studies that analyzed taxonomic groups of bees, hoverflies, bumblebees, and wasps.

General: Refers to studies that analyzed taxonomic groups of insects, mammals, and hummingbirds.

Table 2(on next page)

The subgroup analyses unveil notable differences in observed effects among subgroups of pollinators, plants, continents, anthropogenic activities, and climate.

This detailed analysis offers a more nuanced understanding of the overall effect by accounting for potential differences and variations present across the included studies.

Table 2. The subgroup analyses unveil notable differences in observed effects among subgroups of pollinators, plants, continents, anthropogenic activities, and climate. This detailed analysis offers a more nuanced understanding of the overall effect by accounting for potential differences and variations present across the included studies.

Category	SMD *size effect*	95% confidence intervals	*p* (within groups)	Tau^2
Species			0.02	
Pollinators	0.79	0.22–1.36		0.88
Plants	0.13	-0.58–0.85		1.37
Climate			0.02	
Tropical	1.08	0.43–1.73		1.04
Temperate	-0.02	-0.03–0.50		0.77
Anthropogenic activity			0.02	
Agriculture	0.15	-0.32–0.62		0.62
Fragmentation	2.07	1.06–3.09		0.11
Urbanization	-0.44	-4.54–2.76		0.82
Land use change	0.98	0.11–1.85		0.36
Fires	-0.49	-2.57–1.72		2.26
Continent			0.02	
America	0.66	-0.55–1.87		2.64
Europe	0.50	0.003–1.01		0.57
Africa	0.50	-0.78–1.80		0.84
Asia	0.50	-2.33–2.93		1.59

Figure 1

PRISMA flow diagram illustrating the data compilation process for the systematic review and meta-analysis. In the flowchart, the articles obtained from other sources are a result of reviewing the reference lists of the articles identified in the database

In the flowchart, the articles obtained from other sources are a result of reviewing the reference lists of the articles identified in the database search, while the excluded articles are those that did not meet the evaluation criteria in our review.

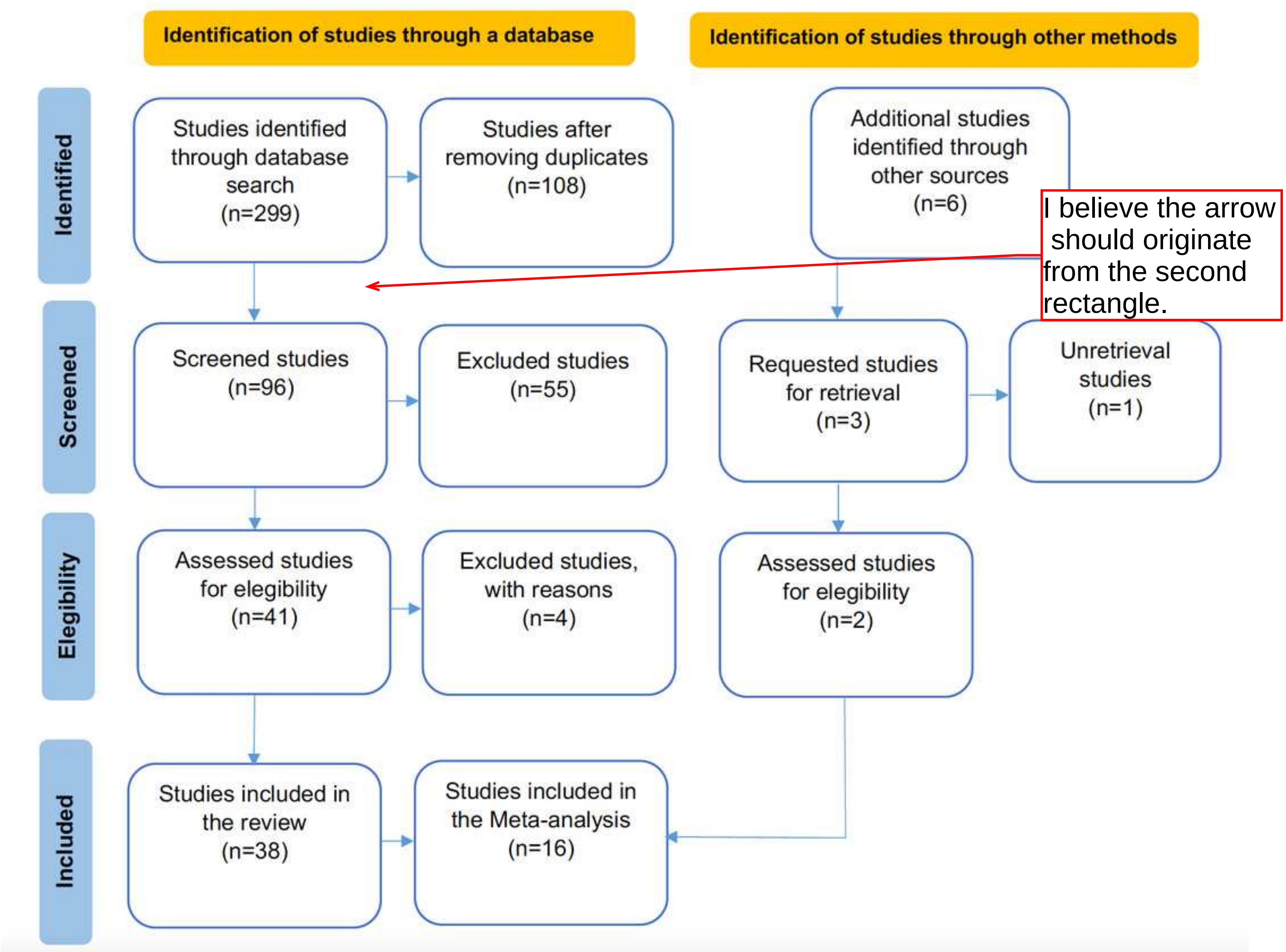


Figure 2

Representativeness of papers by taxonomic group in studies on plant-pollinator networks conducted in locations with anthropogenic activities, which were used in the meta-analysis.

Taxonomic groups were categorized as follows: (1) “Bees,” referring to studies focused on this group of hymenopterans; (2) “Bees and others,” which includes studies that analyze insect groups such as bees, syrphid flies, bumblebees, and wasps; (3) “Insects,” encompassing studies that analyze bees, beetles, and butterflies as a group; (4) “Butterflies,” focusing on Lepidoptera; (5) “Hummingbirds”, covering studies conducted on this group of birds; and (6) “General,” incorporating studies that analyze species groups, including insects, mammals, and hummingbirds.

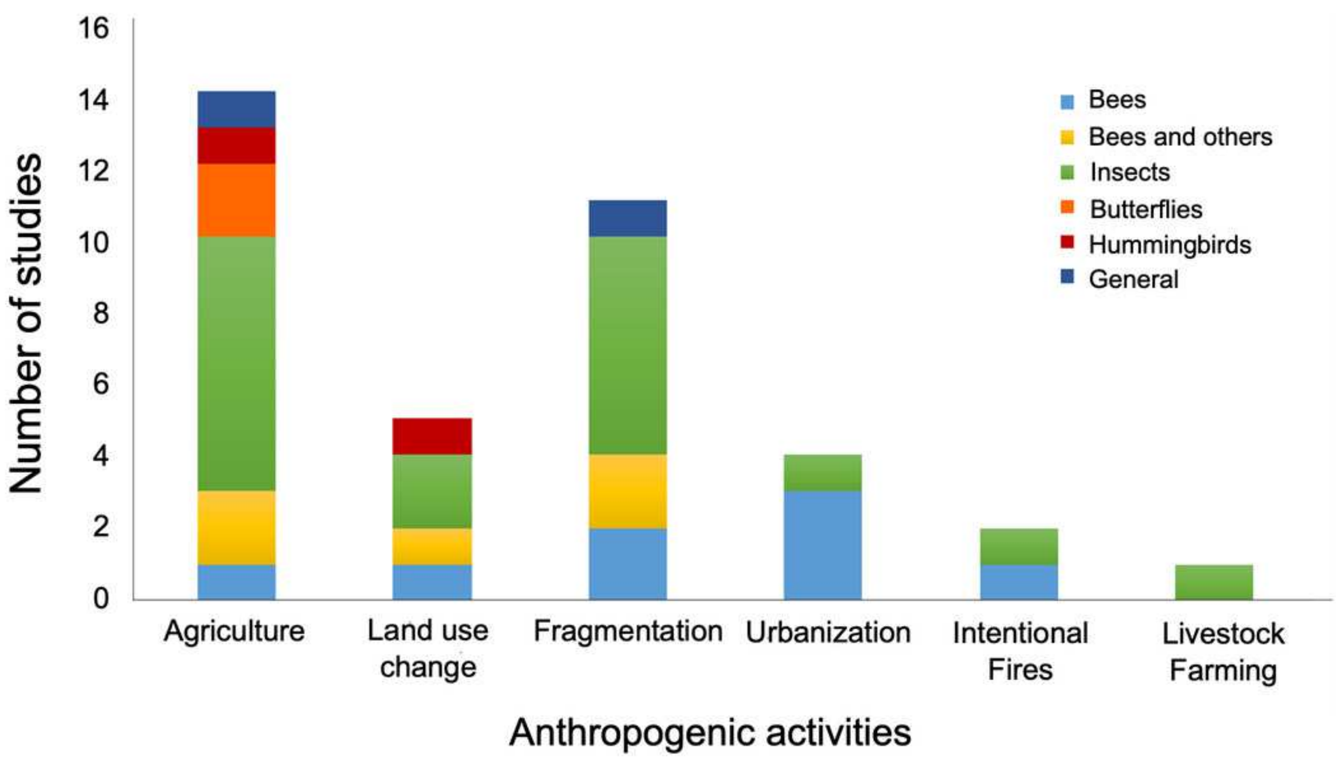
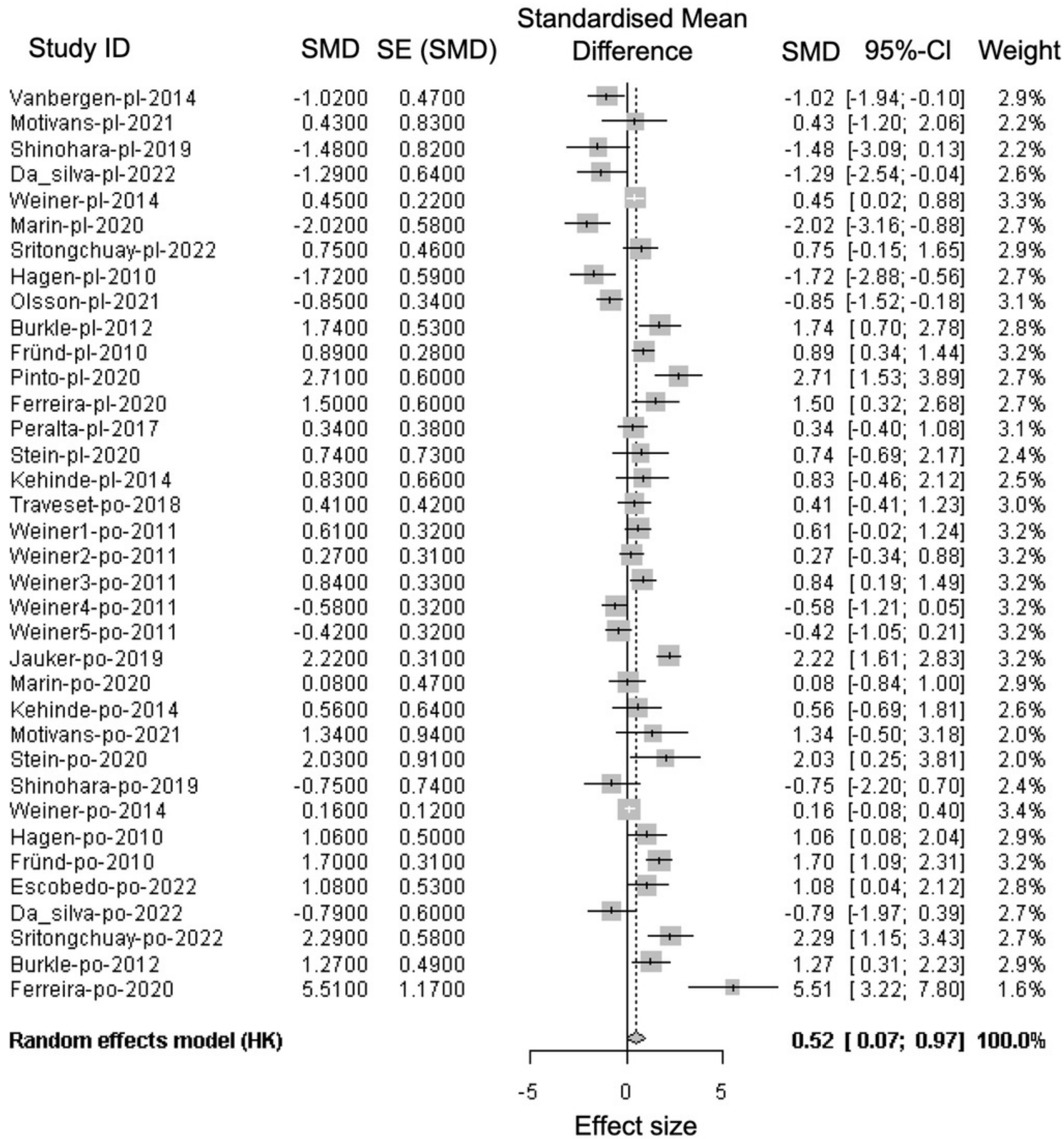


Figure 3

Forest plot for the effect size (grey squares) and 95% confidence intervals (CI, vertical lines) for pollinator ("po") and plant ("pl") richness. The plot displays measurements in conserved (positive effect size values) and disturbed sites (negative effec

The plot displays measurements in conserved (positive effect size values) and disturbed sites (negative effect size values) across each study (Study ID).


Study ID SMD SE (SMD)
Standardised Mean Difference
SMD 95%-CI Weight
Vanbergen-pl-2014 -1.0200 0.4700 -1.02 [-1.94; -0.10] 2.9%
Motivans-pl-2021 0.4300 0.8300 0.43 [-1.20; 2.06] 2.2%
Shinohara-pl-2019 -1.4800 0.8200 -1.48 [-3.09; 0.13] 2.2%
Da_silva-pl-2022 -1.2900 0.6400 -1.29 [-2.54; -0.04] 2.6%
Weiner-pl-2014 0.4500 0.2200 0.45 [0.02; 0.88] 3.3%
Marin-pl-2020 -2.0200 0.5800 -2.02 [-3.16; -0.88] 2.7%
Sritongchuay-pl-2022 0.7500 0.4600 0.75 [-0.15; 1.65] 2.9%
Hagen-pl-2010 -1.7200 0.5900 -1.72 [-2.88; -0.56] 2.7%
Olsson-pl-2021 -0.8500 0.3400 -0.85 [-1.52; -0.18] 3.1%
Burkle-pl-2012 1.7400 0.5300 1.74 [0.70; 2.78] 2.8%
Fründ-pl-2010 0.8900 0.2800 0.89 [0.34; 1.44] 3.2%
Pinto-pl-2020 2.7100 0.6000 2.71 [1.53; 3.89] 2.7%
Ferreira-pl-2020 1.5000 0.6000 1.50 [0.32; 2.68] 2.7%
Peralta-pl-2017 0.3400 0.3800 0.34 [-0.40; 1.08] 3.1%
Stein-pl-2020 0.7400 0.7300 0.74 [-0.69; 2.17] 2.4%
Kehinde-pl-2014 0.8300 0.6600 0.83 [-0.46; 2.12] 2.5%
Traveset-po-2018 0.4100 0.4200 0.41 [-0.41; 1.23] 3.0%
Weiner1-po-2011 0.6100 0.3200 0.61 [-0.02; 1.24] 3.2%
Weiner2-po-2011 0.2700 0.3100 0.27 [-0.34; 0.88] 3.2%
Weiner3-po-2011 0.8400 0.3300 0.84 [0.19; 1.49] 3.2%
Weiner4-po-2011 -0.5800 0.3200 -0.58 [-1.21; 0.05] 3.2%
Weiner5-po-2011 -0.4200 0.3200 -0.42 [-1.05; 0.21] 3.2%
Jauker-po-2019 2.2200 0.3100 2.22 [1.61; 2.83] 3.2%
Marin-po-2020 0.0800 0.4700 0.08 [-0.84; 1.00] 2.9%
Kehinde-po-2014 0.5600 0.6400 0.56 [-0.69; 1.81] 2.6%
Motivans-po-2021 1.3400 0.9400 1.34 [-0.50; 3.18] 2.0%
Stein-po-2020 2.0300 0.9100 2.03 [0.25; 3.81] 2.0%
Shinohara-po-2019 -0.7500 0.7400 -0.75 [-2.20; 0.70] 2.4%
Weiner-po-2014 0.1600 0.1200 0.16 [-0.08; 0.40] 3.4%
Hagen-po-2010 1.0600 0.5000 1.06 [0.08; 2.04] 2.9%
Fründ-po-2010 1.7000 0.3100 1.70 [1.09; 2.31] 3.2%
Escobedo-po-2022 1.0800 0.5300 1.08 [0.04; 2.12] 2.8%
Da_silva-po-2022 -0.7900 0.6000 -0.79 [-1.97; 0.39] 2.7%
Sritongchuay-po-2022 2.2900 0.5800 2.29 [1.15; 3.43] 2.7%
Burkle-po-2012 1.2700 0.4900 1.27 [0.31; 2.23] 2.9%
Ferreira-po-2020 5.5100 1.1700 5.51 [3.22; 7.80] 1.6%
Random effects model (HK) 0.52 [0.07; 0.97] 100.0%
-5
0
5
Effect size