# Dancing on Linnaeus' Palm: Divergence of Species Scapes between ecologists and taxonomists

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**ABSTRACT**

Taxonomy is foundational to the life sciences, yet remains structurally undervalued in systems of research evaluation that rely on short-term citation metrics. To explore the roots of this imbalance, we analysed 360 open-access articles published in 2024 across 12 major journals in ecology and taxonomy. Our results reveal a striking divergence: ecological journals overwhelmingly focus on charismatic vertebrates described in the 18th and 19th centuries, whereas taxonomic journals highlight recently described and often inconspicuous invertebrates. To visualise this contrast, we reconstruct parallel “Species Scapes,” inspired by Wheeler's (1990) concept, which immediately convey the fundamentally different Umwelten of these two scientific communities. The ecological Species Scape is dominated by familiar megafauna, while the taxonomic Species Scape highlights hyperdiverse but underappreciated groups. This mirrored visualisation demonstrates how disciplinary perspectives shape what counts as biodiversity, and how historical and perceptual filters drive a systemic neglect of taxonomic novelty. Recognising and bridging these divergent Umwelten is a necessary step toward correcting the systemic undervaluation of taxonomy and ensuring that taxonomic contributions are fairly recognised as part of a more comprehensive biodiversity science.

*"Objects without names cannot well be talked about or written about; without descriptions they cannot be identified and such knowledge as may have accumulated regarding them is sealed."*

*— Arthur Burton Gahan, The role of the taxonomist in present day entomology, Proceedings, Entomological Society of Washington, 1923*

**How citation-based metrics undervalue taxonomic research**

Taxonomy provides the fundamental framework for the biological sciences, enabling species identification, evolutionary studies, and conservation efforts. Despite its foundational role, taxonomic research —including regional checklists, distributional atlases, and new species descriptions— is systematically undervalued in modern academic evaluation systems, which rely heavily on citation-based metrics such as the Impact Factor (IF) [1, 2, see also Table S1]. Unlike experimental or theoretical research, taxonomic descriptions are rarely cited outside the discipline, particularly within the short two-year citation window used to calculate the IF [3]. This discrepancy has led to a widespread underappreciation of taxonomy in institutional and funding evaluations, and efforts in taxonomy and the taxonomic profession are decreasing drastically [4,5].

We argue that the undervaluation of taxonomy arises from differences in the focal organisms studies in each discipline. In ecological studies (including evolutionary biology, behavioural ecology, and conservation science), researchers tend to work with well-established and charismatic species whose taxonomic identities were resolved decades or even centuries ago. Previous studies have highlighted this taxonomic bias in conservation science [6, 7, 8]. Vertebrates, particularly mammals and birds, receive orders of magnitude more scientific attention than invertebrates, despite invertebrates facing comparable threats [9]. Reliance on flagship, umbrella, and keystone species may oversimplify complex ecological systems and fail to safeguard the broader biodiversity they are assumed to represent [10, 11, 12]. Through an analysis of articles published in major peer-reviewed journals in 2024, we demonstrate that a similar taxonomic bias also appears in broader ecological research, whereas taxonomic articles more often mention invertebrates that are newly or recently described.

**Temporal imbalance in focused species across disciplines**

The distribution of records across eleven 25-year intervals (1753–2024) revealed clear differences between ecological and taxonomic journals (Fig.1A). In ecological journals such as *Animal Behaviour*, *Ecology*, and *Nature Ecology & Evolution*, more than half of the organisms mentioned were described in the eighteenth century, with steep declines in later intervals. In contrast, all three taxonomic journals we reviewed, *Raffles Bulletin of Zoology*, *ZooKeys*, and *Zootaxa*, displayed a markedly different trend. These journals showed a substantial increase in the proportion of species descriptions from the mid-twentieth to the 21st century (Fig. 1A). For example, more than 60% of mentioned species in *Zootaxa* and *ZooKeys* described after 1950, with *Raffles Bulletin of Zoology* showing a particularly steep rise in the twenty-first century (2001–2024), accounting for the majority of its entries.

We further visualised the temporal bias by grouping the records into eight broader historical categories (Fig. 1B): by Linnaeus (1753-1758), eighteenth century (1758–1800), nineteenth century (1801–1850, 1851–1900), twentieth century (1901–1950, 1951–2000), twenty-first (2001–2024) and new species descriptions. These figures also clarify the discrepancy between ecology and taxonomy. For instance, over 75% of entries in *Animal Behaviour*, *Biological Conservation*, *Conservation Biology*, *Ecology*, *Journal of Animal Ecology* and *Nature Ecology & Evolution* were from the eighteenth and nineteenth centuries. In contrast, the three taxonomic journals showed strikingly modern contributions. One possible explanation for this disparity lies in the difficulty non-taxonomists face in recognising newly described species. Many of these organisms remained unnoticed even by taxonomists until recently, making it even more challenging for non-taxonomists to incorporate them into their research.

These findings reinforce the notion that ecologists and taxonomists operate with fundamentally different frames of reference. Ecologists tend to focus on vertebrates and conspicuous species in conservation and ecosystem service studies, while taxonomists shed light on species underrepresented in ecological studies and provide the foundation of biodiversity.

*"Out of the millions of Umwelten, whose abundance would result in confusion, we shall pick out only those dedicated to the investigation of nature – the Umwelten of different scientists."*

*— Jakob von Uexküll, A Stroll Through the Worlds of Animals and Men, in Instinctive Behavior, ed. C. H. Schiller, 1957 [originally published 1934]*

**Ecologists' Umwelt still trapped in the eighteenth century: divergent Species Scapes for ecologists and taxonomists**

The concept of "Umwelt", originally proposed by Uexküll [13] and later popularised in public discourse by Yoon [14], refers to the self-centred, subjective perceptual world of an organism. It highlights how each organism constructs a unique experience of reality, shaped by its sensory capabilities and ecological interactions. Here, we extend this idea metaphorically to the scientific community, suggesting that ecologists and taxonomists operate within fundamentally different *Umwelt* in how they perceive and engage with biodiversity as modern 'Species Scape'. The idea was proposed to show the diversity of life on Earth by scaling organisms' sizes in promotion to the number of described species in 18 taxa [15]. In the original Species Scape, insects (a beetle) loomed large and mammals (an elephant) stood modestly small. This imaginative rendering conveyed a powerful message: some groups — especially insects — dominate Earth's biodiversity. What if the Species Scape was redrawn, not based on actual species richness, but according to the "Umwelt" by scientists in ecological and taxonomic studies? To explore this, we reconstruct a parallel Species Scape: left side from species mentioned in nine ecological journals and right side from in three taxonomic journals, based on 360 open access articles published in 2024 (Fig. 2). Both species are informed by the same systematics used by Wheeler [15], but the resulting Species Scape could not be more different between the ecological and taxonomic sides.

In the ecological Species Scape, charismatic megafauna dominates the landscape: mammals (26.75%) and birds (20.31%) take centre stage (Fig. 2, left side). Despite their relatively low species richness of these conspicuous groups [15], these conspicuous groups receive disproportionate attention in ecological research, likely due to their visibility, accessibility, and appeal to public interest. By contrast, the taxonomic Species

Scape presents a picture radically different from what ecologists perceive (Fig. 2, right side). Here, insects account for 27.55%, followed by other hyperdiverse yet often underappreciated groups such as non-insect arthropods (19.56%), while mammals (3.79%) and birds (0.06%) are nearly absent. These patterns reveal a fundamental divergence in scientific attention: organisms that dominate ecological literature—often those that are visually appealing or "Instagrammable"—are largely absent from taxonomy journals, where arthropods account for nearly half of all mentioned species. This mirrored visualisation allows readers to grasp immediately grasp the disparity in taxonomic attention across scientific disciplines. Despite advances in molecular techniques, non-taxonomists remain heavily reliant on historically familiar taxa, suggesting that species recognition outside taxonomy has not substantially progressed since the Linnaean era. This disconnect perpetuates a systemic neglect of newly described or morphologically inconspicuous species in broader ecological research. This divergence of "Umwelt" is statistically supported by a chi-square test on the distribution of mentioned taxa between ecological and taxonomic journals ($\chi^2$ =1758.5, df = 17, $p < 2.2e-16$, Cramér's V=0.632 ), indicating a significant association between research discipline and taxonomic focus. Visual tools like the Species Scape are not just artistic metaphors—they are critical reflections of scientific attention and systemic imbalance. The twin Species Scape reveals more than disciplinary preference — they expose a structural divergence in how life is recognized, categorized, valued, and investigated. The ecologists' scape is comparatively superficial, focusing on conspicuous and well-known species, while the taxonomist's scape is detailed, comprehensive, and inclined to cover indistinctive and inconspicuous species. Both approaches are valuable, but when combined, they remind us how profoundly our understanding of biodiversity is shaped by the choices we make in where to look. This systematic bias is called as 'taxonomic chauvinism' [16], which highlights structural disadvantages faced by researchers working on less popular taxa. This mirrors the pattern observed in the ecological journals analysed in this study and suggests widespread systemic neglect of underrepresented taxa, which are often the focus of taxonomic work. The disparity in assessment by taxon has implications for practical conservation measures. For example, Cazabonne & Haelewaters [17] point out that only 0.5% of listed fungal species are assessed on the IUCN

Red List, and this lack of academic and policy interest in such 'invisible and unattractive' taxa has structural underpinnings in ecological research. Such bias further reduces the likelihood that newly described species—many of which are invertebrates—are incorporated into ecological research or cited in high-impact journals. This is not merely a matter of scholarly preference; it has profound implications for the comprehensiveness of future scientific knowledge and the effective conservation of biodiversity.

Addressing this issue requires a stronger integration of taxonomic expertise into ecological, evolutionary, and conservation research, as well as a reevaluation of how we define and select model species for study. Our perception of the biological world is shaped by subjective experience, which is recognised as *Umwelt* [14]. This subjectivity may partly explain why ecologists and taxonomists often focus on entirely different segments of biodiversity.

**Invisible infrastructure of biodiversity conservation**

Although more than two million species have been formally described to date [18], the true extent of global biodiversity remains unknown [19, 20, 21]. Many species yet to be described face particularly high risks of extinction [22], underscoring the urgency of strengthening taxonomic efforts to support the discovery and conservation of Earth's remaining life forms [23]. Despite being a cornerstone of biodiversity science, taxonomy continues to be undervalued in research and policy arenas. Studies that establish basic biological knowledge, such as species descriptions, faunal or floral atlases, and regional checklists provide the essential framework on which other fields rely, but tend to receive fewer citations than experimental or modeling studies.

These concerns echo a broader movement within the scientific community to reform research evaluation practices. Notably, the San Francisco Declaration on Research Assessment [24], the Leiden Manifesto [25], and various field-specific critiques [26, 27] all call for moving away from journal-based metrics such as the IF, and instead emphasize the assessment of individual research contributions on their own merits. Inequitable evaluation of the citation metrics as a measure of scientific impact has been discussed for a long time [25, 26, 27], and this inherently disadvantages taxonomy as shown in this study.

If citation counts continue to dictate funding decisions, hiring, and institutional rankings, taxonomy will remain undervalued despite its indispensable contributions to biodiversity science. This is not only because the biological groups taxonomists study are underrepresented in high-impact ecological journals, but also because the publication and citation dynamics differs between the ecological and taxonomic studies. To align scientific incentives with societal and planetary goals, we urgently need new evaluation frameworks that recognize the long-term, foundational, and infrastructural value of taxonomic work. If time passes without the results of taxonomic research being duly exploited, conservation vacancies can expand where the results are not even recorded [28]. While ecology often adheres to hypothesis-driven methods, taxonomy remains rooted in natural history which is based on a tradition of careful observation and description. Descriptive research may not generate immediate citations, but it lays the factual groundwork for all further biological understanding and strategy for biodiversity conservation. To build a science that reflects the full biodiversity of life, both experimental and descriptive styles must be recognised and equally evaluated.

**The role of natural history and descriptive studies: from academic to socio-economic impact**

Looking ahead to the development of a new framework to put biodiversity on a path to recovery by 2050 [29], the importance of taxonomy will only increase. The prevailing research evaluation system, which relies heavily on short-term citation counts and journal impact factors, disincentivises taxonomists from engaging in precisely the kinds of studies most urgently needed to support biodiversity conservation and policy implementation. This foundational role becomes particularly evident in the context of emerging global frameworks such as the Taskforce on Nature-related Financial Disclosures (TNFD), where accurate species identification and occurrence records are prerequisites for evaluating nature-related risks and dependencies. As TNFD drives corporations to identify and manage their biodiversity dependencies and impacts, it becomes increasingly clear that taxonomy—often dismissed as irrelevant in corporate settings—holds a central role.

Despite the fact that biodiversity is still largely overlooked in the mainstream of Environment, Social, and

Governance (ESG) assessments [30], emerging evidence suggests that biodiversity-focused investment indices can deliver competitive financial returns when designed appropriately [31]. This divergence underscores the gap between current evaluation frameworks and the potential value of biodiversity in sustainable finance. The absence of taxonomic expertise within companies is not a reflection of its lack of value, but of the failure to recognise and measure that value. It is time for businesses to recruit and support taxonomists not only as scientists, but as enablers of sustainable decision-making, data credibility, and long-term stewardship of natural capital. As discussed above, taxonomy is undervalued both scientifically and socially, and this trend may have implications for the distribution of conservation resources and policy decisions. The bias in scientific resource allocation is also reflected in the distribution of economic and policy resources. For example, Li [32] argues that the education of financial professionals is key to addressing the underfunding of biodiversity conservation, which also indicates that the legitimate value of taxonomic findings is not being communicated. Jin [33] notes that ESG investment and sustainable practices of small and medium-sized enterprises have contributed to renewable energy growth, and demonstrates that effective resource allocation can only be achieved if it is environmentally justified. As calls for “biodiversity-informed policy” intensify, the need to bridge this perceptual divide becomes ever more urgent.

To bridge this critical gap effectively and ensure the sustained health of biodiversity science, we must move beyond evaluation systems that inadvertently penalise foundational descriptive research. We propose that a crucial step is the adoption of a novel evaluation framework, the Discovery and Description (DD) Index (see Appendix for details). Unlike conventional metrics, the DD Index is specifically designed to quantify the multifaceted impact of natural history and descriptive studies, encompassing novel discoveries, taxonomic revisions, detailed redescriptions, and contributions to global biodiversity databases. It uniquely accounts for the long-term relevance and societal utility of these outputs, including their adoption in non-peer-reviewed but valuable reports and their contribution to nomenclatural stability. By providing a structured and equitable framework, the DD Index aims to incentivise high-quality descriptive research, thereby aligning academic recognition with the urgent societal need for comprehensive biodiversity knowledge.

Furthermore, the potential for such improved evaluation to reshape perceptions and foster greater appreciation for natural history studies is supported by recent findings. By implementing transparent and comprehensive evaluation metrics such as the DD Index, we can highlight the foundational role of natural history and descriptive research and cultivate a broader understanding of their indispensable value. This dual approach holds the promise of correcting the current imbalanced assessment, attracting new talent to these critical disciplines, and ultimately strengthening the scientific infrastructure vital for addressing global biodiversity challenges and informing sustainable economic practices.

Looking ahead, the year 2025 marks the beginning of the final decade leading to the tricentennial of Linnaeus' *Systema Naturae* in 2035. This symbolic moment invites us to reflect on how far we have come—and how far we still must go—to restore the foundational role of taxonomy in the life sciences. We hope the next ten years will witness a renewed societal recognition of species discovery, not as a niche endeavour, but as a vital part of our scientific and cultural infrastructure.

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## Materials and Methods

### *Data selection and journal sampling*

We reviewed a total of 360 open-access articles in twelve major peer-reviewed journals published in 2024 (Table S1). From the list of open access articles published in 2024 from each journal, 30 were selected using random numbers (Table S2). Nine of the twelve journals are those in ecology, evolutionary biology, or conservation biology (*Animal Behaviour*, *Biological Conservation*, *Conservation Biology*, *Ecology*, *Evolution*, *Journal of Animal Ecology*, *Journal of Evolutionary Biology*, *Molecular Ecology*, and *Nature Ecology & Evolution*), and the remaining three were taxonomy journals (*Raffles Bulletin of Zoology*, *ZooKeys*, and *Zootaxa*). Purely theoretical papers and editorials that did not include any scientific names, as well as taxonomic monographs (e.g. checklists or distributional atlases) were excluded from analysis.

***Species identification and classification***

Scientific names of mentioned organisms in each article were systematically extracted and validated. The authorities and years of the original descriptions of the organisms were listed and synonyms were excluded following the taxonomy of databases (including GBIF, WoRMS, and original descriptive articles) where available, and manually verified otherwise (Table S3). For searching original description of scientific names, we used online databases (as listed above) when they were available. All organisms mentioned were identified as taxa according to Wheeler [15]. Although Wheeler's systematics does not correspond to the current systematics, we adopted the 1990 systematics for comparison with the Species Scape of that period.

***Species Scape reconstruction***

Distribution of mentioned taxa (Wheeler's group) across 12 journals are shown as pie charts (Fig. S1), and we reconstructed the recent species scape in different disciplines (Fig. 2). Species Scape used the size of an organism on a landscape to indicate the relative number of species in that group [15]. To make an updated Species Scape for a split discipline, we constructed two parallel Species Scapes based on 360 published articles we reviewed (Tables S2 and S3): left side derived from species mentioned in nine ecological journals, and the right side from three taxonomic journals. We followed Wheeler's 18 major groups, and the symbolized organisms used are listed in Table S4. Taxa ranked eleventh or lower were omitted and not shown in Fig. 2.

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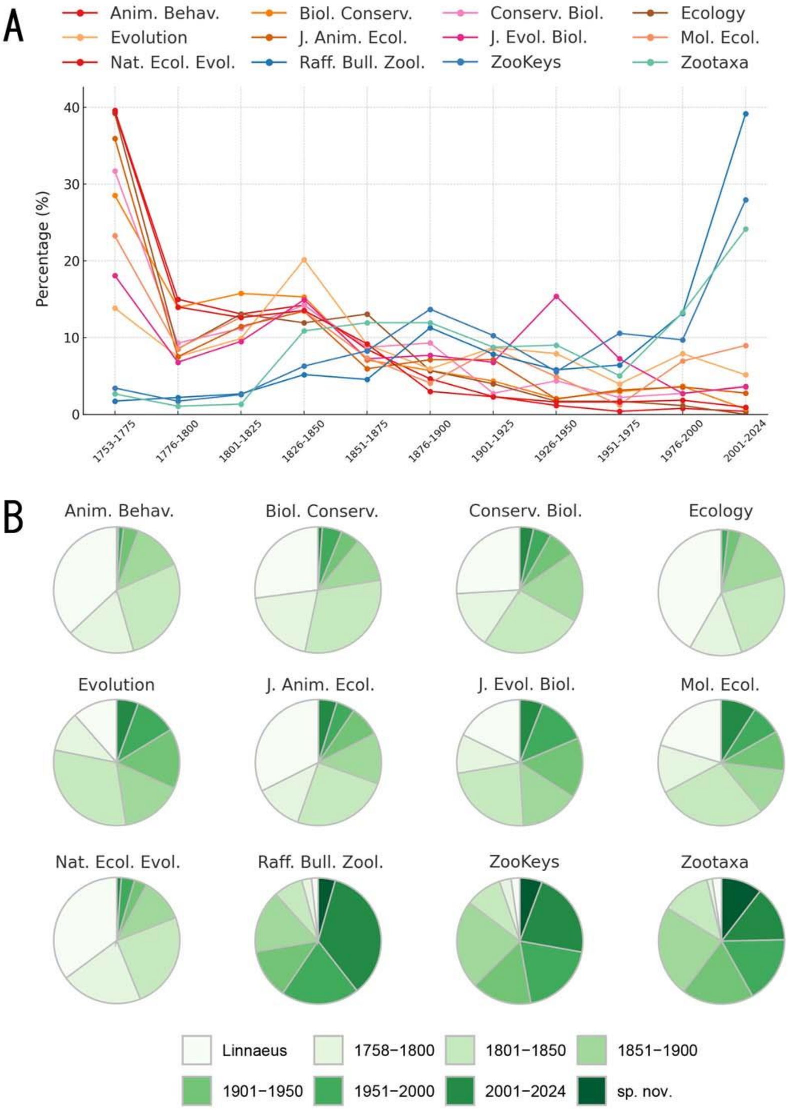
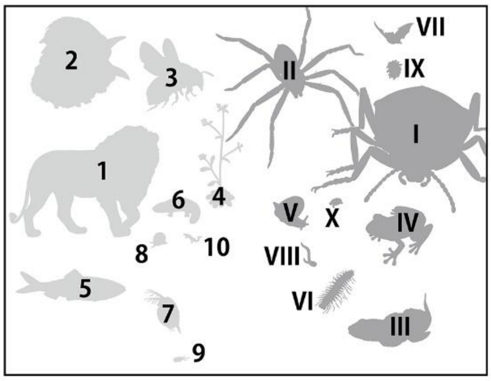



**Figure 1. Temporal distribution of species description dates across ecological and taxonomic journals.** (A) Proportional distribution of species description dates across journals. This line graph shows the relative proportion (as a percentage of each journal's total) of mentioned species descriptions across 11-time intervals (1753–1775 to 2001–2024) for 12 journals. It highlights a clear disparity in temporal reliance: older taxa are predominantly mentioned in ecological journals (represented by warmer colors), whereas taxonomic journals (represented by cooler colors) are strongly skewed toward species described in the late twentieth and 21st centuries. (B) Temporal distribution of described taxa across 12 journals in historical categories. Each pie chart represents the proportion of described taxa across eight historical time categories: by Linnaeus (1753, 1758, and 1766), 1758–1800, 1801–1850, 1851–1900, 1901–1950, 1951–2000, 2001–2024, and as new species (sp. nov.). Linnaeus is positioned at the 12 o'clock mark in all charts, and slices progress counterclockwise. This panel further illustrates the stark contrast between ecological journals, which rely heavily on historically described taxa, and taxonomic journals, where newly described species dominate the recent decades. Both panels collectively demonstrate the significant temporal imbalance in species focus between ecological and taxonomic research.




**Percentages of mentioned taxa in each field**

| For Ecologists | | For Taxonomists | |
|---|---|---|---|
| 1. Mammalia | 26.75 | I. Insecta | 27.55 |
| 2. Aves | 20.31 | II. N-I Arthropoda | 19.56 |
| 3. Insecta | 14.41 | III. Pisces | 14.30 |
| 4. Plantae | 13.03 | IV. Amphibia | 13.43 |
| 5. Pisces | 8.00 | V. Mollusca | 8.52 |
| 6. Reptilia | 4.69 | VI. Annelida | 6.07 |
| 7. N-I Arthropoda | 4.27 | VII. Mammalia | 3.79 |
| 8. Mollusca | 2.13 | VIII. Platyhelminthes | 3.56 |
| 9. Monera | 1.41 | IX. Plantae | 1.98 |
| 10. Amphibia | 1.37 | X. Reptilia | 0.99 |

**Figure 2. Divergent Species Scape reflecting the distinct 'Umwelt' of ecologists and taxonomists.** This illustration visualizes the differing perceptions and research foci within biodiversity science, based on species mentions in 360 open-access articles published in 2024. The left panel represents the 'Species Scape for ecologists', dominated by charismatic megafauna frequently mentioned in nine ecological journals. The right panel depicts the 'Species Scape for taxonomists', highlighting hyperdiverse and often inconspicuous invertebrates predominantly found in three taxonomy journals. Organism size is scaled proportionally to their respective taxonomic group's mention frequency (or species count) within each journal type (details shown in Fig. S1). This mirrored visualization allows readers to immediately grasp the disparity in taxonomic attention across scientific disciplines. Data for this figure were derived from 360 open-access articles published in 2024, as detailed in Table S1, Table S2, and Table S4. The systematics used for categorization follows Wheeler (1990).

**Supplementary Information**

**Table S1. Number of the open access papers published in 2024 in each journal.**

**Table S2. 360 open-access articles analyzed in this study.**

**Table S3. Scientific names of mentioned organisms in 360 articles.**

**Table S4. Ratio of each taxon in ecological and taxonomic journals.**

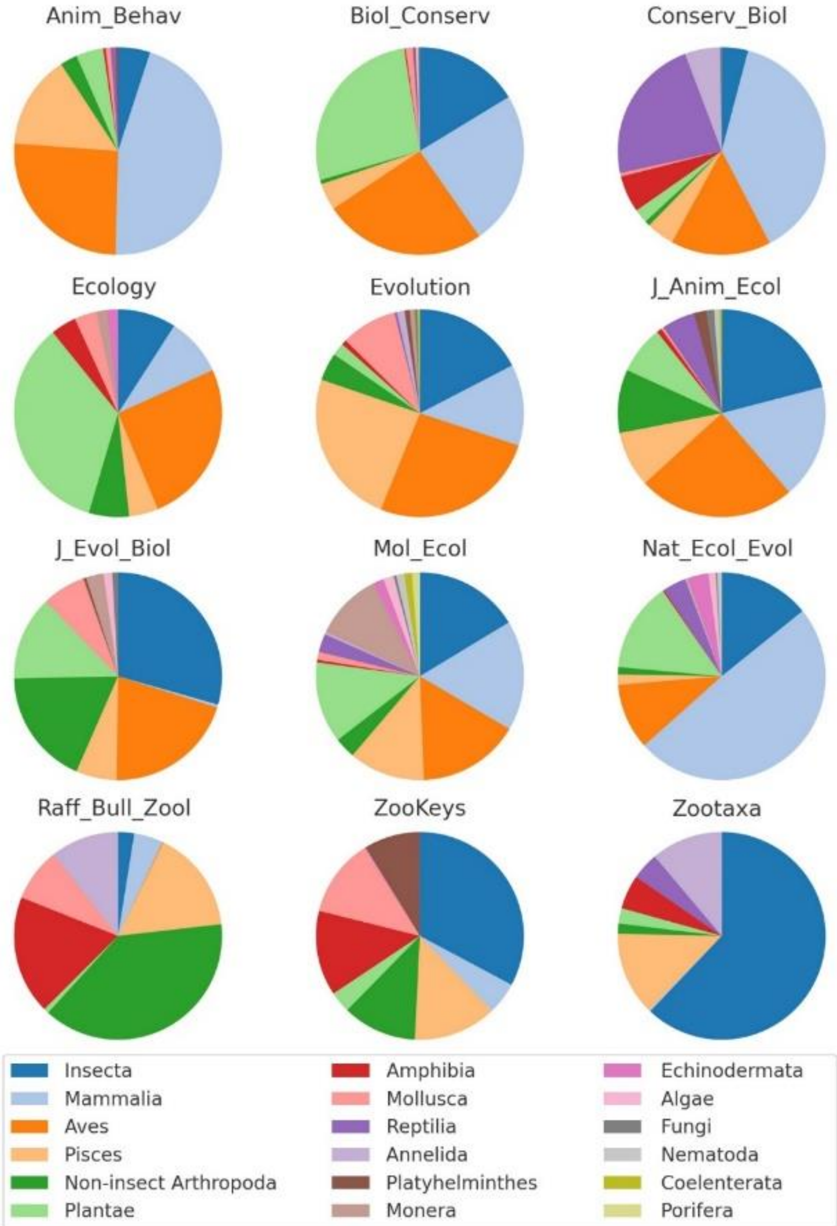



**Fig. S1. Distribution of mentioned taxa across 12 journals.**

Each pie chart represents the proportion of mentioned taxa: Insecta, Mammalia, Aves, Pisces, Non-insect Arthropoda (Mites,Protozoa, Crustaceans etc.), Plantae, Amphibia, Mollusca, Reptilia, Annelida, Platyhelminthes, Monera, Echinodermata, Algae, Fungi, Nematoda, Coelenterata, Porifera.

## Appendix: Discovery and Description (DD) Index

### A. Concept and Purpose, Societal and Economic Relevance

The Discovery and Description Index (DD Index) is introduced as a new metric to evaluate the foundational contributions of descriptive research in taxonomy. Unlike citation-based indicators that capture short-term academic attention, the DD Index recognises the cumulative and enduring value of natural history information. It highlights the long-term impact of species discovery, nomenclatural stability, and biodiversity documentation—cornerstones of taxonomy that provide essential knowledge for science, conservation, and society, yet remain largely invisible in conventional evaluation systems.

The DD Index aims to:

- Capture the scientific and societal impact of taxonomic outputs.
- Provide a structured evaluation framework for descriptive research.
- Connect academic recognition with policy and economic value, particularly in biodiversity disclosure frameworks such as TNFD.

Its inclusive design extends beyond academia, recognising contributions from independent naturalists, local communities, and small societies. Outputs such as regional checklists, long-term records, and society newsletters provide invaluable biodiversity data and should be visible in global evaluation systems.

### B. Structure and Calculation

The DD Index follows the logic of the h-index:
A researcher has a DD Index of h if h of their taxonomic outputs each have an Impact Score of at least h.

Impact Score components (per output):

- Literature mentions: +1 per article (peer-reviewed or not).
- Global database inclusion (GBIF, Catalogue of Life, WoRMS): +3.
- Genetic data linkage (GenBank, BOLD): +3.
- Conservation assessment (IUCN, national plans): +5.
- Nomenclatural stability (valid ≥5 years): +10.

This system ensures recognition of outputs that provide lasting scientific infrastructure.

### C. Expanded Scope of Taxonomic Outputs

Eligible contributions include:

- New descriptions (species, genera, families)
- Taxonomic revisions and reclassifications
- Redescriptions and monographs

- Checklists and database curation

The DD Index also credits scientifically valuable, non-peer-reviewed works such as:

- Local museum bulletins and natural history journals
- Society newsletters and reports
- Institutional or governmental biodiversity surveys

These contributions often provide critical regional and long-term data essential for biodiversity science.

**D. Author Contribution Weighting**

To avoid dilution of credit in multi-authored works, the DD Index adopts an additive scheme rather than fractional models:

- First author: 100% of the Impact Score
- Corresponding author: +50%
- Other co-authors: +30% each

This model maintains visibility of all contributors, ensuring that taxonomic expertise remains recognisable within institutions, databases, and conservation frameworks.

**E. Institutional DD Index**

Institutions (e.g. museums, universities) can be assessed through aggregated DD Index values, reflecting:

- Output volume and quality
- Collection use and curation
- Database contributions
- Outreach and policy engagement, including TNFD-related activities

Such metrics allow institutions to demonstrate leadership in biodiversity science.

**F. Implementation Outlook**

The DD Index can be realised through:

- Automated text mining for literature mentions
- API integration with biodiversity repositories
- Community-driven calibration of scoring weights

Adoption would help revalue taxonomy by rewarding quality, stability, and societal relevance, while integrating overlooked knowledge sources into biodiversity and policy frameworks.