Community and Ecology (2024) Volume 2 Issue 1
doi: 10.59429/ce.v2i1.7755

ARTS AND SCIENCE
ARTS AND SCIENCE PRESS PTE. LTD

RESEARCH ARTICLE

The great insect decline in Argentina

Nicolás Ferreiro

Instituto de Ecología y Desarrollo Sustentable, Universidad Nacional de Luján-CONICET, Luján, Buenos Aires, 6700, Argentina

*** Corresponding author:** Nicolás Ferreiro, nicolasferreiro@conicet.gov.ar

ABSTRACT

A 41% of arthropod species are declining, and one-third of all species are threatened by extinction. Changes in land use are recognized as the primary cause of this decline. The scarcity of data for the Southern Hemisphere is partly due to limited funding but particularly due to the hyperdiversity of tropical regions. The objective of this study was to investigate the presence of this issue in scientific articles and the contribution of insects to the total number of threatened species in Argentina. Globally, the percentage of articles related to insect extinctions in Google Scholar has grown exponentially over the past twenty years, from 0.42% in 2000 to 6% in 2021. However, no significant growth was found in the number of articles on this topic in Argentina during the study period. Currently, only 23 insect species are recognized as at risk out of a total of 572 threatened species according to the "IUCN Red List of Threatened Species" for Argentina. These species belong to the orders Odonata (8), Coleoptera (1), Lepidoptera (2), Hymenoptera (11), and Orthoptera (1 species), representing only 4% of the total threatened species. In comparison, it is estimated that 26% and 27% of threatened species in the much less diverse faunas of Germany and the United Kingdom, respectively, are insects. These results suggest that the percentage of endangered insects in Argentina is being underestimated due to taxonomic and population knowledge gaps, consistent with reports by other authors. In hyperdiverse countries like ours, only molecular techniques can process large samples quickly enough to obtain estimates of insect diversity before they disappear.

Keywords: extinction; species; hyperdiversity; habitat degradation

1. Introduction

Hundreds of moths, water bugs, and beetles once gathered under streetlights, while various bugs and water beetles swam alongside children in pools during the summer of the 1980s. Gardens were filled with dozens of species of wasps and spiders preying on colorful flies, butterflies, and grasshoppers. Even walking sticks and praying mantises were still common in Buenos Aires province up until the 1990s. At the same time, car trips often had to be paused to clean windshields from the insect mash, pantries faced weevil invasions, and “devil's spit” [floating spider webs] sailed through our skies. I can attest to this as I was one of those who reached biology, university, and science through these small creatures. Forty years later, the situation has changed dramatically. In Buenos Aires, first “bagworm moths” disappeared, then fireflies, and for some years now, the scientific literature has indicated that we are facing a major extinction of insects on a global scale.

ARTICLE INFO
Received: 28 October 2024 | Accepted: 13 November 2024 | Available online: 25 November 2024

CITATION
Ferreiro N. The great insect decline in Argentina. *Community and Ecology* 2024; 2(1): 7755. doi: 10.59429/ce.v2i1.7755

Some of the most relevant scientific findings highlighting this crisis include data from Malaise traps between 1989 and 2014 in Germany, documenting a 75% reduction in airborne insect biomass over 27 years[1]. Similarly, the German "Biodiversity Exploratories project" systematically sampled arthropod richness, abundance, and biomass in 2008 and 2017 in grasslands and forests[2], reporting a decrease in richness close to 35% in both environments. This led to the conclusion that insect extinction is a scientifically supported phenomenon, at least in Germany. Moreover, the review by Sánchez-Bayo and Wyckhuys[3] compiled data from studies worldwide, revealing that 41% of insect species are declining and a third of all known species are threatened with extinction. Although rates vary by order and spatial-temporal scale, the current estimated annual decline in abundance is 1-2%[4].

The most critical causes of decline include habitat degradation and loss, agriculture, and climate change[4,5,6]. Recently, increased nitrogen concentrations in aquatic and terrestrial environments have been associated with declines in the abundance of hexapods and arachnids in experimental studies worldwide[7,8]. Aquatic insects, with limited dispersal capacity, are disproportionately affected by warming climates and pollution in aquatic ecosystems. In fact, 41% of threatened insect species on the "IUCN Red List of Threatened Species" are endangered due to water pollution[4].

The industrialization of agriculture in Europe after World War II, which involved consolidating family farms into large commercial conglomerates, the incorporation and automation of machinery, and the widespread application of insecticides and synthetic fertilizers, changed agriculture to the point of making it incompatible with nature[4]. This process is currently underway in the tropics, where deforestation is affecting arthropods in ways that are scarcely being measured[9]. Globally, insects have been studied far less extensively than other groups, such as plants and vertebrates, to the extent that only a small fraction of insect species have been described. The lack of long-term studies on insect occurrence and population dynamics is particularly severe outside of Europe and North America. This is also the case in our country, so the aim of this study was to explore the relevance of this issue in indexed scientific articles from Argentina and to assess the contribution of insects to the total number of threatened species reported for our country, comparing both to the global situation.

2. Materials and methods

2.1. Estimating Reference to Insect Extinction in Scientific Articles

Searches were conducted on Google Scholar for articles from January 1, 2000, to December 31, 2021. We considered publications in English within the field of biology focusing on current insects. The following search terms were used to estimate (i) the number of biology publications: "biology – fossil," and (ii) the number of articles mentioning insect extinction: "insect + extinction + biology – fossil." These searches were repeated, adding the names of specific countries in English: Argentina, Brazil, Canada, China, Germany, United States, Mexico, New Zealand, United Kingdom, and Russia (e.g., "insect+extinction+biology+Argentina -fossil" and "biology+Argentina -fossil").

2.2. Estimating Threat Levels

Searches were conducted on the "IUCN Red List of Threatened Species" to identify endangered species (categories "critically endangered," "endangered," "vulnerable," "lower risk," and "near threatened") for Argentina, Germany, Brazil, Canada, China, United States, Mexico, New Zealand, United Kingdom, Russia, and worldwide. As an estimator of the insect threat level, the ratio of endangered insect species to the total number of threatened species (Tracheophyta + Vertebrata + Insecta) was used.

2.3. Estimating Knowledge Level

Searches were conducted for the total number of Tracheophyta, Vertebrata, and Insecta species reported for Argentina, Germany, Brazil, Canada, China, United States, Mexico, New Zealand, United Kingdom, Russia, and globally. The ratio of Insecta species to the sum of Tracheophyta, Vertebrata, and Insecta species was used as an estimator of insect biodiversity contribution.

3. Results and discussion

Globally, the percentage of articles related to insect extinctions has grown exponentially over the past twenty years, from 0.42% in 2000 to 6% in 2021 (**Figure 1**). The rise since 2017 aligns with major scientific reviews and meta-analyses[3,7,10], as well as with extensive coverage of the issue in major media outlets[11-17]. Analyzing the percentage of articles by country over time, distinct trends emerge, likely reflecting funding opportunities and local issues. In Argentina, interest in the issue has remained relatively stable over the past twenty years, with a modest increase from 3.3% in 2020 to 3.9% in 2021. However, the historical production of insect extinction articles has been low for our country[18-20].

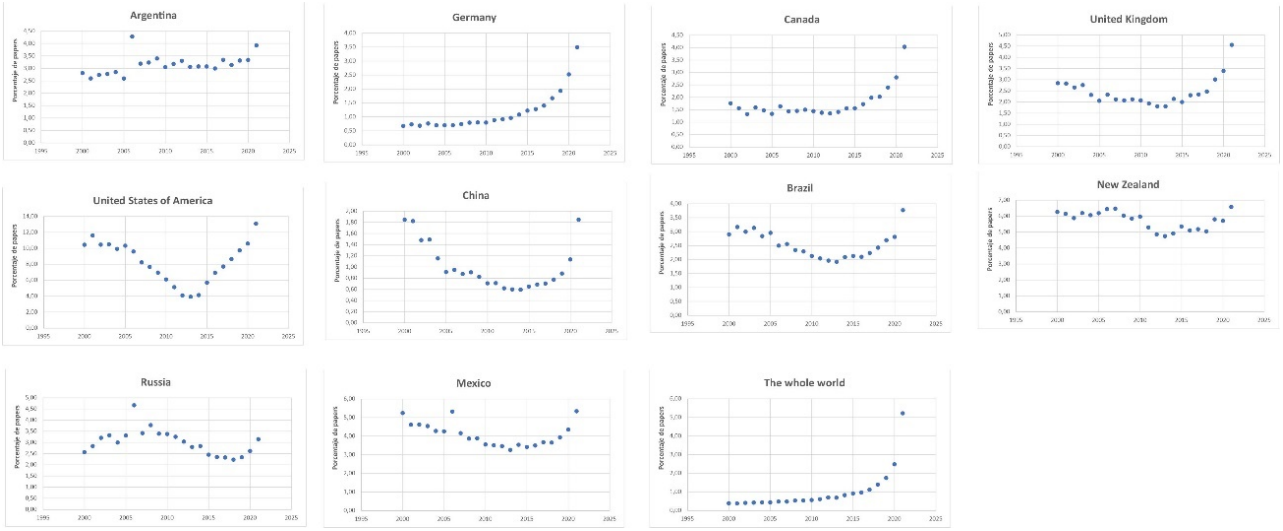

Figure 1. Number of scientific publications referring to insect extinction during the period 2000-2021 per year in Argentina, Germany, Canada, England, United States, China, Brazil, New Zealand, Russia, Mexico, and worldwide.

Globally, 3,068 insect species are threatened according to the "IUCN Red List of Threatened Species": 425 Critically Endangered (CR), 971 Endangered (EN), 949 Vulnerable (VU), 3 Lower Risk (LR), and 720 Near Threatened (NT) out of a total of 51,076 threatened species (IUCN 2023). In Argentina, only 23 insect species have been recognized as endangered to date: CR (0), EN (3), VU (15), LR (0), and NT (5) out of a total of 572 listed species. These species belong to the orders Odonata (8), Coleoptera (1), Lepidoptera (2), Hymenoptera (11), and Orthoptera (1 species) and represent only 4% of the total threatened species in our country[21]. In contrast, less extensive and ecologically diverse countries such as Germany and the United Kingdom recognize that 26% and 27% of their threatened species are insects, respectively. These results suggest that the percentage of endangered insects in Argentina is likely vastly underestimated due to taxonomic and population knowledge gaps, especially in highly diverse areas (**Tables 1 and 2**). This aligns with findings by Barahona-Segovia and Álvaro Zúñiga-Reinoso[22], who analyzed the number of threatened arthropod species per square meter in neotropical countries, concluding that Argentina is one of the most critical examples of arthropod knowledge deficits. They argued that Argentina lacks local lists of threatened arthropods and has only a handful of species listed in the “IUCN Red List of Threatened Species,” despite being one of the largest and most diverse countries in the region.

Data scarcity in the Southern Hemisphere is partly due to limited funding but particularly to the hyperdiversity, small size, and taxonomies based on insect chaetotaxy, which make sample processing and identification nearly impossible except for a few well-studied taxonomic groups[4]. Janzen et al.[23] reported 14,520 "species" (barcode haplotype clusters) from a single Malaise trap in Costa Rica over two consecutive years, of which no more than 2-3% had been identified by taxonomists[4]. "Armies of taxonomists would be needed to sort, name, and curate large trap catches from the tropics, and even larger numbers of lifetimes and resources to describe the world's tropical insect species. It is likely that many will be driven to extinction by anthropogenic stressors before they can be studied or, worse, their value realized," suggest Wagner et al.[4]. Similarly, Rafael et al.[24] reported on Brazil: "The country has about 140 active taxonomists, meaning each professional would handle 3,600 insect species. Each Brazilian taxonomist publishes, on average, about 100 species during their career, so it would take 2-3 thousand years to catalog the country's insect diversity." Within this limited framework, Lewinsohn et al.[25] conducted a valuable approximation in Brazil by surveying local researchers, compiling qualified data and opinions from 75 case studies over a range of 11 years for aquatic insects and 22 years for terrestrial insects, corroborating trends noted globally. This approach might be partially replicable to study trends in Argentina, but in any case, for hyperdiverse countries like ours, it is likely necessary to implement molecular methods to obtain population-level species data from systematic, long-term sampling.

Table 1. (A) Number and percentage of insect species among all threatened species according to IUCN [21] in Germany, Argentina, Brazil, Canada, United States, Mexico, New Zealand, United Kingdom, Russia, and worldwide.

	Number of threatened insect species	**Number of total threatened species**	**Percentage of insects among all threatened species**
Argentina [26-36]	24	572	4%
Brazil [26-31,37]	763	2831	27%
Canada [26-31,38]	24	3758	0.6%
China [26-31,39]	68	1878	44%
Germany [26-31,40]	113	429	26%
Mexico [26-31,41]	116	2906	4%
New Zealand [26-31,42]	7	2225	0.3%
Russia [26-31,46]	63	3629	1.7%
United Kingdom[26-31,44]	93	344	27%
USA [26-31,45]	358	2476	14%
Whole world [26-31,47]	3068	51076	6%

Table 2. Number and percentage of insect species among all species in the three major groups of better-known diversity (Tracheophyta, Vertebrata and Insecta) in Germany, Argentina, Brazil, Canada, United States, Mexico, New Zealand, United Kingdom, Russia, and worldwide.

	Number of insect species	**Number of total species**	**Percentage of insects among all the species**
Argentina [26-36]	22272	35506	63%
Brazil [26-31,37]	110000	163205	72%
Canada [26-31,38]	38925	50157	87%
China [26-31,39]	30000	97774	44%

Germany [26-31,40]	33300	36554	91%
Mexico [26-31,41]	48000	76989	62%
New Zealand [26-31,42]	20000	23861	84%
Russia [26-31,46]	31500	46039	68%
United Kingdom [26-31,44]	27000	30288	89%
USA [26-31,45]	91000	111717	81%
Whole world [26-31,47]	1000000	1434454	70%

Table 2. (*Continued*).

The analysis of the relationship between threat level estimators and knowledge level of entomofauna by country revealed that more than 80% of identified species are insects in wealthy countries (**Figure 2**). In these countries, which likely have a more detailed knowledge of their biodiversity, the percentage of threatened species that are insects is less than 2% in Canada and New Zealand, about 14% in the USA, and over 25% in Germany and the United Kingdom. In the remaining countries, insects made up 60-70% of all species. In Argentina, China, Mexico, and Russia, insects represented less than 5% of threatened species, contrasting with the situation in Brazil, where more than 25% of threatened species are insects. Assuming that Argentina, Brazil, China, Mexico, and Russia have a similar level of biodiversity knowledge, the higher percentage of threatened species that are insects in Brazil could be explained by: A) a higher degree of threat in Brazil, perhaps largely due to the rapid deforestation of the Amazon rainforest, and/or B) greater knowledge of population dynamics in Brazil compared to the other countries, possibly linked to the funding provided by wealthy countries highly interested in the hyperdiverse local entomofauna.

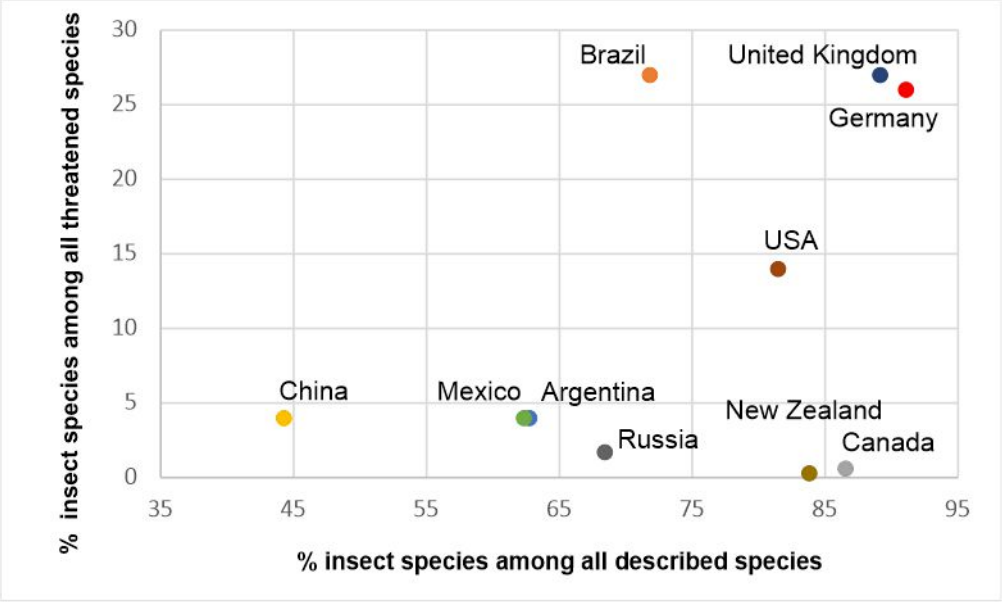

Figure 2. Relationship between the degree of threat and the level of knowledge of insects in Germany, Argentina, Brazil, Canada, United States, Mexico, New Zealand, United Kingdom and Russia.

4. Conclusion

Despite some controversy raised by critics citing inconsistencies in sampling sites and lack of taxonomic determinations in Hallman et al.[1], the recent increase in insect biodiversity in European rivers previously highly polluted (van Klink et al. 2020), questioning conclusions drawn from databases built by volunteers, and criticizing the statistics in Sánchez-Bayo and Wyckhuys's meta-analysis[3], there is now no doubt about the global decline in insect abundance, diversity, and biomass[48]. In fact, intergovernmental institutions have been documenting declines in insect diversity for at least two decades[49], comparable to the decline in birds and plants, although less than that of mammals[50]. The seriousness of the situation is evident from the fact that long-term data series are largely limited to protected areas, as many former sampling sites have been overtaken by agricultural and urban expansion[1,5].

The recognition of the global biodiversity decline crisis has not been enough to halt the ecological disaster, of which insect extinction is just one of the most recently publicized consequences. The progressive detachment of societies from nature, both emotionally and intellectually, partly explains our failure to combat overpopulation, overconsumption, and climate change, recognized as the main causes of biodiversity loss[51]. Indeed, there is considerable global political consensus that human needs, business, economy, quality of life, and social justice take precedence over any other living organism's requirements[52].

Insects perform crucial ecosystem functions such as pollination, nutrient recycling, and soil formation, to name just a few. However, public advocacy for this taxonomic group faces an additional challenge: the aversion that many of its members provoke, such as mosquitoes that account for nearly one million annual deaths[53], aphids and flies that contribute to crop loss alongside other pests, amounting to approximately 30% of crops lost yearly[54], cockroaches that feed on our waste, flies that lay eggs on the deceased... For these reasons, authors often resort to emphasizing the obvious: that insect disappearance would lead to the extinction of insectivorous vertebrates[4]. In fact, the most effective results in species and ecosystem protection often fall under “charismatic biodiversity” — organisms that people choose as desirable, often for aesthetic reasons.

Most insects are far from charismatic or even conspicuous, so it is unsurprising that their extinction holds little interest for most people[55]. Donkersley et al.[48] proposed an “Entomology Fight Plan” consisting of 1) proactively and publicly denouncing government inaction; 2) showcasing the technological knowledge derived from insects to bridge the emotional and intellectual gap; and 3) presenting a united front, aligning insect conservation with that of birds, plants, and mammals, showing interdependence and potential benefits. Unfortunately, in Argentina, we know so little about how insect biodiversity is being lost that we can only hope that ecosystem conservation initiatives, decided based on the needs of other organisms, will be enough to save a considerable diversity of insects.

Extinctions are occurring so rapidly that most biologists agree we are in the early stages of the “Sixth Mass Extinction,” and that we have already crossed the point of no return. Insect decline is only the latest manifestation of a major global crisis that should, as a precaution, be extended to all other organisms that have been even less studied than insects, such as mites, nematodes, fungi, bacteria, etc. Unless proven otherwise, we should assume that most species of living organisms are declining due to human action and act accordingly.

Conflict of interest

The authors declare no conflict of interest.

References

1. Hallmann C. A., M. Sorg, E. Jongejans, H. Siepel, N. Hofland, H. Schwan, W. Stenmans, A. Müller, H. Sumser, T. Hörren, D. Goulson, and H. de Kroon. 2017. More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PLoS ONE 12:1–21.
2. Seibold S., M. M. Gossner, N. K. Simons, N. Blüthgen, J. Müller, D. Ambarlı, C. Ammer, J. Bauhus, M. Fischer, J. C. Habel, K. E. Linsenmair, T. Nauss, C. Penone, D. Prati, P. Schall, E. D. Schulze, J. Vogt, S. Wöllauer, and W. W. Weisser. 2019. Arthropod decline in grasslands and forests is associated with landscape-level drivers. Nature 574:671–673. https://pubmed.ncbi.nlm.nih.gov/31666721/
3. Sánchez-Bayo F., and K. A. G. Wyckhuys. 2019. Worldwide decline of the entomofauna: A review of its drivers. Biological Conservation 232:8–27. https://www.sciencedirect.com/science/article/pii/S0006320718313636
4. Wagner, D. L., E. M. Grames, M. L. Forister, M. R. Berenbaum, and D. Stopak. 2021. Insect decline in the Anthropocene: Death by a thousand cuts. PNAS 118:e2023989118. https://www.pnas.org/doi/10.1073/pnas.2023989118
5. Cardoso, P., P. S. Barton, K. Birkhofer, F. Chichorro, C. Deacon, T. Fartmann, C. S. Fukushima, R. Gaigher, J. C. Habel, C. A. Hallmann, M. J. Hill, A. Hochkirch, M. L. Kwak, S. Mammola, J. A. Noriega, A. B. Orfinger, F. Pedraza, J. S. Pryke, F. O. Roque, J. Settele, J. P. Simaika, N. E. Stork, F. Suhling, C. Vorster, and M. J. Samways. 2020. Scientists' warning to humanity on insect extinctions. Biological Conservation 242:108426. https://www.sciencedirect.com/science/article/pii/S0006320719317823
6. Costante, D. M., A. M. Haines, and M. Leu. 2022. Threats to Neglected Biodiversity: Conservation Success Requires More Than Charisma. Frontiers in Conservation Science 2:727517. https://www.frontiersin.org/journals/conservation-science/articles/10.3389/fcosc.2021.727517/full
7. Nessel, M. P., T. Konnovitch, G. Q. Romero, and A. L. González. 2022. Decline of insects and arachnids driven by nutrient enrichment: A meta-analysis. Ecology. https://doi.org/10.1002/ecy.3897
8. Du, C., F. Zhao, V. Shang, L. Wang, E. Jeppesen, L. Zhang, W. Zhang, and X. Fang. 2023. Ammonia Influences the Zooplankton Assemblage and Beta Diversity Patterns in Complicated Urban River Ecosystems. Water 15:1449. https://www.mdpi.com/2073-4441/15/8/1449
9. Raven, H., and D. L. Wagner. 2021. Agricultural intensification and climate change are rapidly decreasing insect biodiversity. Proc. Natl. Acad. Sci. U.S.A. https://www.pnas.org/doi/10.1073/pnas.2002548117
10. van Klink R., D. E. Bowler, K. B. Gongalsky, A. B. Swengel, A. Gentile, and J. M. Chase. 2020. Meta-analysis reveals declines in terrestrial but increases in freshwater insect abundances. Science 368:417–420. https://www.science.org/doi/10.1126/science.aax9931
11. El País. 2017. Adiós a los insectos de tu infancia. https://elpais.com/elpais/2017/09/19/ciencia/1505835144_925754.html, accessed [07/2024].
12. The New York Times. 2018. The insect apocalypse is here. https://www.nytimes.com/2018/11/27/magazine/insect-apocalypse.html, accessed [07/2024].
13. The New York Times. 2022. When did you last clean bug splatter off your windshield? https://www.nytimes.com/2022/03/05/books/review/when-did-you-last-clean-bug-splatter-off-your-windshield.html, accessed [07/2024].
14. The Guardian. 2019. Plummeting insect numbers 'threaten collapse of nature'. https://www.theguardian.com/environment/2019/feb/10/plummeting-insect-numbers-threaten-collapse-of-nature, accessed [07/2024].

15. The Guardian. 2021. The insect apocalypse: 'Our world will grind to a halt without them'. https://www.theguardian.com/environment/2021/jul/25/the-insect-apocalypse-our-world-will-grind-to-a-halt-without-them, accessed [07/2024].
16. BBC. 23 Apr 2020. Nature crisis: 'Insect apocalypse' more complicated than thought. https://www.bbc.com/news/science-environment-52399373, accessed [07/2024].
17. NASA's Ames Research Center. 10 Nov 2022. Climate Change Can Put More Insects at Risk for Extinction. https://climate.nasa.gov/news/3231/climate-change-can-put-more-insects-at-risk-for-extinction/, accessed [07/2024].
18. Medan D., J. P. Torretta, K. Hodara, E. B. de la Fuente, and N. H. Montaldo. 2011. Effects of agriculture expansion and intensification on the vertebrate and invertebrate diversity in the Pampas of Argentina. Biodivers Conserv 20:3077–3100. https://ri.conicet.gov.ar/handle/11336/15878
19. Mulieri, P. R. 2021. ¿Hay moscas en peligro de extinción? Novedades artropódicas SEA. https://www.seargentina.com.ar/novedades-artropodicas/, accessed [07/2024].
20. Zattara, E. E., and M. Aizen. 2021. Worldwide occurrence records reflect a global decline in bee species richness. One Earth 4:114–123. https://www.sciencedirect.com/science/article/pii/S2590332220306515
21. IUCN. 2023. The IUCN Red List of Threatened Species. https://www.iucnredlist.org, accessed [07/2024].
22. Barahona-Segovia, R. M., and A. Zúñiga-Reinoso. 2021. An overview of Neotropical arthropod conservation efforts using risk assessment lists. Journal of Insect Conservation 25:361–376. https://ui.adsabs.harvard.edu/abs/2021JICon..25..361B/abstract
23. Janzen, D. H., W. Hallwachs, C. R. Morrison, G. F. S. Pereira, E. A. Handley, R. L. Blanco, M. P. Paz, A. Montero, M. R. Chavarria, A. A. Rodriguez, J. B. Salazar, J. Valerio, H. I. Guido, K. I. Perez, K. Hoenle, C. C. J. Mair, S. Ratnasingham, E. V. Zakharov, J. R. DeWaard, & P. D. N. Hebert. 2020. Using DNA-barcoded Malaise trap samples to measure impact of a geothermal energy project on the biodiversity of a Costa Rican old-growth rain forest. Genome, 63(7), 407–436.
24. Rafael, J. A., A. P. Aguiar, and D. Amorim. 2009. Knowledge of insect diversity in Brazil: challenges and advances. Neotropical Entomology 38:565–570. https://www.scielo.br/j/ne/a/FXPsRzHdStW3sq4xTLfLwYh/?lang=en
25. Lewinsohn, T. M., Agostini, K., Lucci Freitas, A. V., and Melo, A. S. 2022. Insect decline in Brazil: an appraisal of current evidence. Biology Letters 18:20220219. https://royalsocietypublishing.org/doi/full/10.1098/rsbl.2022.0219
26. World Conservation Monitoring Centre of the United Nations Environment Programme (UNEP-WCMC). 2024. www.unep-wcmc.org, accessed [07/2024].
27. Froese, R., and D. Pauly (eds.) 2024. FishBase. www.fishbase.org, accessed [07/2024].
28. AmphibiaWeb. 2024. www.amphibiaweb.org, accessed [07/2024].
29. Mammal Diversity Database. 2024. www.mammaldiversity.org, accessed [07/2024].
30. BirdLife International. 2024. www.birdlife.org, accessed [07/2024].
31. Uetz, P., P. Freed, R. Aguilar, F. Reyes, and J. Hošek (eds.) 2024. The Reptile Database. www.reptile-database.org, accessed [07/2024].
32. Morrone J. J., and S. Coscarón (Directores). 1998. Biodiversidad de Artrópodos Argentinos volumen 1. Ediciones Sur, Buenos Aires, Argentina.
33. Claps, L.E., G. Debandi, and S. Roig-Juñent (Directores). 2008. Biodiversidad de Artrópodos Argentinos volumen 2. Editorial Sociedad Entomológica Argentina, Mendoza, Argentina.
34. Roig-Juñent, S., L. E. Claps, and J. J. Morrone (Directores). 2014a. Biodiversidad de Artrópodos Argentinos volumen 3. Editorial INSUE - UNT, San Miguel de Tucumán, Argentina.

35. Roig-Juñent, S., L. E. Claps, and J. J. Morrone (Directores). 2014b. Biodiversidad de Artrópodos Argentinos volumen 4. Editorial INSUE - UNT, San Miguel de Tucumán, Argentina.
36. Pastrana, J. A. 2004. Los lepidópteros argentinos: sus plantas hospedadoras y otros sustratos alimenticios. Sociedad Entomológica Argentina, Argentina.
37. Lewinsohn, T. M., and P. I. Prado. 2005. Quantas espécies há no Brasil. Megadiversidade 1:36–42.
38. Janzen D. H., W. Hallwachs, G. Pereira, R. Blanco, A. Masis, M. M. Chavarria, F. Chavarria, A. Guadamuz, M. Araya, M. A. Smith, J. Valerio, H. Guido, E. Sanchez, S. Bermudez, K. Perez, R. Manjunath, S. Ratnasingham, S. Jacques, M. Milton, J. R. DeWaard, E. Zakharov, S. Naik, M. Langor, D. W. 2019. The diversity of terrestrial arthropods in Canada. ZooKeys 819:9–40. https://zookeys.pensoft.net/article/31947/
39. Xiaoming, C., and F. Ying. 2009. Resource Insects of China. Science Press, Beijing, China.
40. Chimeno C., A. Hausmann, S. Schmidt, M. J. Raupach, D. Doczkal, V. Baranov, J. Hübner, A. Höcherl, R. Albrecht, M. Jaschhof, G. Haszprunar, and P. D. N. Hebert. 2022. Peering into the Darkness: DNA Barcoding Reveals Surprisingly High Diversity of Unknown Species of Diptera (Insecta) in Germany. Insects 13:82. https://www.mdpi.com/2075-4450/13/1/82
41. Falcón-Brindis, A., J. L. León-Cortés, and M. Montañez-Reyna. 2021. How effective are conservation areas to preserve biodiversity in Mexico? Perspectives in Ecology and Conservation 19:399–410. https://www.sciencedirect.com/science/article/pii/S2530064421000730
42. Gordon, D. P. 2010. The New Zealand Inventory of Biodiversity. Volume 2: Kingdom Animalia Chaetognatha, Ecdysozoa, Ichnofossils; Canterbury University Press, Christchurch, New Zealand.
43. https://journals.plos.org/plosone/article%3Fid=10.1371/journal.pone.0185809
44. Lelej, A. S., and S. Yu. Storozhenko. 2010. Insect Taxonomic Diversity in the Russian Far East. Entomological Review 90:372–386. https://link.springer.com/article/10.1134/S001387381003005X
45. Smithsonian Institution. 2024. Numbers of Insects (Species and Individuals). www.si.edu, accessed [07/2024]
46. Woodland Trust. 2024. Insect identification: Common UK insects. www.woodlandtrust.org.uk, accessed [07/2024].
47. Royal Entomological Society. 2024.Facts and figures. www.royensoc.co.uk, accessed [07/2024].
48. Donkersley, P., L. Ashton, G. P. A. Lamarre, and S. Segar. 2022. Global insect decline is the result of wilful political failure: A battle plan for entomology. Ecology and Evolution 12:e9417. https://onlinelibrary.wiley.com/doi/full/10.1002/ece3.9417
49. Forister, M. L., E. M. Pelton, and S. H. Black. 2019. Declines in insect abundance and diversity: We know enough to act now. Conservation Science and Practice 1:e80. https://conbio.onlinelibrary.wiley.com/doi/10.1111/csp2.80
50. Pereira, H. M., P. W. Leadley, V. Proença, R. Alkemade, J. P. W. Scharlemann, J. F. Fernandez-Manjarrés, M. B. Araújo, P. Balvanera, R. Biggs, W. W. L. Cheung, L. Chini, H. D. Cooper, E. L. Gilman, S. Guénette, G. C. Hurtt, H. P. Huntington, G. M. Mace, T. Oberdorff, C. Revenga, and M. Walpole. 2010. Scenarios for global biodiversity in the 21st century. Science 330:1496–1501. https://research.wur.nl/en/publications/scenarios-for-global-biodiversity-in-the-21st-century
51. Díaz S., U. Pascual, M. Stenseke, B. Martín-López, R. T. Watson, Z. Molnár, R. Hill, K. M. A. Chan, I. A. Baste, K. A. Brauman, S. Polasky, A. Church, M. Lonsdale, A. Larigauderie, P. W. Leadley, A. P. E. vanOudenhoven, F. van der Plaat, M. Schröter, S. Lavorel, and Y. Shirayama. 2018. Assessing nature's contributions to people. Science 359:270–272. https://www.science.org/doi/10.1126/science.aap8826
52. Eden, S. 2016. Environmental publics. Taylor & Francis.
53. Tolle M. A. 2009. Mosquito-borne Diseases. Current Problems in Pediatric and Adolescent Health Care 39:97–140. https://pubmed.ncbi.nlm.nih.gov/19327647/

54. Culliney, T. 2014. Crop losses to arthropods. En: Integrated Pest Management: Pesticide Problems. Pimentel D y R Peshin (eds.). Springer.
55. Mishra G., and O. Omkar. 2022. Insects: The Unrecognized Heroes. En: Insects as Service Providers. Springer.