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► **To cite this version:**

Stefano Mammola, Nathan Viel, Dylan Amiar, Atishya Mani, Christophe Herve, et al.. Taxonomic practice, creativity and fashion: what's in a spider name?. *Zoological Journal of the Linnean Society*, 2023, 10.1093/zoolinnea/zlac097 . hal-04010120

**HAL Id: hal-04010120**

**<https://hal.science/hal-04010120>**

Submitted on 1 Mar 2023

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# Taxonomic practice, creativity and fashion: what's in a spider name?

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Received 8 April 2022; revised 9 September 2022; accepted for publication 19 September 2022

There is a secret pleasure in naming new species. Besides traditional etymologies recalling the sampling locality, habitat or morphology of the species, names may be tributes to some meaningful person, pop culture references and even exercises of enigmatography. Using a dataset of 48 464 spider etymologies, we tested the hypothesis that species names given by taxonomists are deeply influenced by their cultural background. Specifically, we asked whether naming practices change through space or have changed through time. In absolute terms, etymologies referring to morphology were the most frequently used. In relative terms, references to morphology peaked in 1850–1900 and then began to decline, with a parallel increase in etymologies dedicated to people and geography. We also observed a dramatic increase in etymologies referring to pop culture and other cultural aspects in 2000–2020, especially in Europe and the Americas. While such fashionable names often carry no biological information regarding the species itself, they help give visibility to taxonomy, a discipline currently facing a profound crisis in academia. Taxonomy is among the most unchanged disciplines across the last centuries in terms of tools, rules and writing style. Yet, our analysis suggests that taxonomists remain deeply influenced by their living time and space.

**ADDITIONAL KEYWORDS:** Arachnida – Araneae – binomial system – ICZN – Linnaeus – nomenclature – scientific names – systematics.

## INTRODUCTION

In a quest to make some sense of the beautiful enigma often referred to as ‘reality’, humans have always attempted to classify natural objects and phenomena into rigid schemes and categories. The periodic table of elements by Mendeleev (Scerri, 2019), the categorization of stars according to their luminosity

(Langer & Kudritzki, 2014) and the schematization of human behaviour into personality traits (Goldberg, 1993), are just a few examples illustrating how the impulse to classify is inherent to any human attempt to understand the natural world (Doolittle, 1999). While some of these classifications may have more grounding than others in underlying reality, they reflect the fact that – as Richard Dawkins (2011) put it – we are all subject to the ‘tyranny of the discontinuous mind’.

Among the most successful and long-lasting scientific classification schemes is the Linnaean binomial system of nomenclature (Linnaeus, 1751, 1758). Proposed by

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Carolus Linnaeus (1707–78) three centuries ago, it is still in use to name living and fossil organisms. A species is unambiguously defined via the juxtaposition of two ‘Latin’ names: the genus and the species epithet. Notwithstanding philosophical discussions around the biological meaning of these categories (Lehman, 1967; Hey, 2001; Slater, 2016), the heuristic of naming species has aided generations of scientists in formulating and testing hypotheses in disciplines as diverse as ecology and evolution (Pante *et al.*, 2015; Fišer *et al.*, 2018), agronomy (Malézieux *et al.*, 2009), medicine (Yang *et al.*, 2020) and conservation biology (Reydon, 2019).

Beyond the theoretical and practical usefulness of establishing unambiguous names to refer to species (Vink *et al.*, 2012; Zeppelini *et al.*, 2021), the use of Linnaean nomenclature comes with an additional benefit for taxonomists: they get to choose species names. Besides a few basic grammatical rules regulating the derivation of etymologies (Vendetti & Garland, 2019), there are virtually no limits to creativity of name authors (Lalchandama, 2014; Jozwiak *et al.*, 2015; Ohl, 2018; Heard, 2020). Names may describe species traits [e.g. the cerulean (or blue) warbler, *Setophaga cerulea* (Wilson, 1810)]. They may refer to the distribution of a species (e.g. the Jiangxi giant salamander, *Andrias jiangxiensis* Lu *et al.*, 2022, only known from Jiangxi Province in China; Chai *et al.*, 2022) or habitat [e.g. the rock- and reef-inhabiting sergeant-major fish, *Abudefduf saxatilis* (Linnaeus, 1758)]. More creatively, they may refer to people (e.g. Kate Winslet’s beetle, *Agra katewinsletae* Erwin, 2002 or Margaret Collins’ ant, *Strumigenys collinsae* Booher, 2021) or simply represent wordplay (the tiny frog *Minimium* Scherz *et al.* 2019 or the braconid wasp *Heerzlukenatcha* Marsh, 1993). The possibility of choosing witty or even playful names contrasts with the usually serious and impersonal writing style of traditional scientific papers (Heard, 2014). This is anecdotally confirmed by listening to a few episodes of the podcast ‘NewSpecies’ (@PodcastSpecies). The podcast hosts invite taxonomists to talk about newly described species; toward the end of each episode, they always pose a key question: ‘Why this name?’. The different answers to this question by the invited speakers, and their enthusiasm in explaining their etymological choices, leave no doubt that there is a distinct pleasure in naming new organisms.

Here, we delve into choices by authors for etymologies more systematically, taking a view of the process of naming species to understand how choices of authors vary in space and have changed over time. Because considering the whole diversity of species across the Tree of Life would be impossible, we here focused on spiders (Arachnida: Araneae). Spiders are a perfect test case for our etymological endeavour, because:

- (1) spider taxonomy is constantly curated and updated online in a central repository, the [World Spider Catalog](#) (2022);
- (2) thanks to a unique online collaborative effort (Nentwig *et al.*, 2015), all literature on spiders is freely available, making it possible to easily inspect species descriptions to ascertain an original etymology (when reported);
- (3) the geographical ubiquitousness of spiders (Piel, 2018), the great diversity of species (currently > 50 000 valid taxa; [World Spider Catalog](#), 2022), their diverse body forms, adaptations and ecological strategies (Cardoso *et al.*, 2011; Foelix, 2011; Mammola *et al.*, 2017), as well as the existence of a broad community of academics and amateurs studying them (Platnick & Raven, 2013; Mammola *et al.*, 2017; Jäger *et al.*, 2021; Holmquist & Gillespie, 2022), all should lead to an ample variety of etymological roots for spider names.

Based on a dataset of 48 464 unique taxonomic entities ([World Spider Catalog](#), 2020), we (1) explored general features of scientific names chosen by taxonomists (length, frequency by letter and etymology types) and (2) modelled the proportional use of different etymology types over time and across continents. Stemming from the fact that taxonomy is an old and conservative science still largely based on the use of Latin and Latinized Greek in naming, our null hypothesis is that there should be no significant variation in the way taxonomists have assigned etymologies since the Linnaean system was introduced. Conversely, if taxonomists are prone to be influenced by their cultural background, we would expect differences in etymological categories across periods and continents.

## MATERIAL AND METHODS

### BACKBONE TAXONOMY

On 2 June 2020, we downloaded the backbone taxonomy of the [World Spider Catalog](#) (2020), consisting at the time of 48 464 unique taxonomic entities (47 956 species and 508 subspecies of spiders). The temporal span of the database goes back to 1757 when Carl Alexander Clerck (1709–65) named 67 spiders using binomial nomenclature in his book *Svenska Spindlar* (Clerck, 1757). Interestingly, Clerck’s book precedes the publication of the 10<sup>th</sup> edition of *Systema Naturae* (Linnaeus, 1758), considered the start of zoological nomenclature, by one year. Therefore, in order to consider Clerck’s spider descriptions valid under the system of zoological nomenclature, *Svenska Spindlar* is deemed to be published on 1 January

1758 (International Code of Zoological Nomenclature; Article 3.1).

#### CLASSIFICATION OF ETYMOLOGIES

We classified species etymologies into six broad categories: those referring to (1) morphology, (2) ecology and behaviour, (3) geography, (4) people, (5) modern and past culture and (6) other. Note that a single etymology may have multiple meanings and, therefore, belong to multiple categories. Within each category, we further broke down the meaning of species names into subcategories (see details in the sections below). However, in all analyses we used the six main categories above as grouping units, both for ease of discussion and because the distinction between subcategories was sometimes blurry (see section ‘Cross-validation of inferred etymologies’).

To assign etymologies, we first and foremost checked original descriptions; second, we inferred etymologies based on our knowledge of Greek and Latin and by consulting previous etymological works (Bonnet, 1961; Nilsson, 2010) and internet resources (e.g. Wikipedia, Wikispecies). When we consulted an original description, we looked for the specific section describing the etymology – typically under headings such as ‘Etymology’ or ‘*Derivatio nominis*’. If such a section was missing, we checked the text of the paper for hints to the meaning of the species epithet. Thanks to our knowledge of different languages, the help of collaborators (see Acknowledgements) and through the use of Google Translate, we were able to inspect papers written in Chinese, English, French, German, Italian, Japanese, Latin, Portuguese, Russian, Spanish and Swedish.

For each species, we indicated in the database whether we based our classification of the etymology on the original description (‘Original’,  $N = 22\,416$ ), whether we consulted the original description but we had to infer the etymology because it was not reported (‘Original + Inferred’,  $N = 1018$ ) or whether we inferred it without consulting the original description (‘Inferred’,  $N = 23\,890$ ). We left blank those etymologies we could not infer (‘Original + Unknown’,  $N = 1140$ ) and excluded these observations from analyses.

#### *Etymologies referring to ‘Morphology’*

We used this category when an etymology referred to the size of the spider (subcategory: ‘size’), the shape of the body or some body part (subcategory: ‘shape’) or the general aesthetic/appearance of the species (e.g. subcategory: ‘colour’). Whenever the name indicated the similarity to another species (usually names ending in *-oides* or beginning with the prefix *sub-*), we

scored it as size = 1, shape = 1 and colour = 1 unless a morphological feature was specified (e.g. ‘... similar in the shape of the cymbium’).

#### *Etymologies referring to ‘Ecology and Behaviour’*

We used this category when a species name referred to the ecology and habitat of the spider (subcategory: ‘ecology’) or some behavioural adaptation (subcategory: ‘behaviour’).

#### *Etymologies referring to ‘Geography’*

We used this category when an etymology referred to the distribution of the species, including those names referring to the type locality.

#### *Etymologies dedicated to ‘People’*

We used this category when the etymology was dedicated to a scientist (subcategory: ‘scientists’) or other people (subcategory: ‘otherPeople’). Whenever the species was dedicated to the collector of the species, we always assigned it to ‘scientists’; this would include amateur collectors, who are being recognized for their contribution to the scientific process. We assigned the species to ‘otherPeople’ when the identity was not specified in the original description, but it was possible to infer that the species was dedicated to a person based on indirect evidence. For example, in old descriptions, the species name was capitalized when referring to a name or surname of a person. When a species name was dedicated to a fictional person, we classified it only in the category ‘Modern and Past Culture’.

#### *Etymologies referring to ‘Modern and Past Culture’*

We used this category when the etymology referred to contemporary culture (subcategory: ‘modernCulture’) or past culture (subcategory: ‘pastCulture’). These may include references to mythology, local tribes, pop culture, music bands and so on. We applied the concept of modern or past culture relative to the species descriptor. For example, what we considered ‘modernCulture’ for Eugène Simon (1848–1924) would be ‘pastCulture’ for Norman Platnick (1951–2020).

#### *‘Other’ etymologies*

We used this category when the etymology did not fit any of the previous categories. These include names that are puns or arbitrary combinations of letters, names that refer to an anecdote related to the collection of the species and many others.

## CROSS-VALIDATION OF INFERRED ETYMOLOGIES

In order to assess the internal consistency in etymology assignments among authors, as well as the validity of inferred etymologies (which represented 49% of the dataset) as compared to original etymologies, we cross-validated the dataset. We based cross-validation on 400 randomly picked inferred etymologies (~1% of the total dataset). For each etymology, we checked the original description and scored whether our inference: (1) matched, i.e. there was a clue in the text that the inferred etymology fitted the given name, like in *Nemosinga atra* Caporiacco, 1947, for which the abdomen is described as ‘completely black’ in the original paper (*ater, atra, -um* meaning ‘black, dark-coloured’); (2) did not match, i.e. there was evidence for another explanation to the given name in the original description; or (3) neither matched nor mismatched, i.e. there was no indication to support the inferred etymology in the original paper, but nothing invalidated the deduction.

Of the 400 cross-validated etymologies, 57.75% matched with the original description, 16.75% did not match with the original description and 25.50% were not reported. Percentages of mismatch decreased to below 3% when the agreement was based on the match of a broad etymological category – in other words, in almost all cases, confusion was between subcategories (e.g. ‘size’ vs. ‘shape’) and so was not influential for our analyses. In a second step, we also evaluated between-author congruence using three pairs of comparisons (DF, JP and SM), each of 40 etymologies. The percentage of agreement was high, ranging from 86.67% match for subcategories to 100% match for category. Given these cross-validation results, we assumed the database to contain only trivial errors.

## STATISTICAL ANALYSES

We carried out all analyses in R v.4.0.3 (R Core Team, 2021). We used the package ‘ggplot2’ v.3.3.4 (Wickham, 2016) for visualizations.

*Assignment of species geographic distribution*

We used the distribution column in our backbone taxonomy to classify species distributions at the continental level. Distribution strings for species in the World Spider Catalog are not standardized: they can mention single countries (e.g. ‘Namibia’), multiple countries (e.g. ‘Italy and Spain’), continents (e.g. ‘Oceania’), ranges (e.g. ‘from Europe to Korea’) and other geographical units (e.g. ‘Alps’, ‘unknown’). We used the *wscmap* dataset from the R package ‘arakno’ v.1.1.1 (Cardoso & Pekar, 2022) to convert each distribution string into a list of corresponding

three-letter ISO country codes. For example, we translated ‘North America’ to the list ‘CAN, MEX, USA,’ and ‘Egypt to Yemen’ to ‘EGY, SAU, YEM’. Next, we used the R package ‘countrycode’ v.1.3.0 (Arel-Bundock *et al.*, 2018) to convert these lists of ISO codes into presence/absence values per continent (‘Asia’, ‘Europe’, ‘Africa’, ‘Oceania’ and ‘Americas’). We manually checked the final output, filling unmatched distributions and fixing errors. Additionally, since the package ‘countrycode’ provides a generic presence/absence value for ‘Americas’, we manually reclassified species in this category into ‘North America’ and ‘South America’. As we were interested in assessing cultural differences, we considered any occurrence below the US/Mexican border as ‘South America’. We acknowledge that this may oversimplify a few cases, for example, when considering the complex colonial history of certain countries, but overall we assumed errors so introduced to be minor.

*Hypothesis testing*

We tested our hypotheses using regression models. In all these analyses, we followed general recommendations by Zuur & Ieno (2016) for data exploration, model fit and model validation. Given the large sample size, we used a conservative approach in the identification of significance, setting an alpha level for significance at 0.001 instead of the usually accepted 0.05 and always reporting effect size (Benjamin *et al.*, 2018; Muff *et al.*, 2021). In all analyses testing temporal patterns, we excluded the year 2020 because we had only partial data up to June.

To ask whether the way taxonomists choose etymologies has changed over time, we first calculated the annual proportion of etymologies for each etymology type (a factor variable with six levels, as described in the section ‘Classification of etymologies’). We acknowledge that, because these categories must add to 1, their values are not fully independent. Statistical tests of trends in each should thus be interpreted with some caution.

We performed a generalized additive model with the proportion of etymologies as a response variable, testing the effect of a smooth function of year of publication (a discrete variable from 1757 to 2019) in interaction with the etymology category. We used additive models in order to account for possible non-linear trends of the sampling period. We ran the model with the R package ‘mgcv’ v.1.8-35 (Wood, 2004) assuming a binomial distribution, a logit link function and a thin plate regression spline. We estimated the optimal amount of smoothing through generalized cross-validation. As the initial model was overdispersed (dispersion ratio = 1.91), we switched to a quasi-binomial distribution, a quasi-distribution that

includes an extra parameter to describe additional variance in the data that cannot be explained by a binomial distribution alone. The model sample size was 1386 observations.

Next, we asked whether the temporal trends identified in the previous analysis changed across continents. We constructed a second model with the proportion of etymologies as a response variable, testing the effect of a smooth function of year of publication in interaction with the continent in which the species occurs (a categorical variable with six levels, see section ‘Species geographic distribution’). In this case, we stuck to a binomial distribution because overdispersion was minimal (dispersion ratio = 1.26). The model sample size was 6378 observations.

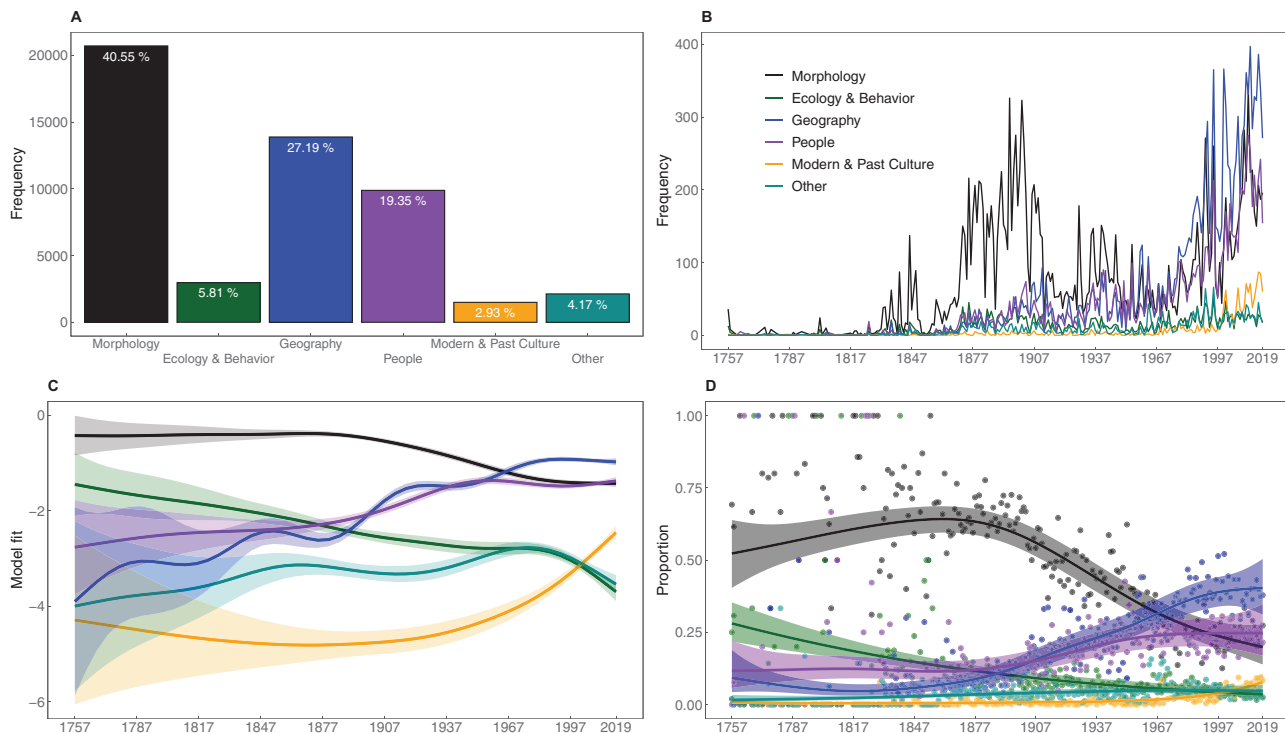
Finally, we tested whether taxonomists are more likely to choose a given etymology category over others across continents. We constructed six generalized linear models, one for each etymology type, testing the effect of the factor continent on the use of a given etymology type. As the response variables were binary variables (0–1 discrete), we specified a Bernoulli distribution and a complementary log–log link function (clog–log), as

recommended in [Zuur \*et al.\* \(2009\)](#) for datasets with unbalanced sets of zeros and ones. To avoid confounding effects of including species that occur across multiple continents, we used for the analysis the subset of species occurring in a single continent, resulting in a total sample size of 44 541 observations.

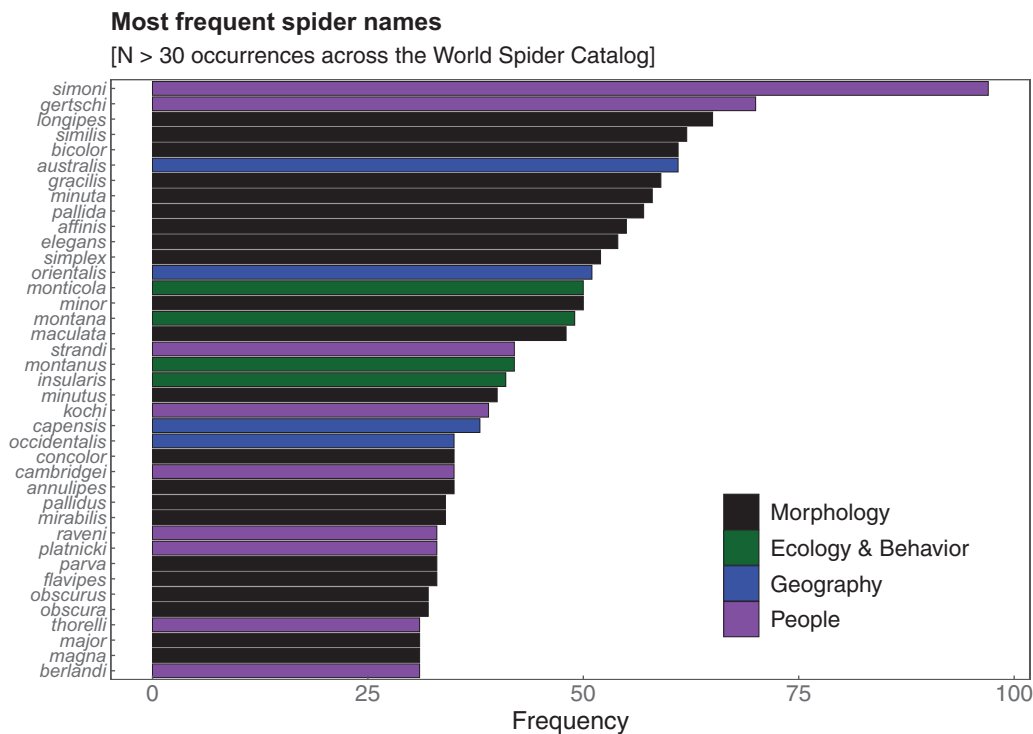
## RESULTS

### SPIDER ETYMOLOGIES BY THE NUMBERS

We classified the meaning of 47 325 spider species and subspecies names, of which 44063 had a single meaning and 3262 multiple meanings. Most etymologies referred to morphology (41%,  $N = 20\,702$ ), geography (27%,  $N = 13\,880$ ) or were dedicated to people (19%,  $N = 9881$ ) ([Fig. 1A](#)). The most frequently used names across the database mostly belonged to these three categories ([Fig. 2](#)) as well. The least used etymologies belonged to the category Other (4%,  $N = 2128$ ). Over 90% of names attributed to species had a single meaning (i.e. we classified them into a single subcategory). However, there were names with



**Figure 1.** Temporal variations in the way taxonomists assign spiders etymologies. A, breakdown of the total number of etymologies by category. B, temporal variations in the number of etymologies (annual sum by etymology type) between 1757 and 2019. C, plot of smooth terms for the temporal variations in the relative proportion of different types of etymologies, according to a generalized additive model. D, temporal variations in the proportional use of etymologies. In C and D, coloured lines and shaded surfaces are, respectively, the predicted trend and 95% confidence interval for each level of the factor type, according to a generalized additive model. Exact model estimates are given in the [Supporting Information, Table S1](#).



**Figure 2.** Most frequent spider epithets. Only epithets shared by more than 30 species across the database are shown. Colour-coding refers to the most frequent use of each name (e.g. *similis* is most often used in a morphological sense, but in a few instances it was also used as a reference to the similarity in the geographic distribution of one species to another).

multiple meanings – typically two, although there were etymologies with up to four meanings. The average length of species epithets was eight letters (Box 1).

#### TEMPORAL PATTERNS

Are we naming species differently today than in the past? Looking at absolute numbers, there were some striking temporal differences in the way taxonomists name species (Fig. 1B). This was confirmed by modelling the relative proportion of etymologies over time (Fig. 1C), whereby we found a significant interaction between the year of the description and the type of etymology (estimated parameters are in the Supporting Information, Table S1). In the first 150 years from the introduction of the Linnaean system of nomenclature, the most frequently used etymologies referred to morphology and ecology. The relative use of morphological etymologies peaked in 1850–1900 and then started to decline (Fig. 1D) along with a parallel increase in etymologies dedicated to people and geography. Etymologies referring to geography quickly rose, overtaking morphological etymologies around 1950, and currently are the most widely used (~38% of all etymologies of species described in the last ten years referred to geography, ~25% to people and

~25% to morphology). Etymologies referring to modern and past culture began to rise in use after the year 2000. Although such etymologies are not widely used in absolute terms, their relative use has increased dramatically in the last two decades (especially those referring to pop culture).

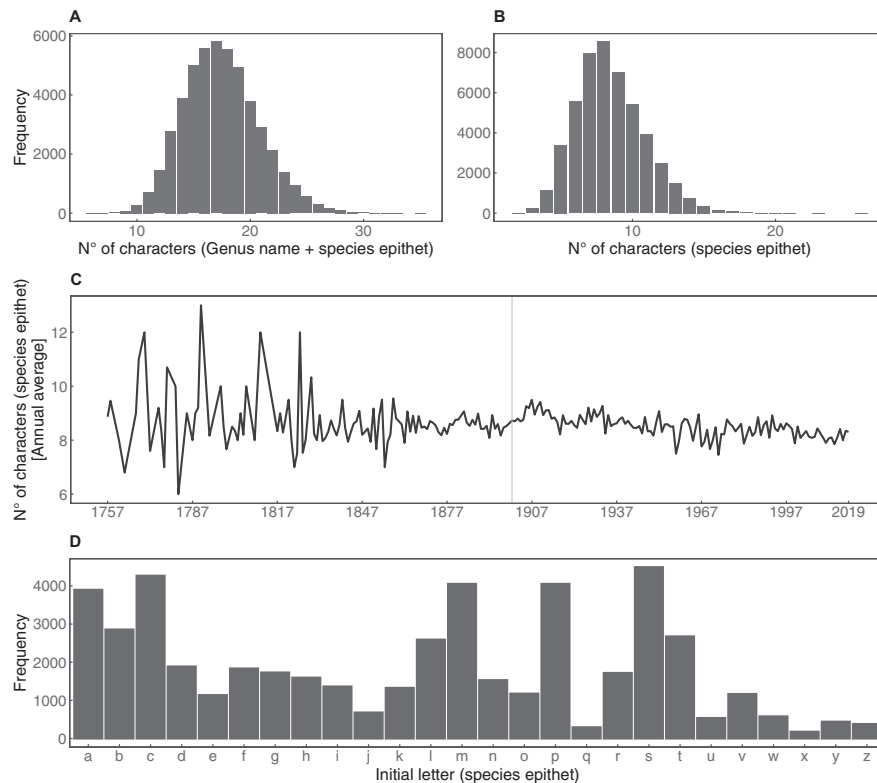
A second model testing the interaction of etymology by continent revealed that the temporal trends differed significantly across regions, especially with respect to Oceania (Fig. 3). However, the general direction of temporal trends across regions was qualitatively similar to those in Figure 1D.

#### SPATIAL PATTERNS

While the proportions of names from the six etymological categories were consistent across continents (Fig. 4), we found some notable spatial patterns in the way taxonomists assign species names (model estimates in the Supporting Information, Tables S2–S7). Spiders from Europe are less likely to be named in reference to morphology, but more likely to bear names dedicated to some person, compared to spiders from other continents. Species from Europe and North America are also more frequently named after ecology and behaviour. Asian and Oceanian species are more likely to be named in reference to

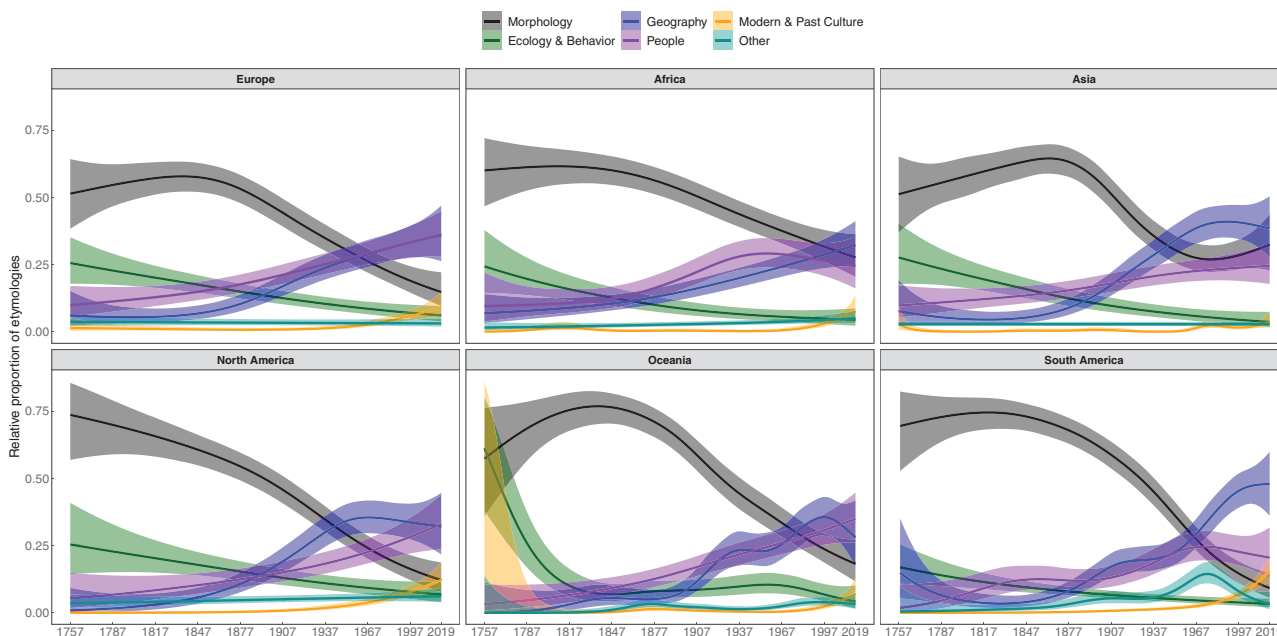
### Box 1. Spider etymologies by numbers and some spider world records

The number of characters in spider names is roughly normally distributed, considering either the sum of letters in the genus and species (Fig. A) or the species epithet alone (Fig. B). The average number of characters in the species epithet hasn't changed substantially between 1757 and today (Fig. C; note that the variability in the average prior to 1850 is largely attributable to the lower sample size). The average and frequency distribution of the length of species epithets in spiders is strikingly similar to what was observed for parasite species names by Poulin *et al.* (2022a), possibly suggesting the existence of broader patterns within taxonomy. When considering the sum of letters in the genus and species, the record for the longest (spider) scientific name goes to the recently described theraphosid *Chilobrachys jonitriantisvansickleae* Nanayakkara *et al.*, 2019 (35 characters), dedicated to Joni Triantis Van Sickle (Nanayakkara *et al.*, 2019). This newly described species beat the previous records of 33 characters (Mammola *et al.*, 2017), which was held by *Dipoena santaritadopassaquatrensis* Rodrigues, 2013 (Theridiidae) and *Phormingochilus pennellhewlettorum* Smith & Jacobi, 2015 (Theraphosidae). When only taking into account the species epithet, however, *D. santaritadopassaquatrensis* still yields the record for the longest name (26 characters). The etymology is derived from the type locality, Santa Rita do Passa Quatro in the state of São Paulo, Brasil (Rodrigues, 2013). Conversely, the shortest etymology (genus + species) is six letters in *Gea eff* Levi, 1983 (Araneidae) (Mammola *et al.*, 2017). According to the original description, *eff* is simply an 'arbitrary combination of letters' (Levi, 1983). Several two-letter epithets have also been attributed to various species (*ab*, *an*, *ef*, *fo*, *la*, *kh*, *mi*, *no*, *oz*, *wa*, *wu*, *yi* and *zu*). Interestingly, some of these short epithets are used intentionally to refer to the small size of the species. For example, *Selenops ab* Logunov & Jäger, 2015 (Selenopidae) and *Selenops ef* Jäger, 2019 (Selenopidae) are arbitrary combinations of letters reflecting the small size of the species by using the smallest allowable number of letters to form a specific name (Logunov & Jager, 2015; Jäger, 2019). It is worth noting that *ab* is currently also the first spider epithet alphabetically. This, until someone names a species *aa* – the challenge is open!



**Box Figure.** A, frequency of etymologies by the number of letters, summing genus plus species. B, frequency of etymologies by the number of letters in the species epithet. C, variation in the length of species epithets (annual average) over time (1757–2019). D, frequency of etymologies by the initial letter of the species epithet.





**Figure 3.** Temporal trends in the way taxonomists assign etymology by region. Coloured lines are predicted values and shaded surfaces represent 95% confidence intervals.

geography compared to other continents. Furthermore, the probability of a species name being a reference to modern and past culture was higher in Europe, North America and Oceania than in other continents (Fig. 4).

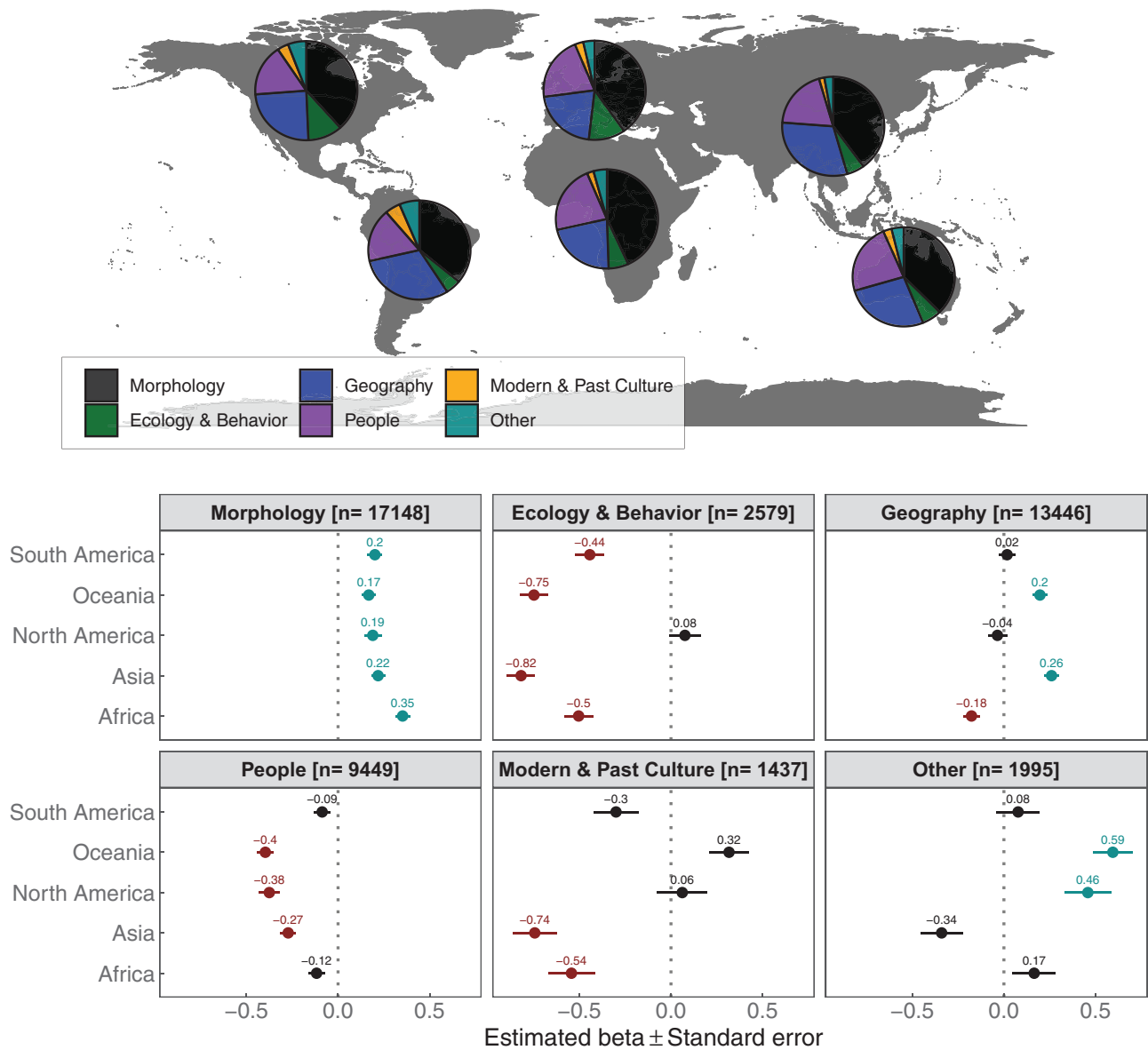
## DISCUSSION

### TEMPORAL PATTERNS IN NAMING TRENDS

Despite gigantic advances in molecular and bioinformatic tools (Anderson *et al.*, 2021; Tosa *et al.*, 2021), taxonomy remains a conservative science that still mostly relies on morphological methods and the basic grammar rules of the scientific Latin language used in the 18<sup>th</sup> century. At the same time, it is a domain of science home to vigorous and even heated debates, for example, around the role of taxonomy and taxonomists in academia (Drew, 2011; Zeppelini *et al.*, 2021) and around emerging new approaches to species descriptions [e.g. photography-based taxonomy (Ceríaco *et al.*, 2016; Zamani *et al.*, 2021) and sequence-based taxonomy (Sharkey *et al.*, 2021; Zamani *et al.*, 2022)]. Spider names echo the traditional nature of taxonomy, insofar as most etymologies refer to biological features of spiders and their ecology and distributions. Indeed, the categories of morphology and geography were overwhelmingly represented across the database (Fig. 1B). However, naming practice has changed: names based on morphology, as well as those based on ecology and

behaviour, have both declined substantially since the late-19<sup>th</sup> century. Interestingly, the same trend is seen in species etymologies in the plant genus *Aloë* L. (Figueiredo & Smith, 2010): names from morphology have fallen by about half over the 20<sup>th</sup> century, while names for geography and people have increased. Figueiredo and Smith speculate that this may reflect either decreasing knowledge of technical Latin or a saturation effect where simple morphological names have increasingly been used up. In spiders, at least, we suspect the latter is more likely. However, it is difficult to distinguish this hypothesis from an increasing receptivity to more creative naming, perhaps reflecting broader acceptance that science is, like all human enterprises, culturally situated.

While names based on morphology, geography and ecology can be seen as deeply rooted in taxonomic tradition, there are some extravagant outliers. For instance, some names combine morphological features and cultural references with unexpected outcomes. Just to cite a few cases: *Heteropoda hippie* Jäger, 2008 is named after the Hippie movement and refers to the long hairs of the male spider metatarsi (Jäger, 2008); *Eriovixia gryffindori* Ahmed *et al.*, 2016, a spider with a hat-shaped abdomen, is a reference to the sorting hat in the Harry Potter books by J. K. Rowling (Ahmed *et al.*, 2016); and *Heteropoda ninahagen* Jäger, 2008 is a tribute to the songs of Nina Hagen that, according to the descriptor, are '[...] as unusual as the shape of the retrolateral tibial apophysis' (Jäger, 2008) – we



**Figure 4.** Spatial variations in the way taxonomists assign spiders etymologies. Pie charts display the proportions of etymology types by continent. Estimates ( $\pm$  standard errors) are based on Bernoulli generalized linear models testing for differences in the proportion of different etymology types by continent. Significant differences ( $P < 0.001$ ) from the baseline (Europe) are highlighted with colours (positive = turquoise; negative = red). Exact model estimates are given in the Supporting Information, Tables S2–S7.

recommend listening to a few albums to fully appreciate this analogy.

Both in the past and today, a substantial fraction of names were also dedicated to people, with the proportion of such etymologies slowly but steadily increasing between 1757 and 2019. In the past, these names were mostly honouring species collectors or other scientists, especially arachnologists (see Fig. 2). However, in recent years these etymologies have been also used to pay tribute to artists and celebrities or to

make statements about politics and the environment. An emblematic case is a study by Agnarsson *et al.* (2018): in documenting a radiation of *Spintharus Hentz, 1850* in the Caribbean, they named 15 species after famous people who stood up for human rights or were committed to nature conservation – Sir David Attenborough (*S. davidattenboroughi* Agnarsson *et al.* (2018), Barack Obama (*S. barackobamai* Agnarsson *et al.* (2018), Michelle Obama (*S. michelleobamaae* Agnarsson & Sargeant, 2018 and Leonardo Di

Caprio (*S. leonardodicaprio* Agnarsson *et al.* (2018), among others. Interestingly, in helminth parasites the frequency of eponymous names that honour scientists has not changed, at least over a recent two-decade window, but the frequency of eponymous names honouring other people has increased (Poulin *et al.*, 2022b). Together with our results, which span a much longer period of time, we see this as further evidence of increasing interest in eponymous naming, combined with growing socio-cultural engagement in the coining of names.

In the last two decades, with taxonomy entering the Internet era, there has also been a rise in etymologies dedicated to modern cultures, especially for European and American species. Such etymologies have referred to topics as diverse as the human cultural heritage itself: we found mentions to spiders in fantasy and fantastic literature (e.g. all species described in Brescovit *et al.*, 2018), references to cartoons (e.g. *Ianduba dabadu* Magalhaes *et al.*, 2016 is intended to sound like the famous yell of Fred Flintstone), tributes to musicians (e.g. *Balmaceda abba* Edwards & Baert, 2018, honouring the Swedish pop group ABBA, allusions to urban legends (e.g. *Antilloides chupacabras* Magalhaes, 2018; see detailed explanation in Magalhaes, 2018) and countless other local traditions.

Finally, under the category Other we grouped a miscellany of difficult-to-classify etymologies. Just to cite a few cases: the oonopid spider *Gamasomorpha insomnia* Eichenberger, 2012 owes its name to several 'sleepless nights' experienced by the author during discrimination of intraspecific variation and feasible characters (Eichenberger *et al.*, 2012); *Hortipes aelurisiepae* Bosselaers & Jocqué, 2000 is in memory of '...the cat Siep, which was run over by a truck when this species was being described' (Bosselaers & Jocqué, 2000); and *Filistatinella howdyall* Magalhaes & Ramírez, 2017 simply recall the Texan salute 'howdy, y'all!'. Interestingly, 465 of the 2128 etymologies that we classified as Other were 'arbitrary combinations of letters'. This naming strategy was frequently employed by prolific authors who described thousands of species, including Willis J. Gertsch (1906–98), Herbert W. Levi (1921–2014) and Norman I. Platnick (1951–2020). While some of these arbitrary names actually have hidden meanings (e.g. they were anagrams of the type locality), it was perhaps also a convenient naming strategy when lacking ideas.

#### SPATIAL PATTERNS IN NAMING PRACTICES

In general, we observed consistent trends in the proportions of names from the six etymological categories across continents. However, there were some notable spatial patterns in naming practices whose explanation is not always clear-cut. For example, the fact that species from Europe and North America are

more frequently named after ecology and behaviour compared to other continents may reflect a stronger tradition of (academic) ecological studies in these regions, but also simply a greater knowledge on the natural history of spider groups in temperate regions compared to mega-diverse faunas from tropical areas. Furthermore, in proportional terms, spiders described in the 'Global North' – Europe, North America and some Oceanian countries (Australia, New Zealand) – are more frequently dedicated to cultural features, especially when compared to African and Asian species. This may suggest a growing socio-cultural engagement in the coining of names in these regions, which has yet to become widespread elsewhere, but could also speak about subtle cultural differences that are difficult to ascertain.

It must be noted that our analysis assumes that the continent on which a spider species was found is the same as that where the taxonomist(s) responsible for choosing its name actually live. This will not always be true, either because a species is described by an expert living elsewhere or because a species is described by a team of taxonomists of different nationalities. This complication adds a degree of uncertainty to our interpretations of the observed patterns. This is confirmed when considering the widespread practice in naming species from Africa and South America by researchers from other continents, resulting in numerous species commemorating persons unfamiliar to inhabitants of these regions (e.g. Gillman & Wright, 2020; Trisos *et al.*, 2021; Smith & Figueiredo, 2022).

#### A FUTILE EXERCISE?

One may argue that our classification exercise was of limited and mainly technical interest – especially after the knowledge that it took us almost two years to annotate the full list of spider names. However, we do not think this is merely a technical exercise. Besides the narrow-in-scope goal of better understanding naming practices in arachnology, we contend that our analysis can be a benchmark for future studies. More importantly, we believe that our work should foster reflections about the science of taxonomy more generally, and about the way science and scientists are situated in a cultural context that influences everything we do.

First, our analysis comes at an historical time when the science of taxonomy is experiencing a profound crisis (Godfray, 2002; Bilton, 2014; Engel *et al.*, 2021). Despite gigantic leaps forwards in artificial intelligence and molecular technologies, taxonomy – and especially species description – remains a largely conservative discipline, probably one of the most unchanged during the last centuries in terms of background, tools and

rules (but see: Ceriaco *et al.*, 2016; Sharkey *et al.*, 2021; Zamani *et al.*, 2021, 2022; Fernandez-Triana, 2022). Currently, basic taxonomy faces marginalization, being in constant shortage of personnel and receiving limited research funding, attention and credit (Godfray, 2002; Engel *et al.*, 2021). However, taxonomy is pivotal to any discipline focusing on living organisms and it is fundamental to ensuring reproducibility of biological studies, given that species misidentifications or changes in taxonomy may deeply affect conclusions (Vink *et al.*, 2012). Although some names currently fashionable in modern-day taxonomy carry little or no biological information regarding the species itself, they can help to give visibility to taxonomic and species-discovery research. For example, homages to celebrities – from Johnny Cash (*Aphonopelma johnnycashi* Hamilton *et al.*, 2016) to Angelina Jolie (*Aptostichus angelinajolieae* Bond, 2008 in Bond & Stockman, 2008) to David Bowie (*Heteropoda davidbowie* Jäger, 2008 and *Spintharus davidbowiei* Agnarsson & Chomitz, 2018 in Agnarsson *et al.*, 2018) to Arnold Schwarzenegger (*Predatoroonops schwarzeneggeri* Brescovit, Rheims & Ott, 2012 in Brescovit *et al.*, 2012) – often attract huge scientific and media attention. This raises the important question: can this attention be harnessed to spotlight problems surrounding the taxonomy crisis? It would be interesting, but challenging, to ask whether public attention to species naming translates to public or governmental support for species discovery and conservation.

Second, our classification exercise allowed us to discover hidden gems of unconventional and sparkling scientific writing, illustrating how the reputation of taxonomy as tedious (e.g. Leather & Quicke, 2009) is not entirely deserved. The number of witty etymologies we documented is a reminder that even the writing (and reading) of taxonomic papers can be simultaneously rigorous and enjoyable (Heard, 2014). Also, the recent dramatic increase in non-traditional etymologies is symptomatic of an ongoing transition toward a modern writing style that retreats to some extent from the dense, impersonal and difficult-to-access orthodox style of scientific writing (Sword, 2012; Greene, 2013; Doubleday & Connell, 2017; Freeling *et al.*, 2019; Mammola, 2020) – otherwise known as ‘academese’ (Pinker, 2015). To us, the creativity of taxonomists in devising new species names is inspirational and can foster reflection about the way we communicate science.

Third, our database can be a starting point to explore important topics related to academic life, especially the timely debate around inequalities in the scientific community. An illustrative example comes from a recent work by Trisos *et al.* (2021). They mapped Latin names of birds globally, showing that most of the species occurring outside Europe in formerly colonized countries are named after European surnames rather than indigenous ones. In

our case, a subset of spider etymologies dedicated to people could be used to confirm the generality of this pattern beyond birds. Also, one could test whether there is a gender bias in the way taxonomists assign species names and if gender ratios in names are changing through time [as studied for plants by Lindon *et al.* (2015)]. We believe the latter would be a timely endeavour, given that reflections around gender issues are gaining ground in the arachnological community (Holmquist & Gillespie, 2022; Marusik & Sherwood, 2022; see also the multiple initiatives by the group SWA – Support Women in Arachnology; @SwaWomen). We leave the answers to these and other questions for future work, while welcoming anyone to explore and re-use the database uploaded alongside this submission. For now, we simply highlight two recent examples: *Grymeus dharmapriyai* Ranasinghe & Benjamin, 2018, and *Tmarus manojkaushalyai* Ileperuma Arachchi & Benjamin, 2019, both named by a young Sri Lankan woman as part of her taxonomic training. She named them for her husband (Ranasinghe & Benjamin, 2018; Ileperuma Arachchi & Benjamin, 2019). Here, taxonomy and creativity come together to express perhaps the most mysterious of human emotions: love. Science and scientists will always be embedded in human culture, and because they allow such free expression, scientific names can be a way to shine a light on this connection.

#### ACKNOWLEDGEMENTS

We are grateful to the World Spider Catalog’s team (<https://wsc.nmbe.ch/boards>) for their immense contribution to spider taxonomy. Special thanks to people who helped us with inferring etymologies in specific languages, namely Malin Teräväinen (Swedish) and Svetlana Pétilon (Russian). This project has received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 882221.

#### AUTHOR CONTRIBUTION

JP conceived the idea. JP, DF and SM designed methodology. All authors collected data. SM analysed data and wrote the first draft. All authors contributed to the writing with suggestions, ideas and additions to the text.

#### CONFLICT OF INTEREST

None declared.

## DATA AVAILABILITY

R codes to generate the analyses and plots are available in GitHub ([https://github.com/StefanoMammola/Spider\\_Etymologies\\_Analysis](https://github.com/StefanoMammola/Spider_Etymologies_Analysis)). The database supporting the study is available in Figshare (<https://doi.org/10.6084/m9.figshare.19126658>).

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## SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher’s web-site.

**Table S1.** Estimated model parameters for the generalized additive model testing the effect of a smooth function of year of publication in interaction with the etymology category on the proportion of etymologies.

**Table S2.** Estimated parameters for the Bernoulli generalized linear model testing the effect of the factor continent on the use of the etymology type Morphology.

**Table S3.** Estimated parameters for the Bernoulli generalized linear model testing the effect of the factor continent on the use of the etymology type Ecology & Behavior.

**Table S4.** Estimated parameters for the Bernoulli generalized linear model testing the effect of the factor continent on the use of the etymology type Geography.

**Table S5.** Estimated parameters for the Bernoulli generalized linear model testing the effect of the factor continent on the use of the etymology type People.

**Table S6.** Estimated parameters for the Bernoulli generalized linear model testing the effect of the factor continent on the use of the etymology type Modern & Past Culture.

**Table S7.** Estimated parameters for the Bernoulli generalized linear model testing the effect of the factor continent on the use of the etymology type Others.