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Opinion note

# Endemism inflation and the unit problem: biogeographical consequences of taxonomic oversplitting

## *Inflación del endemismo y el problema de la unidad: consecuencias biogeográficas de la fragmentación taxonómica excesiva*

Farrokh Ghahremaninejad *

*Kharazmi University, Faculty of Biological Sciences, Department of Plant Sciences, 15719-14911 Tehran, Iran*

*Corresponding author: fgh@khu.ac.ir (F. Ghahremaninejad)

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**Abstract**

Endemism is a cornerstone concept in biogeography, yet persistent inconsistencies in how it is defined and, more importantly, what taxonomic units are counted, have made many endemism-based studies difficult to compare. In practice, "endemics" are often tallied using mixed analytical currencies: species alongside subspecies, varieties, and forms, sometimes also under species concepts that encourage splitting. Here I revisit the historical development of endemism and emphasize the species as the primary analytical unit for biogeographical inference. I formalize a related phenomenon, endemism inflation, defined as the apparent increase in endemic units produced by taxonomic oversplitting and by the uncritical inclusion of infraspecific ranks in endemism metrics. Drawing on literature on species concepts and biodiversity assessment, I argue that endemism inflation is not merely semantic; it changes maps of endemism, affects the identification of centres of endemism, and can distort conservation prioritization. Even classical comparisons show that endemism values vary across taxonomic groups and with taxonomic practice, not only biology. Finally, I outline practical recommendations for reporting endemism in ways that preserve comparability, including explicit statements of the analytical unit and parallel reporting of species-only versus mixed-rank endemism where feasible.

*Keywords*: Endemism; Endemism inflation; Species concept; Taxonomic oversplitting; Infraspecific ranks; Biogeography; Comparability

**Resumen**

El endemismo es un concepto fundamental en biogeografía, pero las inconsistencias en su definición y en las unidades taxonómicas contabilizadas dificultan la comparación entre estudios. En la práctica, los "endemismos" suelen calcularse usando criterios mixtos: especies junto a subespecies, variedades y formas, a veces bajo conceptos de especie que fomentan la fragmentación. En este trabajo, reviso el desarrollo histórico del endemismo y enfatizo

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a la especie como la unidad analítica primaria para la inferencia biogeográfica. Formalizo el concepto de inflación del endemismo, definido como el aumento aparente de unidades endémicas debido al exceso de fragmentación taxonómica y a la inclusión acrítica de rangos infraespecíficos. Con base en la literatura sobre conceptos de especie y evaluación de la biodiversidad, sostengo que esta inflación no es meramente semántica, altera los mapas de endemismo, afecta la identificación de sus centros y puede distorsionar las prioridades de conservación. Los valores de endemismo varían según la práctica taxonómica, no solo por la biología. Finalmente, propongo recomendaciones prácticas para preservar la comparabilidad, como declarar explícitamente la unidad analítica y reportar paralelamente el endemismo de solo especies frente al de rangos mixtos, cuando sea factible.

*Palabras clave*: Endemismo; Inflación del endemismo; Concepto de especie; Fragmentación taxonómica excesiva; Categorías infraespecíficas; Biogeografía; Comparabilidad

## Introduction

Endemism, broadly, the restriction of a taxon to a defined geographic area, sits at the centre of biogeography and conservation. Recent work has highlighted the need for greater conceptual precision in endemism terminology, including the proposal of "euendemic" for fully restricted taxa (Ghahremaninejad, 2026), reinforcing the importance of clearly defined analytical units. It is used to interpret distributional patterns, recognize biogeographic regions, delineate biodiversity hotspots, and support conservation decisions. The catch is that endemism is often invoked as if it were a single, stable measurement, when in fact it behaves more like a family of related ideas whose meaning depends on 2 key choices: *(i)* what counts as an "endemic unit", and *(ii)* which taxonomic rank(s) are used as the unit of analysis.

This is not just pedantry. Endemism metrics are routinely compared across regions and across studies, and are sometimes fed directly into prioritization tools. Yet many studies report endemic "taxa" in ways that mix species with infraspecific entities (subspecies, varieties, forms), or apply taxonomic frameworks that differ sharply in their tendency to split or lump. The result is a conceptual and methodological bottleneck: endemism values that look comparable on paper may not be comparable in reality.

This paper is conceptual and synthetic. It does not propose new species delimitations or introduce new primary distribution datasets. Instead, it clarifies the unit problem in endemism, analyses and formalizes a phenomenon that follows from it: endemism inflation —the apparent increase in endemic counts produced by taxonomic oversplitting and/or by treating infraspecific ranks as equivalent analytical units.

Recent checklist-based revisions show how endemic counts can change markedly depending on circumscription and rank treatment, even within the same country and time window (Baasanmunkh et al., 2021, 2022). Similar sensitivity emerges when endemism is summarized across different spatial frameworks (e.g., phytochoria versus floristic provinces), including in regional syntheses for Iran and adjacent Irano-Turanian areas (Assadi, 2025; Memariani et al., 2016).

*Historical background and conceptual development of endemism.* The term "endemic" derives from the Greek endēmios, "native to a place". Before it entered natural history, it had medical usage, distinguishing diseases persistent in a locality from epidemics. Spatial restriction is therefore the original core meaning, while the biological unit (species? genus? "taxa"?) was never built into the term in a strict way.

In botanical science, de Candolle (1820) recognized the concept of geographically restricted plants, describing taxa restricted to particular regions; endemism at this stage was largely descriptive and qualitative. Wallace (1876) later integrated endemism into a broader theory of animal distribution, linking restricted ranges to barriers and historical processes. Vavilov (1992) emphasized regions rich in endemic taxa as historically and evolutionarily meaningful, especially in the context of crop origins and genetic diversity. This historical path helps explain why endemism is foundational and yet methodologically flexible. As Fattorini (2017) and Morrone (2008) note, endemism has been used for diverse analytical purposes, often without making its assumptions explicit, which encourages heterogeneity in practice.

A practical driver of heterogeneity is checklist tradition. National and regional checklists differ in whether they report endemic units as species only or as mixed sets of species and infraspecific ranks, and in how they treat synonymization and taxonomic changes in biogeographic summaries (Baasanmunkh et al., 2022). Those choices affect not only raw endemic counts but also derived products like "hotspot maps" or province-level endemism rates.

*The species concept and its role in biogeographical analyses.* Species remain the most widely used currency of biogeography, evolutionary biology, and conservation. Yet the "species problem" is longstanding: multiple species concepts coexist, and their practical consequences can be large (Hey, 2001). Mayr's biological species concept emphasizes reproductive isolation (Mayr, 1942, 1970). In contrast, lineage-based and phylogenetic views treat species as independently evolving lineages (de Queiroz, 2005; Simpson, 1951). Synthesis treatments stress that no single concept fits all datasets and organisms; the choice is partly methodological, and it shapes delimitation and downstream inference (Aldhebiani, 2018; Ereshefsky, 1999; Mayden, 1997). As Sites and Crandall (1997) frame it, the gap between theoretical agreement and practical delimitation remains one of the central issues.

Infraspecific ranks (subspecies, varieties, forms) describe structured variation within species. These categories often have diffuse boundaries, are sensitive to sampling intensity and local taxonomic tradition, and can vary widely in their stability. Yet they are frequently incorporated into endemism datasets and then treated as equivalent to species-level units —sometimes without even stating that this has happened. Darwin (1859) captured the continuity behind this problem bluntly: "I was much struck how entirely vague and arbitrary is the distinction between species and varieties."

That observation does not resolve modern taxonomy, but it does highlight a key point for biogeography: if the boundary between species and infraspecific variation can be fuzzy, then mixing ranks without stating analytical intent almost guarantees that endemism values will be difficult to compare across studies.

*Effects of species concepts on biodiversity and endemism estimates*. A substantial literature demonstrates that species concepts and delimitation practice influence biodiversity estimates. Agapow et al. (2004) showed that applying phylogenetic species concepts often increases species counts relative to non-phylogenetic approaches, with knock-on effects on inferred ranges and population sizes. Other studies emphasize sensitivity to sampling and data type, including the risk of artificial fragmentation of biological units (Walsh, 2000; Wiens & Penkrot, 2002). Templeton (1989) framed part of this as reflecting the gradual, process-like nature of divergence rather than discrete biological discontinuities.

The important point for the present argument is modest: endemism metrics inherit these sensitivities, because endemism is calculated over whatever units the analyst provides. Change the units, and you may change the apparent strength, and even the spatial pattern, of endemicity without any change in underlying distributions or processes.

## Conceptualizing endemism inflation

Endemism inflation refers to the apparent increase in endemic richness caused not by underlying evolutionary or biogeographical processes, but by changes in taxonomic circumscription and analytical units. It arises most commonly when: *1)* species and infraspecific ranks are pooled without distinction; *2)* recently described or narrowly delimited taxa are treated as equivalent to long-recognized species; and *3)* taxonomic revisions are interpreted as mere nomenclatural updates, without considering their biogeographical consequences. Endemism inflation has 2 main pathways: *1)* taxonomic oversplitting, where delimitation practice produces a larger number of recognized units with smaller ranges (including via species concepts or local taxonomic traditions that facilitate splitting); and *2)* rank mixing, where infraspecific entities are counted as equivalent analytical units to species in endemism calculations. In both cases, the numerical "signal" of endemic richness can rise without any underlying change in the evolutionary or ecological processes that generate restricted ranges. That is why endemism inflation is not merely terminological: it is a methodological effect with consequences for inference.

Illustrative checklist contrasts underline this point. In recent vascular-plant synthesis work for Mongolia, endemic counts differ depending on circumscription and on whether endemic "taxa" include infraspecific ranks (Baasanmunkh et al., 2021, 2022). Again, this is not an argument about which taxonomy is "right", it is an argument that results are not directly comparable unless the analytical currency is explicit.

It is also worth noting that the problem is not confined to modern checklists. Classic empirical comparisons already showed that endemism values can be non-equivalent across groups and can shift with taxonomic practice, not only with biology. Delgadillo et al. (2003), comparing 3 plant groups in Mexico, documented strongly different endemism patterns and explicitly cautioned that endemism values may decline with improved taxonomic knowledge and synonymization, an observation that, in effect, foreshadows the logic of endemism inflation.

## Biogeographical and conservation implications

Comparability and the erosion of "apples-to-apples" inference. Comparisons among regions and studies are meaningful only if the analytical units are equivalent. Yet it is common to see one study reporting endemic species, another reporting endemic taxa (species plus infraspecific ranks), and a third using a strongly split taxonomy under a particular concept or tradition. These may all be labeled "endemism studies," but they are not necessarily measuring the same thing.

This becomes particularly consequential when endemism is used to identify centres of endemism or to infer historical processes. A region may appear to be an "endemism hotspot" partly because it has experienced intensive taxonomic subdivision or because infraspecific units were counted. Conversely, a region might look comparatively poor simply because a conservative species-level approach was used. If the unit was never stated, this mismatch cannot be repaired after the fact.

*Spatial frameworks and interpretive sensitivity.* Endemism counts also shift with spatial framing. Floristic-province syntheses for the Khorassan-Kopet Dagh area highlight local endemics within an Irano-Turanian chorological structure (Memariani et al., 2016). National-scale revisions of Iran's geobotanical structure emphasize phytochoria recognition using endemic distributions and large specimen bases (Assadi, 2025). These approaches are valuable, but they illustrate the same point: endemism metrics are intertwined with both spatial units and taxonomic units. If either varies, comparability becomes unstable.

*Conservation prioritization and unit sensitivity.* Conservation assessments often combine endemicity with other rarity constructs (restricted AOO, local rarity, threat category). This increases sensitivity to analytical units because "more units" can become "more threatened units", even when the underlying biological reality is structured variation within a broader species. For example, when endemicity is combined with threat assessments at fine scale, the resulting prioritization list may not be designed to be directly comparable to species-only endemism summaries (Malekpourzadeh et al., 2025).

Regional floristic surveys can help illustrate both sides of this issue. Species-level inventories often provide more stable baselines across regions (e.g., Akhavan-Roofigar & Feizi, 2025), while local floristic work tied to specific protected areas can be method- and scale-dependent in ways that should not be silently merged with broader endemism syntheses (Aliabadi & Ghahremaninejad, 2025).

*Practical recommendations.* To minimize endemism inflation and improve comparability, endemism-based studies should: *1)* state the analytical unit explicitly (species-only versus taxa including infraspecific ranks); *2)* report parallel results where feasible, for example endemic species and endemic taxa (species plus infraspecific ranks); *3)* document taxonomic changes that affect endemic counts, including synonymization and rank changes, and indicate how these changes alter summaries; and *4)* separate biogeographical inference from conservation ranking when endemicity is combined with threat criteria or other rarity metrics.

These steps are simple, but they impose a discipline that is often missing: they force the analyst to declare when a change in taxonomic currency is being used and what that implies for comparison.

## Final remarks

Endemism inflation emerges from the interaction between a historically flexible concept (endemism) and inconsistent analytical practice (mixed ranks and divergent delimitation). Because endemism is inherently unit-dependent, clarity about analytical currency is essential. A conservative, species-centred approach does not deny the biological reality of infraspecific variation, but it preserves comparability and interpretability in biogeographical analysis. Explicitly stating whether endemism refers to species only or to mixed taxonomic ranks should be considered a minimum methodological requirement. Where possible, parallel reporting of species-level and taxon-level endemism can further enhance transparency. Without such measures, endemism risks losing its explanatory power and becoming an artefact of taxonomic practice rather than a window into evolutionary and geographical history.

In short, endemism without an explicit unit is not a measurement, but a moving target.

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