

1 **Tapping into non-English-language science for the conservation of global biodiversity**

2

3 Short title: Non-English-language science for global biodiversity conservation

4

5 Tatsuya Amano^{1, 2*}, Violeta Berdejo Espinola^{1, 2}, Alec P. Christie^{3, 4}, Kate Willott³,
6 Munemitsu Akasaka^{5, 6}, Andrés Báldi⁷, Anna Berthinussen⁸, Sandro Bertolino⁹, Andrew J.
7 Bladon³, Min Chen^{10, 11}, Chang-Yong Choi¹², Magda Bou Dagher Kharrat¹³, Luis G. de
8 Oliveira¹⁴, Perla Farhat¹³, Marina Golivets¹⁵, Nataly Hidalgo Aranzamendi¹⁶, Kerstin Jantke¹⁷,
9 Joanna Kajzer-Bonk^{18, 19}, M. Çisel Kemahlı Aytekin²⁰, Igor Khorozyan²¹, Kensuke Kito²², Ko
10 Konno²³, Da-Li Lin^{1, 24}, Nick Littlewood^{3, 25}, Yang Liu²⁶, Yifan Liu²⁷, Matthias-Claudio
11 Loretto^{28, 29}, Valentina Marconi^{30, 31}, Philip Martin³, William H. Morgan³, Juan P.
12 Narváez-Gómez^{32, 33}, Pablo Jose Negret^{2, 34}, Elham Nourani^{28, 29}, Jose M. Ochoa Quintero³⁵,
13 Nancy Ockendon³⁶, Rachel Rui Ying Oh^{1, 2, 37}, Silviu Petrovan³, Ana C. Piovezan-Borges³⁸,
14 Ingrid L. Pollet³⁹, Danielle L. Ramos⁴⁰, Ana L. Reboredo Segovia⁴¹, A. Nayelli
15 Rivera-Villanueva⁴², Ricardo Rocha^{3, 43, 44}, Marie-Morgane Rouyer⁴⁵, Katherine A.
16 Sainsbury^{3, 46}, Richard Schuster⁴⁷, Dominik Schwab⁴⁸, Çağan H. Şekercioğlu^{20, 49}, Hemin
17 Seo¹², Gorm Shackelford^{3, 4}, Yushin Shinoda⁵, Rebecca K. Smith³, Shan-dar Tao⁵⁰,
18 Ming-shan Tsai⁵¹, Elizabeth Tyler³, Flóra Vajna^{7, 52}, José Osvaldo Valdebenito^{53, 54}, Svetlana
19 Vozykova⁵⁵, Paweł Waryszak⁵⁶, Veronica Zamora-Gutierrez⁵⁷, Rafael D. Zenni⁵⁸, Wenjun
20 Zhou²⁶, William J. Sutherland^{3, 4}

21

22 ¹ School of Biological Sciences, The University of Queensland, Brisbane, 4072 Queensland,
23 Australia.

24 ² Centre for Biodiversity and Conservation Science, The University of Queensland, Brisbane,
25 4072 Queensland, Australia.

26 ³ Conservation Science Group, Department of Zoology, University of Cambridge, The David
27 Attenborough Building, Downing Street, Cambridge CB3 3QZ, UK.

28 ⁴ BioRISC, St. Catharine's College, Cambridge CB2 1RL, UK.

29 ⁵ Faculty of Agriculture, Tokyo University of Agriculture and Technology, 183-8509 Tokyo,
30 Japan.

31 ⁶ Institute of Global Innovation Research, Tokyo University of Agriculture and Technology,
32 Fuchu, 183-8509 Tokyo, Japan.

33 ⁷ Lendület Ecosystem Services Research Group, Institute of Ecology and Botany, Centre for
34 Ecological Research, H-2163 Alkotmány u. 2-4, Vácrátót, Hungary.

35 ⁸ Conservation First, Ampleforth, York YO62 4DB, UK.

36 ⁹ Department of Life Sciences and Systems Biology, University of Turin, Via Accademia
37 Albertina 13, 10123 Torino, Italy.

38 ¹⁰ School of Life Sciences, Institute of Eco-Chongming (IEC), East China Normal University,
39 Shanghai, 200241 China.

40 ¹¹ Yangtze Delta Estuarine Wetland Ecosystem Observation and Research Station, Ministry of
41 Education & Shanghai Science and Technology Committee, Shanghai, 202162, China.

42 ¹² Department of Agriculture, Forestry, and Bioresources, Seoul National University, Seoul
43 08826, Republic of Korea.

44 ¹³ Laboratoire Biodiversité et Génomique Fonctionnelle, Faculté des Sciences, Université
45 Saint-Joseph, Campus Sciences et Technologies, Beirut, Lebanon.

46 ¹⁴ Joint Nature Conservation Committee, Monkstone House, City Road, Peterborough PE1
47 1JL, UK.

48 ¹⁵ Department of Community Ecology, Helmholtz-Centre for Environmental Research - UFZ,
49 Theodor-Lieser-Str. 4, 06120 Halle, Germany.

50 ¹⁶ School of Biological Sciences, Monash University, Melbourne VIC, Australia.

51 ¹⁷ Center for Earth System Research and Sustainability, University of Hamburg, 20144
52 Hamburg, Germany.

53 ¹⁸ Institute of Nature Conservation, Polish Academy of Sciences, Mickiewicza 33, 31-120
54 Kraków, Poland.

55 ¹⁹ Institute of Zoology and Biomedical Research, Faculty of Biology, Jagiellonian University,
56 Gronostajowa 9, 30-387 Kraków, Poland.

57 ²⁰ Department of Molecular Biology and Genetics, Koç University, Rumelifeneri Yolu 34450
58 Sarıyer, Istanbul, Turkey.

- 59 ²¹ Department of Conservation Biology, Georg-August-Universität Göttingen, Bürgerstrasse
60 50, Göttingen 37073, Germany.
- 61 ²² Department of Ecosystem Studies, Graduate School of Agricultural and Life Sciences, The
62 University of Tokyo, 1-1-1 Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan.
- 63 ²³ School of Natural Sciences, Bangor University, Gwynedd LL57 2UW, UK.
- 64 ²⁴ Endemic Species Research Institute, 1, Ming-Shen East Road, Jiji, Nantou 55244, Taiwan.
- 65 ²⁵ Department of Rural Land Use, SRUC, Craibstone Estate, Bucksburn, Aberdeen, AB21
66 9YA, UK.
- 67 ²⁶ State Key Laboratory of Biocontrol, School of Ecology, Sun Yat-sen University,
68 Guangzhou, Guangdong, China, 510275.
- 69 ²⁷ School of Agriculture and Biology, Shanghai Jiao Tong University, Shanghai 200240,
70 China.
- 71 ²⁸ Department of Migration, Max Planck Institute of Animal Behavior, Am Obstberg 1, 78315,
72 Radolfzell, Germany.
- 73 ²⁹ Department of Biology, University of Konstanz, Universitätsstraße 10, 78464 Konstanz,
74 Germany.
- 75 ³⁰ Faculty of Natural Sciences, Department of Life Sciences (Silwood Park), Imperial College
76 London, Buckhurst Road, Ascot, Berks SL5 7PY, UK.
- 77 ³¹ Institute of Zoology, Zoological Society of London, Regent's Park, London NW1 4RY, UK.
- 78 ³² Departamento de Botânica, Instituto de Biociências, Universidade de São Paulo, Rua do
79 Matão nº 277, Cidade Universitária, São Paulo, SP, CEP 05508-090, Brazil.
- 80 ³³ Forest Ecology and Conservation Group, Conservation Research Institute and Department
81 of Plant Sciences, University of Cambridge, Cambridge, CB2 3EA, UK.
- 82 ³⁴ School of Earth and Environmental Sciences, The University of Queensland, Queensland
83 4072, Australia.
- 84 ³⁵ Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, Avenida
85 Circunvalar No. 16-20, Bogotá, DC, Colombia.
- 86 ³⁶ Endangered Landscapes Programme, The Cambridge Conservation Initiative, The David
87 Attenborough Building, Cambridge, CB2 3QZ, UK.

- 88 ³⁷ German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Puschstraße
89 4, 04103 Leipzig, Germany.
- 90 ³⁸ Programa de Pós-Graduação em Ecologia e Conservação, Instituto de Biociências (INBIO),
91 Universidade Federal de Mato Grosso do Sul (UFMS), Campo Grande, Mato Grosso do Sul,
92 Brazil.
- 93 ³⁹ Acadia University, Wolfville NS B4P 2R6, Canada.
- 94 ⁴⁰ Plantem - Plant Tecnology and Environmental Monitoring Ltd., Av. Doutor Altino
95 Bondesan 500, Sao Jose dos Campos, Sao Paulo, Brazil.
- 96 ⁴¹ Department of Earth and Environment, Boston University, 685 Commonwealth Avenue,
97 Boston, MA 02215, USA.
- 98 ⁴² Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional Unidad
99 Durango (CIIDIR), Instituto Politécnico Nacional, Durango, México.
- 100 ⁴³ CIBIO □ InBIO, Research Center in Biodiversity and Genetic Resources, University of
101 Porto, 4485-661 Vairão, Portugal.
- 102 ⁴⁴ CIBIO □ InBIO, Research Center in Biodiversity and Genetic Resources, Institute of
103 Agronomy, University of Lisbon, 1349-017 Lisbon, Portugal.
- 104 ⁴⁵ CEFE, Univ Montpellier, CNRS, EPHE, IRD, Montpellier, France.
- 105 ⁴⁶ Faculty of Kinesiology, Sport, and Recreation, University of Alberta, 2-130V Van Vliet
106 Complex (University Hall), Edmonton, Alberta, T6G 2H9, Canada.
- 107 ⁴⁷ Department of Biology, 1125 Colonel By Drive, Carleton University, Ottawa ON, K1S 5B6
108 Canada.
- 109 ⁴⁸ Agroecology, Department of Crop Sciences, University of Göttingen, Grisebachstrasse 6,
110 37077 Göttingen, Germany.
- 111 ⁴⁹ School of Biological Sciences, University of Utah, Salt Lake City, Utah, USA.
- 112 ⁵⁰ Graduate School of Engineering and Science, University of the Ryukyus, Semburu,
113 Nakagami Gun Nishihara Cho, Okinawa Ken, 903-0129, Japan.
- 114 ⁵¹ Wildlife Conservation Research Unit, Department of Zoology, University of Oxford, 11a
115 Mansfield Road, Oxford OX1 3SZ, UK.
- 116 ⁵² Department of Ecology, Institute for Biology, University of Veterinary Medicine, H-1077
117 Rottenbiller u. 50, Budapest, Hungary.

118 ⁵³ Milner Centre for Evolution, University of Bath, Claverton Down, Bath BA2 7AZ, UK.

119 ⁵⁴ Department of Evolutionary Zoology and Human Biology, University of Debrecen, H-4010,
120 Debrecen Egyetem tér1, Hungary.

121 ⁵⁵ Faculty of Energy and Ecotechnology (GreenTech), ITMO University, Kronverkskiy
122 Prospekt 49, St Petersburg, 197101 Russia.

123 ⁵⁶ School of Life and Environmental Sciences, Centre for Integrative Ecology, Deakin
124 University, VIC 3125, Australia.

125 ⁵⁷ Cátedras CONACYT—Centro Interdisciplinario de Investigación para el Desarrollo Integral
126 Regional Unidad Durango (CIIDIR), Instituto Politécnico Nacional, Durango, México.

127 ⁵⁸ Departamento de Ecologia e Conservação, Instituto de Ciências Naturais, Universidade
128 Federal de Lavras. Campus Universitário, Lavras, Minas Gerais, CEP 37200-900, Brazil.

129

130 * Corresponding author: t.amano@uq.edu.au

131

132 **Abstract**

133 The widely held assumption that any important scientific information would be available in
134 English underlies the underuse of non-English-language science across disciplines. However,
135 non-English-language science is expected to bring unique and valuable scientific information,
136 especially in disciplines where the evidence is patchy, and for emergent issues where
137 synthesising available evidence is an urgent challenge. Yet such contribution of
138 non-English-language science to scientific communities and the application of science is
139 rarely quantified. Here we show that non-English-language studies provide crucial evidence
140 for informing global biodiversity conservation. By screening 419,680 peer-reviewed papers
141 in 16 languages, we identified 1,234 non-English-language studies providing evidence on the
142 effectiveness of biodiversity conservation interventions, compared to 4,412 English-language
143 studies identified with the same criteria. Relevant non-English-language studies are being
144 published at an increasing rate, and can expand the geographical (by 12-25%) and taxonomic
145 (by 5-32%) coverage of English-language evidence, especially in biodiverse regions, albeit
146 often based on less robust study designs. Our results show that synthesising
147 non-English-language studies is key to overcoming the widespread lack of local,
148 context-dependent evidence and facilitating evidence-based conservation globally. We urge
149 wider disciplines to rigorously reassess the untapped potential of non-English-language
150 science in informing decisions to address other global challenges.

151

152 **Introduction**

153 History demonstrates that important scientific information is published not just in English but
154 also other languages. The structure of the Nobel Prize-winning antimalarial drug was first
155 published in Chinese [1]. An important rule regarding biodiversity was founded on evidence
156 published in Spanish [2]. Many of the earliest papers on COVID-19 were written, again, in
157 Chinese [3]. Yet the contribution of such non-English-language science to scientific
158 communities, and the broader society, is rarely quantified.

159 We test this untapped potential of non-English-language science through an assessment of
160 non-English-language studies' contribution to evidence synthesis—the process of compiling

161 and summarising scientific information from a range of sources. Evidence synthesis plays a
162 major role in informing decisions for tackling global challenges in fields such as healthcare [4],
163 international development [5], and biodiversity conservation [6]. To date
164 non-English-language studies have largely been ignored in evidence synthesis [7-9]. The
165 consequences of this common practice are, however, rarely investigated in most disciplines
166 apart from healthcare. And even there, the focus has almost exclusively been on how including
167 non-English-language studies might change the statistical results of meta-analyses [10, 11]
168 (see Supplementary Text for a review of earlier relevant studies). However,
169 non-English-language studies may also enhance the synthesis of evidence with specific types
170 of scientific information that is not available in English-language studies, especially in
171 disciplines dealing with more geographically and taxonomically diverse targets and
172 phenomena than healthcare [12].

173 Synthesising non-English-language studies could be an effective avenue for reducing the
174 existing, severe gaps in the geographical and taxonomic coverage of available scientific
175 evidence for biodiversity conservation [13, 14]. Compiling evidence on what does or does not
176 work in biodiversity conservation, and informing decisions with robust scientific evidence is
177 critical to halting the ongoing biodiversity crisis [6]. As local and context-dependent evidence
178 is crucially required for conservation-related decision making [15], the geographical and
179 taxonomic gaps in evidence, especially in biodiverse regions, pose a major challenge to our
180 scientific understanding of the biodiversity crisis and the implementation of evidence-based
181 conservation globally. Non-English-language studies could be particularly important in
182 biodiversity conservation for the following reasons. First, over one-third of scientific
183 documents on biodiversity conservation are published in languages other than English [16].
184 Second, gaps in globally compiled English-language evidence are often found in areas where
185 English is not widely spoken [13]. Third, important evidence in biodiversity conservation is
186 routinely generated by local practitioners, who often prefer publishing their work in their first
187 language, which for many is not English [16].

188 Here we adopted the discipline-wide literature search method [17] to screen 419,680
189 peer-reviewed papers in 326 journals, published in 16 languages (Data S1), to identify

190 non-English-language studies testing the effectiveness of interventions in biodiversity
191 conservation (see Materials and Methods). Combining this dataset with English-language
192 studies identified with the same criteria, stored in the Conservation Evidence database [17],
193 enabled us to assess the contribution of non-English-language studies to evidence synthesis
194 through the testing of the following common perceptions that are rarely corroborated together:
195 (i) the amount of relevant scientific evidence that is available only in non-English languages is
196 negligible [18], (ii) the number of relevant studies being published in non-English languages
197 has been decreasing over time [19], (iii) the quality of non-English-language studies (measured
198 using the study designs adopted) is lower than that of English-language studies [7], and (iv)
199 evidence published in English represents a random subset of evidence published across all
200 languages [12].

201

202 **Results**

203 Our search elicited a total of 1,234 eligible non-English-language studies (including 53 studies
204 on amphibians, 247 on birds, and 161 on mammals, which were used for a detailed
205 species-level comparison with English-language studies) testing the effectiveness of
206 conservation interventions, published in 16 languages (Data S2 and S3). This adds a
207 considerable amount of scientific evidence for biodiversity conservation to the Conservation
208 Evidence database, which now stores 4,412 English-language studies (including 284 studies on
209 amphibians, 1,115 on birds, and 1,154 on mammals). The proportion of eligible studies in each
210 journal varied among languages, with Japanese (the highest proportion of eligible studies in a
211 journal was 26.7%), Hungarian (15.3%), French (12.9%), and German (9.1%) showing
212 particularly high proportions (largely < 5% of the studies screened were eligible in journals of
213 other languages) (Fig. S1). In all languages, except Hungarian, many journals searched had
214 almost no eligible studies, showing that our search had covered and gone beyond most of the
215 relevant journals (see *Limitations* in Materials and Methods for more details).

216 The yearly number of eligible non-English-language studies published in each journal has
217 increased significantly over time, especially since 2000, in six out of the 12 languages covered,
218 with Portuguese and Russian showing a particularly rapid increase, while traditional Chinese

219 also showed a marginally significant increase (Fig. 1). The other five languages did not show a
220 significant change in the number of eligible studies over time. This result thus refutes the
221 common perception that the number of non-English-language studies providing evidence is
222 declining. The recent increase in eligible studies indicates that performing searches only on
223 volumes from the most recent ten years in some long-running journals had minimal impact.

224 Our results largely support one of the common perceptions—that non-English-language
225 studies tend to be based on less robust study designs. Studies in ten out of the 16 languages we
226 searched were significantly more likely to adopt less robust designs, compared to
227 English-language studies, when controlling for the effect of study taxa and countries where
228 English-language studies were conducted (Fig. 2 and Table S1). Of the other six languages
229 showing no significant difference in designs from English-language studies (Persian,
230 Portuguese, Spanish, traditional Chinese, Turkish, and Ukrainian), only Portuguese and
231 Spanish had reasonable sample sizes (i.e., ten or more studies in each taxonomic group),
232 indicating that designs adopted in studies in those two languages were comparable to those in
233 English-language studies.

234 There was a clear bias in study locations between languages. English-language studies were
235 conducted in a total of 952 of the $2^\circ \times 2^\circ$ grid cells and non-English-language studies in 353
236 grid cells, 238 of which had no English-language studies (those grid cells shown in black in Fig.
237 3). Therefore, non-English-language studies expanded the geographical coverage of
238 English-language studies by 25%. More non-English-language studies tended to be found in
239 grid cells with fewer English-language studies, especially in East/Central/Western Asia, Russia,
240 northern Africa and Latin America (Fig. 3 and Fig. S2), but the relationship was not significant
241 when controlling for spatial autocorrelation (posterior median slope in a conditional
242 autoregressive model: -0.012, 95% credible interval (CI): -0.032 – 0.005; see an inset in Fig. 3).
243 Non-English-language studies expanded the geographical coverage based on English-language
244 studies by 12% for amphibians (Fig. S3), 16% for birds (Fig. S4), and 12% for mammals (Fig.
245 S5). In all three taxa, significantly more non-English-language studies were found in grid cells
246 with fewer English-language studies (amphibians: slope: -0.51, 95% CI: -0.94 – -0.17; birds:
247 slope: -0.23, 95% CI: -0.44 – -0.073; mammals: slope: -0.48, 95% CI: -0.74 – -0.25; also see

248 insets in figs. S3-5).

249 The 1,234 non-English-language studies together provided evidence on the effectiveness of
250 conservation interventions for a total of 1,954 unique species recognised by the International
251 Union for Conservation of Nature (IUCN) (including 40 amphibian, 564 bird, and 194
252 mammal species). Although species with more studies in non-English languages also tended to
253 have more studies in English for all three taxa (generalised linear mixed models for
254 amphibians: slope = 0.12, $z = 7.93$, $p < 0.001$; birds: slope = 0.060, $z = 13.18$, $p < 0.001$;
255 mammals: slope = 0.026, $z = 5.65$, $p < 0.001$; also see insets in Fig. 4), non-English-language
256 studies provided scientific evidence on the effectiveness of conservation interventions for an
257 additional nine amphibian, 217 bird, and 64 mammal species that were not covered by
258 English-language studies (Fig. 4), meaning 5%, 32%, and 9% increases in the evidence
259 coverage of amphibian, bird, and mammal species, respectively. Similarly,
260 non-English-language studies increased the evidence coverage of threatened species (Critically
261 Endangered, Endangered and Vulnerable species classified in the IUCN Red List of
262 Threatened Species) by 23% for birds and 3% for mammals. All threatened amphibian species
263 covered by non-English-language studies were also studied in English-language studies (Fig.
264 S6). Threatened species with more studies in non-English languages had fewer studies in
265 English for birds (slope = -0.34, $z = -2.35$, $p = 0.019$) but not for mammals (slope = 0.030, $z =$
266 0.923, $p = 0.356$; also see insets in Figure S6. Threatened amphibians could not be modelled as
267 only two species were covered by non-English-language studies).

268

269 **Discussion**

270 Our analyses demonstrate that three out of the four common perceptions on the role of
271 non-English-language scientific knowledge are not supported by evidence. We show that,
272 instead, (i) a considerable amount of scientific evidence underpinning effective conservation is
273 available in non-English languages (over 1,000 studies found in our searches), (ii) the number
274 of published studies providing such evidence has been increasing in many languages, and (iii)
275 non-English-language studies can provide evidence that is relevant to species (including
276 threatened species) and locations (including highly biodiverse regions, such as Latin America)

277 for which little or no English-language evidence is available. These results, based on a global
278 empirical analysis of 5,646 studies in 17 languages, corroborate earlier arguments on the
279 potential importance of non-English-language scientific knowledge in evidence-based
280 biodiversity conservation [16]. A poor availability of species- and location-specific evidence,
281 especially in countries where English is not widely spoken, has been recognised as a major
282 impediment to evidence-based conservation [20], as scientific knowledge is often used only if
283 it is relevant to the specific context of policies and practices [15, 21]. Meanwhile, a systematic
284 bias in study characteristics, such as species and ecosystems studied, has been found between
285 English- and Japanese-language studies in ecology [12]. Our study attests to the
286 between-language bias in study characteristics, namely study species and locations, at the
287 global scale, showing that incorporating non-English-language studies in evidence syntheses is
288 an effective approach to rectifying biases and filling gaps in the availability of evidence over
289 space and species. Examples of such non-English-language evidence on threatened species
290 include a Spanish-language study testing the use of guardian dogs to alleviate conflicts
291 between low-income livestock farmers in northern Patagonia and carnivores including
292 endangered Andean mountain cats (*Leopardus jacobita*) [22], and a Japanese-language study
293 reporting the effectiveness of relocation for endangered Blakiston's fish owls (*Bubo blakistoni*)
294 [23].

295 The other perception, that non-English-language studies tend to adopt less robust designs,
296 seems to be supported by our results, although a reasonable number of non-English-language
297 studies with robust designs also exist, especially in Portuguese (25 studies with Randomised
298 Controlled Trial) and Spanish (13 studies with Before-After-Control-Impact and three with
299 Randomised Controlled Trial). Scientific evidence presented in non-English-language studies
300 could thus be lower in quality, and suffer from more serious biases, on average, compared to
301 that provided by English-language studies [24]. This difference in evidence quality between
302 English-language and non-English language studies is likely to create a trade-off in
303 evidence-poor regions, between the availability of context-specific evidence and the quality of
304 evidence; for some species and locations, the only available evidence might be found in
305 non-English-language studies based on less robust designs [25]. Nevertheless, blindly

306 discarding such lower-quality, yet relevant, studies—a common practice in conventional
307 evidence syntheses—could unnecessarily delay, misinform, or hinder evidence-based decision
308 making, especially in disciplines, such as conservation, where robust evidence bases are patchy
309 [14], and for emergent issues, such as pandemics, where making the best use of available
310 evidence is an urgent challenge [26, 27]. A promising approach here is the model-based
311 synthesis of evidence with varying qualities and degrees of relevance to a specific context [24],
312 where non-English-language studies are expected to play a crucial role as an important source
313 of highly context-specific evidence.

314 We should note, however, that even searching for, and including, non-English-language
315 studies would not fully address the large evidence gaps in some regions faced with the most
316 pressing issues including biodiversity loss, such as Southeast Asia, tropical Africa and Latin
317 America. Therefore, the use of existing non-English-language science is not a panacea.
318 Generating more local evidence, based on robust study designs, and publishing it in any
319 language should be further encouraged and supported globally, but especially in those
320 evidence-poor regions, for example, through the distribution of free teaching materials to
321 facilitate the testing of conservation interventions [28] (also see *Limitations* in Materials and
322 Methods for other limitations).

323 This study showcases the continued vital role of non-English-language studies in providing
324 evidence for tackling the ongoing biodiversity crisis, given the increasing number of relevant
325 studies being published in many non-English languages. However, the degree of importance of
326 such evidence will vary depending on the topic and discipline of focus. Relatively little
327 evidence may be available in non-English languages for a highly specific purpose—for
328 example for understanding the effectiveness of a single intervention for a specific
329 species—while much evidence may be available for more descriptive purposes, such as for
330 understanding species occurrence. However, for global-scale evidence syntheses with a broad
331 scope, such as those conducted by the Intergovernmental Science-Policy Platform on
332 Biodiversity and Ecosystem Services, incorporating non-English-language scientific
333 knowledge should become the norm. Generating new scientific knowledge through individual
334 studies requires sizable financial investment, as well as associated time costs [29]. Therefore,

335 making better use of existing knowledge that has yet to be fully utilised due to the language of
336 publication should be a cost- and time-efficient approach for filling gaps and rectifying biases
337 in the evidence base for tackling urgent global challenges. In 1922 the philosopher Ludwig
338 Wittgenstein stated “Die Grenzen meiner Sprache bedeuten die Grenzen meiner Welt” (the
339 limits of my language mean the limits of my world) [30]. Hundred years on, his quote still
340 seems applicable to science today. Scientific communities should stretch the limits of our
341 shared knowledge, and its benefits, by uncovering knowledge that has long been accumulating
342 and continues to be produced in languages other than English.

343

344 **Materials and Methods**

345 **Searches for non-English-language studies on the effectiveness of conservation**

346 **interventions**

347 *Objective of the searches*

348 The searches aimed to identify peer-reviewed scientific studies (a study is defined as a paper
349 published in a peer-reviewed journal) written in a language other than English that tested the
350 effectiveness of one or more conservation interventions for any species group or habitat. Our
351 search strategy was based on the protocol for discipline-wide literature searching, established
352 and adopted for the development of the Conservation Evidence database [17] and published
353 elsewhere [31]. Discipline-wide literature searching involves first identifying literature sources
354 (peer-reviewed academic journals in our case) that are likely to contain relevant information,
355 and manually scanning titles and abstracts (or summaries) of every document in those sources.
356 We adopted discipline-wide literature searching, rather than systematic mapping/reviewing, as
357 the former approach does not depend on search term choice, and can identify novel
358 conservation interventions that would not necessarily have been identified on the basis of
359 predetermined criteria for study inclusion [32]. For more details on the Conservation Evidence
360 database, see Section **English-language studies on the effectiveness of conservation**
361 **interventions**. Although non-English-language grey literature (e.g., reports, theses, etc.) could
362 also play an important role in environmental evidence syntheses [33], our searches focused
363 only on studies published in peer-reviewed journals, so as to enable a comparison between
364 eligible non-English-language studies and peer-reviewed English-language studies stored in

365 the Conservation Evidence database.

366 *Selecting languages*

367 We originally aimed to cover the top 15 non-English languages on the basis of the number of
368 conservation-related publications, provided in Table S1 of [16]. However, we could not find
369 native speakers of Swedish and Dutch who were willing to collaborate, and thus both
370 languages were excluded from our searches. Instead, we were able to cover three additional
371 languages (Arabic, Hungarian, and Ukrainian). In total, our searches covered 16 languages
372 (Table S2).

373 *Searchers*

374 Our searches were conducted by a total of 38 native speakers of the 16 languages covered
375 (hereafter referred to as searchers). The number of searchers for each language ranged from
376 one to six (see Table S2 for more detail). We used a range of approaches (e.g., known networks,
377 social media, e-mail lists, and the website of the *translatE* project:

378 <https://translatesciences.com/>) to recruit our searchers. The searchers were required to be at
379 least undertaking or have a bachelor's degree, but often had higher research (i.e., master's or
380 doctorate) degrees, in a relevant discipline (e.g., ecology, biodiversity conservation, etc.), to
381 ensure that they could fully understand the relevant studies and assess their eligibility during
382 screening.

383 Before starting the searches, every searcher was trained through the following four steps.
384 First, searchers were directed to read through a guidance document detailing the objectives and
385 processes of the searches. Second, searchers were also requested to read and understand the full
386 criteria for selecting eligible studies during the searches, which were described in detail,
387 together with examples of 14 eligible and five non-eligible English-language studies, each with
388 a full explanation on why it was or was not eligible. Third, searchers were advised to visit the
389 Conservation Evidence website, particularly the page providing training resources
390 (<https://www.conservationevidence.com/content/page/89>), and familiarise themselves with
391 eligible English-language studies that tested the effectiveness of conservation interventions
392 (listed at: <https://www.conservationevidence.com/data/studies>). Finally, all searchers were

393 asked to conduct a test study screening, where they were requested to read the metadata
394 (publication year, journal, volume, issue, authors, title, and abstract) of 51 English-language
395 papers (29 from volume 200 (2016) of *Biological Conservation*, and 22 from volume 30 (2016)
396 of *Conservation Biology*), which included a total of 14 eligible studies, decide if each study
397 was eligible or not, and provide the full reasoning for their decisions. The outcome of the test
398 screening was examined by either T.A., V.B.E, or other members of the Conservation
399 Evidence project, who provided searchers with feedback.

400 *Identifying and selecting journals for each language*

401 We first identified and listed peer-reviewed academic journals published in each language
402 which were likely to contain eligible studies. This process involved one to four researchers for
403 each language (all native speakers of the target language, with at least a bachelor's, and often
404 higher, research degree; this often included the searchers) from relevant disciplines (see Table
405 S2 for more detail), who used a range of approaches (e.g., personal knowledge, opinions from
406 colleagues, local literature databases, web searches, etc.) to identify as many potentially
407 relevant journals as possible. All journals identified were then grouped into three categories:
408 “very relevant” (often journals in ecology and biodiversity conservation, as well as taxonomic
409 journals, such as those in ornithology, mammalogy, herpetology, plant sciences, etc.),
410 “relevant” (mostly journals in relevant disciplines, such as agricultural/forest sciences and
411 general zoology), and “maybe relevant” (all others). Subsequent searches aimed to at least
412 cover all journals categorised as “very relevant” and, when possible, those in the other two
413 categories (see Data S1 for the list of all journals searched).

414 *Screening papers in each journal*

415 Searches for eligible studies in each journal were conducted by manually scanning the title and
416 abstract (or summary) of every peer-reviewed non-English-language paper published in the
417 journal, and by reading the main text of all papers for which the title and/or abstract were
418 suggestive of fulfilling the eligibility criteria (fully described below). All papers that appeared
419 to meet the eligibility criteria were identified as potentially eligible studies, with the relevant
420 metadata recorded (see *Data coding*), and were then passed on to the validation process (see
421 *Study validity assessment*). The journals were searched backwards from the latest volume,

422 either to the earliest published volume or going back ten years for long-running journals (see
423 Data S1 for publication years covered for each journal). We also recorded the total number of
424 papers screened in each journal.

425 The following eligibility criteria, which were developed and published by the Conservation
426 Evidence project (<https://osf.io/mz5rx/>), were used.

427 **Criteria A: Include studies that measure the effect of an intervention that might be done**
428 **to conserve biodiversity**

429 1. Does this study measure the effect of an intervention that is or was under the control of
430 humans, on wild taxa (including captives), habitats, or invasive/problem taxa? If yes, go to
431 3. If no, go to 2.

432 2. Does this study measure the effect of an intervention that is or was under the control of
433 humans, on human behaviour that is relevant to conserving biodiversity? If yes, go to
434 **Criteria B**. If no, the study will be excluded.

435 3. Could the intervention be put in place by a conservationist/decision maker to protect,
436 manage, restore or reduce impacts of threats to wild taxa or habitats, or control or mitigate
437 the impact of the invasive/problem taxon on wild taxa or habitats? If yes, the study will be
438 included. If no, the study will be excluded.

439 · Eligible populations or subjects

440 *Included:* Individuals, populations, species, or communities of wild taxa, habitats or
441 invasive/problem taxa.

442 *Excluded:* Domestic/agricultural species.

443 · Eligible interventions

444 *Included:* Interventions that are carried out by people and could be put in place for
445 conservation. Interventions within the scope of the searches include, but not limited to:

446 · Clear management interventions, e.g., closing a cave to tourism, prescribed burning,
447 mowing, controlling invasive species, creating or restoring habitats,

448 · International or national policies,

449 · Reintroductions or management of wild species in captivity, and

450 · Interventions that reduce human-wildlife conflict.

451 See **Criteria B** for interventions that have a measured outcome on human behaviour only.

452 Also see <https://www.conservationevidence.com/data/index> for more examples of
453 interventions.

454 *Excluded:* Impacts of threats (interventions which remove threats would be included),
455 impacts from natural processes (e.g., tree falls, natural fires), and impacts from
456 background variation (e.g. soil type, vegetation, climate change).

457 · Eligible outcomes

458 *Included:* Any outcome (can be negative, neutral or positive, does not have to be
459 statistically significant) that is quantified and has implications for the health of individuals,
460 populations, species, communities or habitats, including, but not limited to:

461 · Individual health, condition or behaviour, including in captivity: e.g., growth, size,
462 weight, stress, disease levels or immune function, movement, use of natural/artificial
463 habitat/structure, range, predatory or nuisance behaviour that could lead to retaliatory
464 action by humans.

465 · Breeding: egg/offspring/seed/sperm production, sperm motility/viability after
466 freezing, natural/artificial breeding success, birth rate, offspring condition/survival,
467 and overall recruitment.

468 · Genetics: genetic diversity, genetic suitability (e.g., adaptation to local conditions, use
469 of flyways for migratory species etc.).

470 · Life history: age/size at maturity, survival, mortality.

471 · Population measures: number, abundance, density, presence/absence, biomass,
472 movement, cover, age-structure, species distributions (only in response to a human
473 action), disease prevalence, and sex ratio.

474 · Community/habitat measures: species richness, diversity measures (including
475 trait/functional diversity), community composition, community structure (e.g.,
476 trophic structure), area covered (e.g., by different habitat types), and physical habitat
477 structure (e.g. rugosity, height, basal area).

478 · Eligible types of study design

479 *Included:* Studies with After, Before-After, Control-Impact, Before-After-Control-Impact,

480 or Randomised Controlled Trial designs (using the definition provided in [34]). Literature
481 reviews, systematic reviews, meta-analyses or short notes that review studies that fulfil the
482 eligibility criteria are also included. Studies that use statistical/mechanistic/mathematical
483 models to analyse real-world data or compare models to real-world situations are also
484 included (if they otherwise fulfil the eligibility criteria).

485 *Excluded:* Theoretical modelling studies, opinion pieces, correlations with habitat types
486 where there is no test of a specific intervention by humans, or pure ecology (e.g.,
487 movement, distribution of species).

488 **Criteria B: Include studies that measure the effect of an intervention that might be done**
489 **to change human behaviour for the benefit of biodiversity**

490 1. Does this study measure the effect of an intervention that is or was under human control on
491 human behaviour (actual or intentional) which is likely to protect, manage, restore or
492 reduce threats to wild taxa or habitats (including mitigating the impact of
493 invasive/problem taxon on wild taxa or habitats)? If yes, go to 2. If no, the study will be
494 excluded.

495 2. Could the intervention be put in place by a conservationist, manager or decision maker to
496 change human behaviour? If yes, the study will be included. If no, the study will be
497 excluded.

498 · Eligible populations or subjects

499 *Included:* Actual or intentional human behaviour including self-reported behaviours.

500 Change in human behaviour must be linked to outcomes for wild taxa or habitats.

501 *Excluded:* Human psychology (tolerance, knowledge, awareness, attitude, perceptions or
502 beliefs). Changes in behaviour linked to outcomes for human benefit, even if these
503 occurred under a conservation program (e.g., we would exclude a study demonstrating
504 increased school attendance in villages under a community-based conservation program).

505 · Eligible interventions

506 *Included:* Interventions that are under human control and change human behaviour,
507 resulting in the conservation, management, and restoration of wild taxa or habitats.

508 Interventions which are particularly likely to have a behaviour change outcome include,

509 but are not limited to:

- 510 · Enforcement: hunting restrictions, market inspections, increase number of rangers,
511 patrols or frequency of patrols in, around or within protected areas, improve
512 fencing/physical barriers, improve signage.
- 513 · Behaviour change: promote alternative/sustainable livelihoods, payment for
514 ecosystem services, ecotourism, poverty reduction, increased appreciation or
515 knowledge, debunking misinformation, altering or re-enforcing local taboos, financial
516 incentives.
- 517 · Governance: protect or reward whistle-blowers, increase government transparency,
518 ensure independence of judiciary, provide legal aid.
- 519 · Market regulation: trade bans, taxation, supply chain transparency laws.
- 520 · Consumer demand reduction: increase awareness or knowledge, fear appeals
521 (negative association with undesirable product), benefit appeal (positive association
522 with desirable behaviour), worldview framing, moral framing, employing decision
523 defaults, providing decision support tools, simplifying advice to consumers,
524 promoting desirable social norms, legislative prohibition.
- 525 · Sustainable alternatives: certification schemes, artificial alternatives, sustainable
526 alternatives.
- 527 · New policies for conservation/protection.

528 *Excluded:* Impacts from climatic or other natural events. Studies with no intervention, e.g.
529 correlating human personality traits with likelihood of conservation-related behaviours.

530 · Eligible outcomes

531 *Included:* Any human behaviour outcome (can be negative, neutral or positive, does not
532 have to be statistically significant) that is quantified and is likely to have an outcome on
533 wild taxa or habitats, including, but not limited to:

- 534 · Change in adverse behaviours (which directly threaten biodiversity), e.g.,
535 unsustainable hunting, burning, grazing, urban encroachment, creating noise, entering
536 sensitive areas, polluting or dumping waste, clearing or habitat destruction,
537 introducing invasive species.

- 538 · Change in positive behaviours, e.g., uptake of alternative/sustainable livelihoods,
539 number of households adopting sustainable practices, donations.
- 540 · Change in policy or conservation methods, e.g., placement of protected areas,
541 protection of key habitats/species.
- 542 · Change in consumer or market behaviour, e.g., purchasing, consuming, buying,
543 willingness to pay, selling, illegal trading, advertising, consumer fraud.
- 544 · Behavioural intentions to do any of the above.
- 545 · Eligible types of study design
- 546 Same as **Criteria A**.

547 *Data coding*

548 From each of the studies that were identified by searchers as potentially eligible, the following
549 metadata were extracted and recorded using a template file:

- 550 - Journal language
- 551 - Journal publication country
- 552 - Reference type (either original article, review, short note or others)
- 553 - Authors
- 554 - Publication year
- 555 - Title in English (if available) and in the non-English language
- 556 - Journal name in English (if available) and in the non-English language
- 557 - Volume / Issue / Pages
- 558 - Abstract in English (if available) and in the non-English language
- 559 - Keywords in English (if available) and in the non-English language
- 560 - Link to the article (URL, if available)
- 561 - Study site locations (coordinates; mean coordinates where a study had multiple sites, or
562 city/state/province/country if coordinates were not available)
- 563 - Study design (either After, Before-After, Control-Impact, Before-After-Control-Impact,
564 Randomised Controlled Trial, or review; using the definition of each design provided in
565 [34])
- 566 - Broad species group(s) / habitat(s) studied

- 567 - Scientific name of study species (if available)
- 568 - Common name of study species in English and in the non-English language (if available)
- 569 - One-sentence summary in the form of: “This study tested the effect of [*intervention(s)*] on
- 570 [*measured outcome*] of [*target species or ecosystem(s)*]” (e.g., “This study tested the effect
- 571 of providing nest boxes on the breeding success of blue tits”)

572 The metadata were extracted largely by the searchers, but, for some languages where the
573 searchers were not available, by other collaborators who are native speakers of the language
574 and are at least undertaking or have a bachelor’s, but often higher research, degree in a relevant
575 discipline (see Table S2 for more detail). They were all requested to first read and fully
576 understand our guidance detailing the definitions of different study designs (provided in [34])
577 before starting data coding.

578 For all studies that were validated as eligible (see *Study validity assessment*), the recorded
579 names of birds, mammals, and amphibians were standardised based on the lists of bird species
580 names used by BirdLife International [35], and mammal and amphibian species names used by
581 IUCN [36]. We focused on these three taxa for comparing study locations and species between
582 languages because English-language studies testing the effectiveness of conservation
583 interventions for these three taxa have extensively been searched using both discipline-wide
584 literature searches and subject-wide evidence syntheses [17]. To identify species name
585 synonyms we used the package ‘taxize’ [37] in R [38] with API keys generated at the NCBI
586 (<https://www.ncbi.nlm.nih.gov/account/>) and IUCN
587 (<https://apiv3.iucnredlist.org/api/v3/token>) websites.

588 *Study validity assessment*

589 The eligibility of each study that was identified as being potentially eligible was validated by at
590 least one experienced literature searcher (assessors) at the Conservation Evidence project (see
591 Table S2 for more detail), who regularly screen, identify, and summarise eligible studies using
592 the same eligibility criteria (see *Screening papers in each journal*) but who mostly are not
593 native speakers of each non-English language. This process was conducted by assessing the
594 English-language title, abstract and one-sentence summary of each study identified by the
595 searchers (see *Data coding*), and, where the validity could not be determined easily, also

596 involved direct discussions between the relevant searchers and assessors to obtain clarification
597 on the details of each study. Those studies that were deemed ineligible by the assessors were
598 excluded from the final list of eligible studies in each language.

599

600 *Limitations*

601 Although, as described above, we adopted a search strategy that allowed us to identify eligible
602 studies in as unbiased a way as possible, our search results can still suffer from some inevitable
603 limitations:

604 · Language selection

605 Of the top 15 non-English languages on the basis of the number of conservation-related
606 publications, our searches could not cover Swedish and Dutch. Nevertheless, we expect
607 that the exclusion of these two languages only had a minimal effect on our conclusions, as
608 conservation-related publications in these two languages were estimated to only constitute
609 0.87% of publications in the top 15 non-English languages [16], while we also covered
610 three additional languages.

611 · Journal selection

612 Although we identified 465 journals in 16 languages, we were only able to screen 326 of
613 them, as we prioritised journals ranked as “very relevant” and “relevant” for some
614 languages when there was a shortage of searchers and/or their time that could be dedicated
615 to the search process. Therefore, we assessed whether our choice of journals screened in
616 each language was appropriate for identifying the most eligible studies in the language, by
617 examining the “rank-abundance” curve for each language, where the x axis of the curve
618 was the rank of searched journals according to the % of eligible studies (the journal with the
619 highest % of eligible studies was given rank 1), and the y axis was the % of eligible studies.
620 If a curve reached zero (i.e., there were almost no eligible studies) in lower-ranked journals,
621 we interpreted it as an indication that sufficient coverage of journals had been reached for
622 that language (see Fig. S1 for the result).

623 · Publication year selection

624 Searches for some long-running journals only went back ten years from the latest volume,

625 thus potentially missing some eligible studies dating back further. We thus assessed the
626 effects of excluding earlier volumes of long-running journals from our searches, by testing
627 how the number of eligible studies changed over time in each journal (see Fig. 1 for the
628 result).

629 · Possibility of missing eligible studies

630 We tried to identify as many eligible studies as possible in each language, by making sure
631 that (i) every searcher was well qualified and trained before starting the searches (see
632 *Searchers*) and (ii) when in doubt searchers keep, rather than reject, a study as potentially
633 eligible, the validity of which was later assessed by independent experts (see *Study validity*
634 *assessment*). Nevertheless, we cannot dismiss the possibility that some eligible studies
635 were missed during the searches. This would have caused a potential underestimation of
636 the number of eligible studies published in non-English languages. However, this should
637 not undermine our main conclusion that scientific evidence published in non-English
638 languages could fill gaps in the geographic and taxonomic coverage of English-language
639 evidence for conservation.

640 · Potential variations in assessment outcomes of eligible studies and study designs among
641 searchers

642 Although we did our best to train searchers to fully understand the eligibility criteria (see
643 *Screening papers in each journal*) and the definition of different study designs (see *Data*
644 *coding*), some inevitable variations may remain in the assessment outcomes of eligible
645 studies and study designs among searchers. This would potentially affect the reported
646 patterns in (i) the number and proportion of eligible studies among non-English languages
647 (Fig. S1), and (ii) the proportion of different study designs among different languages (Fig.
648 2). Nevertheless, among-searcher variations in judgements should affect neither (i) yearly
649 increases in the number of eligible non-English-language studies in each journal (Fig. 1), as
650 the same journal was searched by a single searcher, nor (ii) the spatial and taxonomic
651 complementarity between English- and non-English-language studies (Figs. 3 and 4),
652 assuming that any such variations in assessment outcomes only affected a limited number
653 of non-English-language studies, and thus have not drastically changed the overall patterns

654 in the differences between English and non-English-language studies.

655 · Effects of publication bias

656 We focused only on studies published in peer-reviewed academic journals and thus did not
657 consider the effects of publication bias, caused by ignoring grey literature, within each
658 language, while recognizing that important scientific knowledge may also be published in
659 non-English-language grey literature [33]. Therefore, it should be noted the conclusions of
660 this study are limited to peer-reviewed studies published in academic journals.

661 **English-language studies on the effectiveness of conservation interventions**

662 To compare study characteristics (i.e., study design, study location and study species) between
663 eligible English- and non-English-language studies, we used English-language studies stored
664 in the Conservation Evidence database [17]. Those English-language studies were identified
665 through a screening of peer-reviewed papers published in over 330 English-language academic
666 journals including local and taxonomic journals (see the list at:
667 <https://www.conservationevidence.com/journalsearcher/english>) based on the same eligibility
668 criteria as described in the section “*Screening papers in each journal*” above (also see [17] for
669 more detail). We extracted the metadata (including publication year, study site
670 coordinates—mean coordinates where a study had multiple sites, study design, scientific and
671 common names of study species) for each of the 4,412 English-language studies (Data S4)
672 (including 284 studies on amphibians, 1,115 studies on birds, and 1,154 studies on mammals;
673 Data S5) from the database on 11/12/2020. Again, here we defined a paper published in a
674 peer-reviewed journal as a study. The Conservation Evidence database also stores some
675 non-English-language peer-reviewed studies, most of which were identified incidentally by the
676 project. Those non-English-language studies were also incorporated into our dataset of
677 non-English-language studies, if they were in any of the 16 languages covered in this study (a
678 total of 74 non-English-language studies, see records with “Source” being “Ad hoc” in Data
679 S3). For birds, mammals, and amphibians, species names were standardised using the lists of
680 bird, mammal, and amphibian species names used by BirdLife International [35] and the IUCN
681 [36].

682 **Analyses of eligible studies**

683 *Comparing the proportion of eligible studies in each journal*

684 We first calculated the proportion of eligible studies for each non-English-language journal, by
685 dividing the number of eligible studies by the total number of studies screened in the journal.
686 Journals with 30 or fewer studies screened were excluded from this calculation, as the
687 estimated proportions would be unreliable given the small sample size.

688 *Testing yearly changes in the number of eligible non-English-language studies*

689 To test whether the number of eligible non-English-language studies had changed over time,
690 we focused only on journals with ten or more eligible studies, resulting in journals/studies in a
691 total of 12 languages (shown in Fig. 1) being used in the following analysis. For each language,
692 we fitted a generalised linear model (GLM) assuming a Poisson distribution with the number of
693 eligible studies in each year in each journal as the response variable, and year and journal (for
694 languages with more than one journal) as the explanatory variables. Journals were included in
695 each model as a fixed, not random, effect, as the number of journals with ten or more eligible
696 studies in each language was relatively small (nine for Japanese, five for German, and < 5 for
697 all others), making it difficult to estimate the among-journal variance accurately in a mixed
698 model [39].

699 *Comparing study designs*

700 To test whether there was a difference in study designs adopted between studies in different
701 languages, we only included studies based on one of the following five designs: After,
702 Before-After (BA), Control-Impact (CI), Before-After-Control-Impact (BACI), and
703 Randomised Controlled Trial (RCT). These study designs were recorded as an ordinal variable
704 with RCT being the least biased design, followed by BACI, CI, BA, and After, based on results
705 from [24]. Considering that English-language studies in English-speaking countries (especially
706 the UK and the US) may adopt more robust study designs than English-language studies in
707 other countries, English-language studies were further divided into two groups; studies
708 conducted in countries where English is an official language (“English – official”), and studies
709 in all other countries (“English – others”), using information on countries’ official languages in
710 [40]. We then fitted a cumulative link model using the ordinal package [41] in R, with ordered

711 study designs in each study as the response variable and languages (16 non-English languages
712 and “English – official”, compared to “English – others” as the reference category) and taxa
713 (birds, mammals, and others, compared to amphibians as the reference category) as the
714 explanatory variables.

715 *Comparing study locations*

716 To test whether there was a systematic bias in study locations between English- and
717 non-English-language studies, we first calculated the number of studies for each language in
718 each $2^\circ \times 2^\circ$ grid cell. Studies without study coordinates were excluded from this calculation,
719 leading to 4,254 English-language studies (including 267 studies on amphibians, 1,084 studies
720 on birds, and 1,062 studies on mammals) and 1,202 non-English-language studies (including
721 53 studies on amphibians, 244 studies on birds, and 153 studies on mammals) being used in the
722 following analysis. As the latest English-language studies on birds, amphibians, and mammals
723 stored in the Conservation Evidence database were those published in 2011, 2012, and 2018,
724 respectively, non-English-language studies after those years were excluded from the
725 comparison of studies on each taxon, leading to 31 studies on amphibians, 182 studies on birds,
726 and 146 studies on mammals being used in the analysis. We used a conditional autoregressive
727 (CAR) model assuming a Poisson distribution to test the association between the number of
728 non-English-language studies (the response variable) and the number of English-language
729 studies (the explanatory variable) within each grid cell while accounting for spatial
730 autocorrelation in residuals (see Data availability for the availability of the R code). We fitted
731 the model to the data with the Markov chain Monte Carlo (MCMC) method in OpenBUGS
732 3.2.3 [42] and the R2OpenBUGS package [43] in R. We set prior distributions of parameters as
733 non-informatively as possible, so as to produce estimates similar to those generated by a
734 maximum likelihood method; we used an improper uniform distribution (i.e., a uniform
735 distribution on an infinite interval) for the intercept following [44], a normal distribution with a
736 mean of 0 and variance of 100 for the coefficient of the explanatory variable, and Gamma
737 distributions with a mean of 1 and variance of 100 for the inverse of variance in an intrinsic
738 Gaussian CAR distribution. We ran each MCMC algorithm with three chains with different
739 initial values for 35,000 iterations with the first 5,000 discarded as burn-in and the remainder

740 thinned to one in every 12 iterations to save storage space. Model convergence was checked
741 with R-hat values.

742 *Comparing species*

743 To test whether there was a systematic bias in study species between English- and
744 non-English-language studies, we first calculated the number of English- and
745 non-English-language studies available for each species. We used generalised linear mixed
746 models (GLMMs) assuming a Poisson distribution to test the association between the number
747 of non-English-language studies (the response variable) and the number of English-language
748 studies (the explanatory variable) for each species while accounting for phylogenetic
749 autocorrelation by incorporating the family of each species as a random factor (see Data
750 availability for the availability of the R code). The GLMMs were implemented in R with the
751 lme4 package [45].

752 Other R packages used in the analyses and data visualization were: data.table [46], dplyr [47],
753 gridExtra [48], mapdata [49], mcmcplots [50], MCMCvis [51], plyr [52], RColorBrewer [53],
754 rgdal [54], readxl [55], tidyverse [56], viridis [57], and writexl [58].

755

756 **Data availability**

757 All data and code used in the analysis are available at: <http://doi.org/10.17605/OSF.IO/Y94ZT>.

758

759 **References**

- 760 1. Tu Y. The discovery of artemisinin (qinghaosu) and gifts from Chinese medicine. *Nature*
761 *Medicine*. 2011;17(10):1217-20. doi: 10.1038/nm.2471.
- 762 2. Rapoport EH. *Areografía: estrategias geográficas de las especies*. Mexico: Fondo de
763 *Cultura Económica*; 1975.
- 764 3. Xiang Y-T, Li W, Zhang Q, Jin Y, Rao W-W, Zeng L-N, et al. Timely research papers
765 about COVID-19 in China. *The Lancet*. 2020;395(10225):684-5. doi:
766 10.1016/s0140-6736(20)30375-5.
- 767 4. Sackett DL, Rosenberg W, Gray JA, Haynes RB, Richardson WS. Evidence based
768 *medicine: what it is and what it isn't*. *BMJ*. 1996;312(7023):71-2.
- 769 5. Mallett R, Hagen-Zanker J, Slater R, Duvendack M. The benefits and challenges of using
770 *systematic reviews in international development research*. *Journal of Development*
771 *Effectiveness*. 2012;4(3):445-55. doi: 10.1080/19439342.2012.711342.
- 772 6. Sutherland WJ, Pullin AS, Dolman PM, Knight TM. The need for evidence-based
773 *conservation*. *Trends in Ecology and Evolution*. 2004;19:305-8.
- 774 7. Song F, Parekh S, Hooper L, Loke YK, Ryder J, Sutton AJ, et al. Dissemination and
775 *publication of research findings: an updated review of related biases*. *Health Technology*
776 *Assessment*. 2010;14:8. doi: 10.3310/hta14080.
- 777 8. Neimann Rasmussen L, Montgomery P. The prevalence of and factors associated with
778 *inclusion of non-English language studies in Campbell systematic reviews: a survey and*
779 *meta-epidemiological study*. *Systematic Reviews*. 2018;7(1). doi:
780 10.1186/s13643-018-0786-6.
- 781 9. Lynch AJ, Fernández-Llamazares Á, Palomo I, Jaureguiberry P, Amano T, Basher Z, et al.
782 *Culturally diverse expert teams have yet to bring comprehensive linguistic diversity to*
783 *intergovernmental ecosystem assessments*. *One Earth*. 2021;4(2):269-78. doi:
784 <https://doi.org/10.1016/j.oneear.2021.01.002>.
- 785 10. Grégoire G, Derderian F, Le Lorier J. Selecting the language of the publications included
786 *in a meta-analysis: Is there a tower of babel bias?* *Journal of Clinical Epidemiology*.
787 1995;48(1):159-63. doi: [https://doi.org/10.1016/0895-4356\(94\)00098-B](https://doi.org/10.1016/0895-4356(94)00098-B).
- 788 11. Jüni P, Holenstein F, Sterne J, Bartlett C, Egger M. Direction and impact of language bias

- 789 in meta-analyses of controlled trials: empirical study. *International Journal of*
790 *Epidemiology*. 2002;31(1):115-23. doi: 10.1093/ije/31.1.115.
- 791 12. Konno K, Akasaka M, Koshida C, Katayama N, Osada N, Spake R, et al. Ignoring
792 non-English-language studies may bias ecological meta-analyses. *Ecology and Evolution*.
793 2020;10:6373-84. doi: 10.1002/ece3.6368.
- 794 13. Amano T, Sutherland WJ. Four barriers to the global understanding of biodiversity
795 conservation: wealth, language, geographical location and security. *Proceedings of the*
796 *Royal Society B: Biological Sciences*. 2013;280(1756):20122649. doi:
797 10.1098/rspb.2012.2649.
- 798 14. Christie AP, Amano T, Martin PA, Petrovan SO, Shackelford GE, Simmons BI, et al. The
799 challenge of biased evidence in conservation. *Conservation Biology*. 2020. doi:
800 10.1111/cobi.13577.
- 801 15. Gutzat F, Dormann CF. Exploration of concerns about the evidence-based guideline
802 approach in conservation management: hints from medical practice. *Environmental*
803 *Management*. 2020;66(3):435-49. doi: 10.1007/s00267-020-01312-6.
- 804 16. Amano T, González-Varo JP, Sutherland WJ. Languages are still a major barrier to global
805 science. *PLOS Biology*. 2016;14(12):e2000933.
- 806 17. Sutherland WJ, Taylor NG, MacFarlane D, Amano T, Christie AP, Dicks LV, et al.
807 Building a tool to overcome barriers in research-implementation spaces: The Conservation
808 Evidence database. *Biological Conservation*. 2019;238:108199. doi:
809 <https://doi.org/10.1016/j.biocon.2019.108199>.
- 810 18. King DA. The scientific impact of nations. *Nature*. 2004;430(6997):311-6. doi:
811 10.1038/430311a.
- 812 19. Montgomery SL. Does science need a global language? Chicago: The University of
813 Chicago Press; 2013.
- 814 20. Christie AP, Amano T, Martin PA, Petrovan SO, Shackelford GE, Simmons BI, et al. Poor
815 availability of context-specific evidence hampers decision-making in conservation.
816 *Biological Conservation*. 2020;248:108666. doi: 10.1016/j.biocon.2020.108666.
- 817 21. Kano H, Hayashi TI. A framework for implementing evidence in policymaking:
818 perspectives and phases of evidence evaluation in the science-policy interaction.

- 819 Environmental Science & Policy. 2021;116:86-95. doi: 10.1016/j.envsci.2020.09.001.
- 820 22. Novaro AJ, González A, Pailacura O, Bolgeri MJ, Hertel MF, Funes MC, et al. Manejo del
821 conflicto entre carnívoros y ganadería en Patagonia utilizando perros mestizos protectores
822 de ganado. *Mastozoología Neotropical*. 2017;24(1):32-51 (in Spanish with English
823 abstract).
- 824 23. Hayashi Y. Translocation of a Blakiston's Fish Owl in Northern Hokkaido. *Japanese*
825 *Journal of Conservation Ecology*. 2009;14(2):249-61 (in Japanese with English abstract).
826 doi: https://doi.org/10.18960/hozen.14.2_249.
- 827 24. Christie AP, Abecasis D, Adjeroud M, Alonso JC, Amano T, Anton A, et al. Quantifying
828 and addressing the prevalence and bias of study designs in the environmental and social
829 sciences. *Nature Communications*. 2020;11(1):6377. doi: 10.1038/s41467-020-20142-y.
- 830 25. Gurevitch J, Nakagawa S. Research synthesis methods in ecology. In: Fox GA,
831 Negrete-Yankelevich S, Sosa VJ, editors. *Ecological statistics: contemporary theory and*
832 *application*. Oxford, UK: Oxford University Press; 2015. p. 201-28.
- 833 26. The Royal Society and the British Academy. Face masks and coverings for the general
834 public: behavioural knowledge, effectiveness of cloth coverings and public messaging.
835 London, UK: The Royal Society; 2020.
- 836 27. Greenhalgh T. Will COVID-19 be evidence-based medicine's nemesis? *PLOS Medicine*.
837 2020;17(6):e1003266. doi: 10.1371/journal.pmed.1003266.
- 838 28. Downey H, Amano T, Cadotte M, Cook CN, Cooke SJ, Haddaway NR, et al. Training
839 future generations to deliver evidence-based conservation and ecosystem management.
840 *Ecological Solutions and Evidence*. 2021;2(1):e12032. doi:
841 <https://doi.org/10.1002/2688-8319.12032>.
- 842 29. Dicks LV, Walsh JC, Sutherland WJ. Organising evidence for environmental management
843 decisions: a '4S' hierarchy. *Trends in Ecology and Evolution*. 2014;29(11):607-13.
- 844 30. Wittgenstein L. *Tractatus Logico-Philosophicus*. London: Kegan Paul, Trench, Trubner &
845 Co., Ltd.; 1922.
- 846 31. Berthinussen A, Richardson OC, Altringham JD, Smith RK. Effects of conservation
847 interventions on bats: a protocol for subject-wide evidence synthesis. *OSF Registries*.
848 2019. doi: <http://doi.org/10.17605/OSF.IO/DY36W>.

- 849 32. Sutherland WJ, Wordley CFR. A fresh approach to evidence synthesis. *Nature*.
850 2018;558(7710):364-6. doi: 10.1038/d41586-018-05472-8.
- 851 33. Nuñez MA, Amano T. Monolingual searches can limit and bias results in global literature
852 reviews. *Nature Ecology & Evolution*. 2021;5:264. doi: 10.1038/s41559-020-01369-w.
- 853 34. Christie AP, Amano T, Martin PA, Shackelford GE, Simmons BI, Sutherland WJ. Simple
854 study designs in ecology produce inaccurate estimates of biodiversity responses. *Journal*
855 *of Applied Ecology*. 2019;56(12):2742-54. doi: 10.1111/1365-2664.13499.
- 856 35. BirdLife International and Handbook of the Birds of the World. Bird species distribution
857 maps of the world. Version 2019.1.: <http://datazone.birdlife.org/species/requestdis>; 2019.
- 858 36. IUCN. The IUCN Red List of Threatened Species. Version 2020-3.:
859 <https://www.iucnredlist.org>; 2021.
- 860 37. Chamberlain S, Szoecs E, Foster Z, Arendsee Z, Boettiger C, Ram K, et al. taxize:
861 Taxonomic information from around the web. R package version 0.9.98:
862 <https://github.com/ropensci/taxize>; 2020.
- 863 38. R Core Team. R: A language and environment for statistical computing. Vienna, Austria
864 (<http://www.R-project.org/>): R Foundation for Statistical Computing; 2019.
- 865 39. Harrison XA, Donaldson L, Correa-Cano ME, Evans J, Fisher DN, Goodwin CED, et al. A
866 brief introduction to mixed effects modelling and multi-model inference in ecology. *PeerJ*.
867 2018;6:e4794. doi: 10.7717/peerj.4794.
- 868 40. Central Intelligence Agency. The World Factbook 2021. Washington, DC: Central
869 Intelligence Agency: <https://www.cia.gov/the-world-factbook/>; 2021.
- 870 41. Christensen RHB. Package 'ordinal': Regression Models for Ordinal Data: Available at:
871 <https://cran.r-project.org/web/packages/ordinal/>; 2015.
- 872 42. Spiegelhalter D, Thomas A, Best N, Lunn D. OpenBUGS user manual version 3.2.3.
873 <http://www.openbugs.net/Manuals/Manual.html>2014.
- 874 43. Sturtz S, Ligges U, Gelman A. R2WinBUGS: a package for running WinBUGS from R.
875 *Journal of Statistical Software*. 2005;12(3):1-16.
- 876 44. Thomas A, Best N, Lunn D, Arnold R, Spiegelhalter D. GeoBUGS User Manual:
877 Available at: <http://www.mrc-bsu.cam.ac.uk/software/bugs/>; 2004.
- 878 45. Bates D, Maechler M, Bolker B, Walker S. Fitting linear mixed-effects models using lme4.

- 879 Journal of Statistical Software. 2015;67(1):1-48. doi: 10.18637/jss.v067.i01.
- 880 46. Dowle M, Srinivasan A. data.table: extension of 'data.frame'. R package version 1.10.4-3.
881 <https://CRAN.R-project.org/package=data.table2017>.
- 882 47. Wickham H, Francois R, Henry L, Muller K. dplyr: a grammar of data manipulation. R
883 package version 0.7.4. <https://CRAN.R-project.org/package=dplyr2017>.
- 884 48. Auguie B. gridExtra: miscellaneous functions for "grid" graphics. R package version 2.3.
885 <https://CRAN.R-project.org/package=gridExtra2017>.
- 886 49. Brownrigg R. mapdata: extra map databases. R package version 2.3.0.
887 <https://CRAN.R-project.org/package=mapdata2018>.
- 888 50. Curtis SM, Goldin I, Evangelou E. mcmcplots: create plots from MCMC output. R
889 package version 0.4.3.
890 <https://cran.r-project.org/web/packages/mcmcplots/index.html2018>.
- 891 51. Youngflesh C, Che-Castaldo C, Hardy T. MCMCvis: tools to visualize, manipulate, and
892 summarize MCMC output. R package version 0.14.0.:
893 <https://cran.r-project.org/web/packages/MCMCvis/index.html>; 2020.
- 894 52. Wickham H. plyr: tools for splitting, applying and combining data. R package version
895 1.8.6. <https://cran.r-project.org/web/packages/plyr/index.html2020>.
- 896 53. Neuwirth E. RColorBrewer: ColorBrewer Palettes. R package version 1.1-2.
897 <https://CRAN.R-project.org/package=RColorBrewer2014>.
- 898 54. Bivand R, Keitt T, Rowlingson B. rgdal: bindings for the geospatial data abstraction
899 library. R package version 1.2-8. <https://CRAN.R-project.org/package=rgdal2017>.
- 900 55. Wickham H, Bryan J, RStudio, Kalicinski M, Valery K, Leitiene C, et al. readxl: Read
901 Excel Files. R package version 1.3.1.:
902 <https://cloud.r-project.org/web/packages/readxl/index.html>; 2019.
- 903 56. Wickham H, Averick M, Bryan J, Chang W, McGowan LDA, François R, et al. Welcome
904 to the tidyverse. Journal of Open Source Software. 2019;4(43):1686. doi:
905 <https://doi.org/10.21105/joss.01686>.
- 906 57. Garnier S. viridis: default color maps from 'matplotlib'. R package version 0.5.1.
907 <https://CRAN.R-project.org/package=viridis2018>.
- 908 58. Ooms J, McNamara J. writexl: Export Data Frames to Excel 'xlsx' Format. R package

- 909 version 1.3.1.: <https://cran.r-project.org/web/packages/writexl/index.html>; 2020.
- 910 59. Egger M, Zellweger-Zähner T, Schneider M, Junker C, Lengeler C, Antes G. Language
911 bias in randomised controlled trials published in English and German. *The Lancet*.
912 1997;350(9074):326-9. doi: [http://dx.doi.org/10.1016/S0140-6736\(97\)02419-7](http://dx.doi.org/10.1016/S0140-6736(97)02419-7).
- 913 60. Pan Z, Trikalinos TA, Kavvoura FK, Lau J, Ioannidis JPA. Local literature bias in genetic
914 epidemiology: an empirical evaluation of the Chinese literature. *PLOS Medicine*.
915 2005;2(12):e334.
- 916 61. Preble JH, Ohte N, Vincenot CE. In the shadow of the rising sun: a systematic review of
917 Japanese bat research and conservation. *Mammal Review*. 2020;51(1):109-26. doi:
918 10.1111/mam.12226.
- 919 62. Fernández-Bellón D. Limited accessibility and bias in wildlife-wind energy knowledge: A
920 bilingual systematic review of a globally distributed bird group. *Science of The Total
921 Environment*. 2020;737:140238. doi: 10.1016/j.scitotenv.2020.140238.
- 922 63. Teo HC, Campos-Arceiz A, Li BV, Wu M, Lechner AM. Building a green Belt and Road:
923 A systematic review and comparative assessment of the Chinese and English-language
924 literature. *PLOS ONE*. 2020;15(9):e0239009. doi: 10.1371/journal.pone.0239009.
- 925 64. Angulo E, Diagne C, Ballesteros-Mejia L, Adamjy T, Ahmed DA, Akulov E, et al.
926 Non-English languages enrich scientific knowledge: The example of economic costs of
927 biological invasions. *Science of The Total Environment*. 2021:144441. doi:
928 <https://doi.org/10.1016/j.scitotenv.2020.144441>.

929

930 **Acknowledgements**

931 Thanks to I. Mangold and H. Korn for their help during the data collection, and M. Amano for
932 all the support. This communication reflects only the authors' view and any of the funders is
933 not responsible for any use that may be made of the information it contains.

934

935 **Author contributions**

936 Conceptualization: T.A., Formal analysis: T.A., V.B.E. and A.P.C., Funding acquisition: T.A.,
937 A.P.C., A. Báldi, S.B., K.J., J.K.-B, I.K., M.-C.L., V.M., J.P.N.G., P.J.N., A.N.R.V., M.-M.R.,

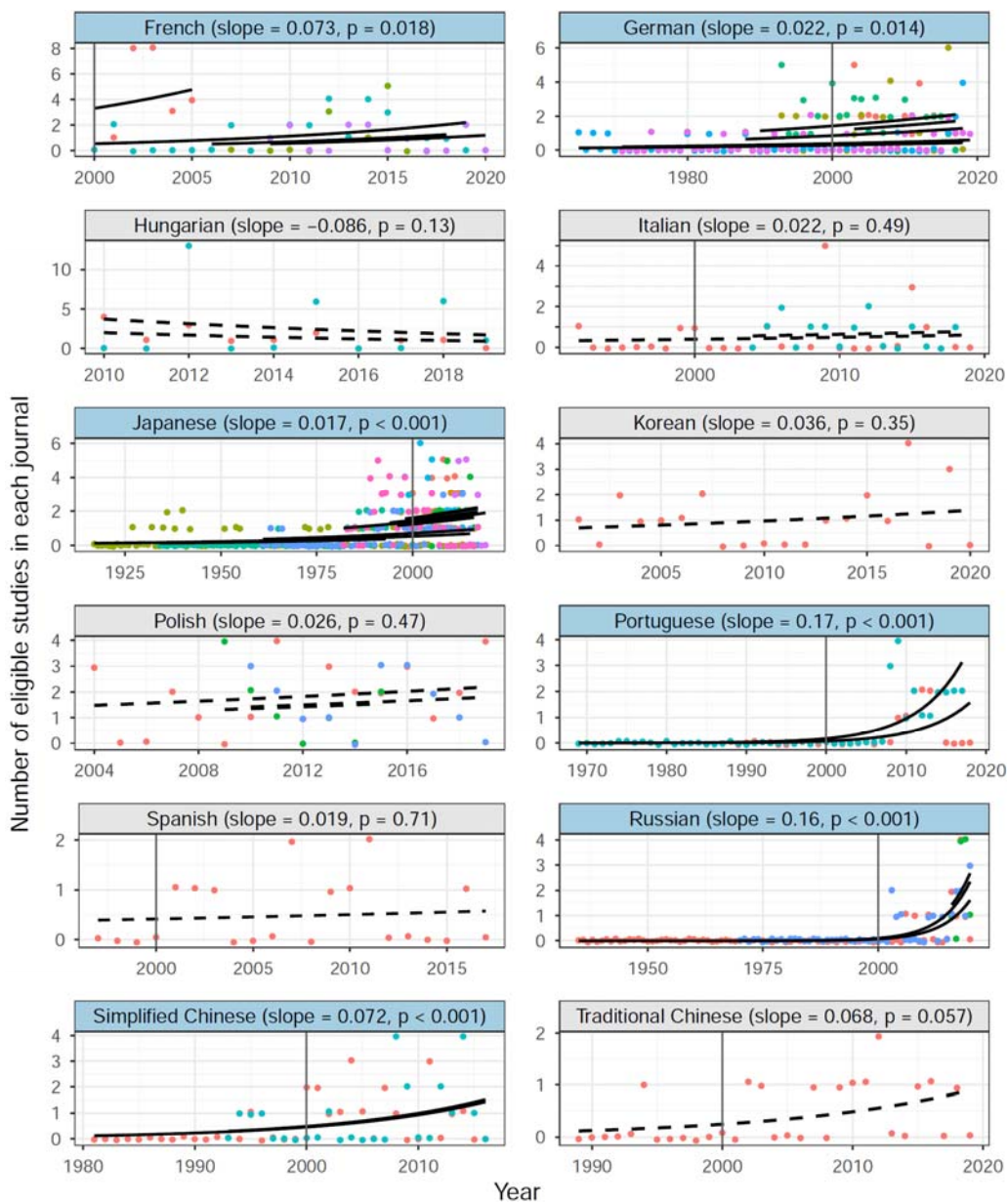
938 F.V., J.O.V., R.D.Z. and W.J.S., Investigation: T.A., V.B.E., A.P.C., M.A., A. Báldi, S.B.,
939 C.M., C.C.Y., M.B.D.K., L.G.O., P.F., M.G., N.H.A., K.J., J.K.-B., M.Ç.K.A., I.K., K. Kito,
940 K. Konno, D.-L.L., Yang L., Yifan L., M.-C.L., V.M., J.P.N.G., P.J.N., E.N., J.M., R.R.Y.,
941 A.C.P.-B., I.L.P., D.L.R., A.L.R.S., A.N.R.V., R.R., M.-M.R., R.S., D.S., Ç.H.Ş., H.S., Y.S.,
942 S.D.T., M.S.T., F.V., J.O.V., S.V., P.W., V.Z.G., R.D.Z. and W.Z., Methodology: T.A.,
943 V.B.E., A.P.C. and W.J.S., Project administration: T.A., V.B.E., K.W., E.T. and W.J.S.,
944 Supervision: T.A. and W.J.S., Validation: T.A., V.B.E., K.W., A. Berthinussen, A.J.B., N.A.,
945 P.A., W.H.M., N.O., S.O.P., R.R., K.A., G.S., R.K.S. and E.T., Visualization: T.A. and
946 A.P.C., Writing – original draft: T.A., Writing – review & editing: T.A., V.B.E., A.P.C.,
947 K.W., M.A., A. Báldi, A. Berthinussen, S.B., A.J.B., C.M., C.C.Y., M.B.D.K., L.G.O., P.F.,
948 M.G., N.H.A., K.J., J.K.-B., M.Ç.K.A., I.K., K. Kito, K. Konno, D.-L.L., N.A., Yang L.,
949 Yifan L., M.-C.L., V.M., P.A., W.H.M., J.P.N.G., P.J.N., E.N., J.M., N.O., R.R.Y., S.O.P.,
950 A.C.P.-B., I.L.P., D.L.R., A.L.R.S., A.N.R.V., R.R., M.-M.R., K.A., R.S., D.S., Ç.H.Ş., H.S.,
951 G.S., Y.S., R.K.S., S.D.T., M.S.T., E.T., F.V., J.O.V., S.V., P.W., V.Z.G., R.D.Z., W.Z. and
952 W.J.S.

953

954 **Competing interests**

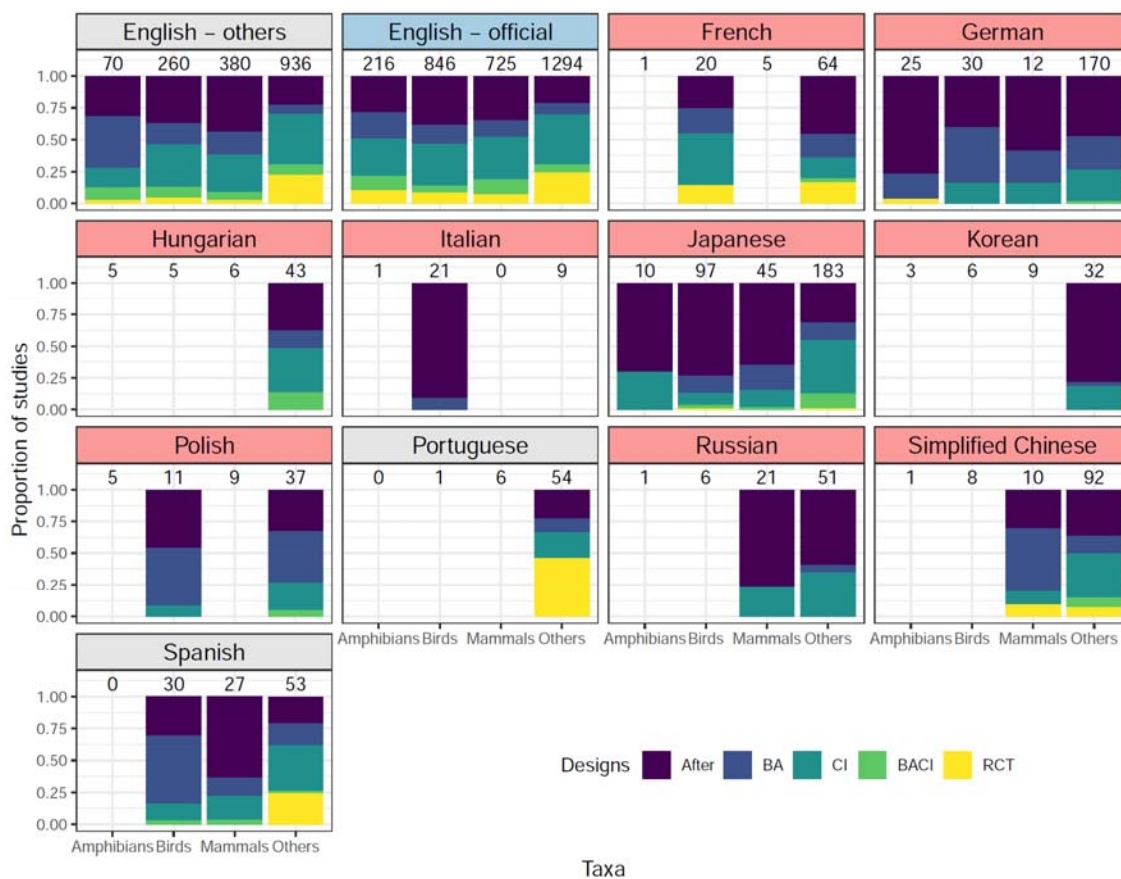
955 The authors declare no competing interests.

956



957

958 **Fig. 1. Language-specific yearly changes in the number of non-English-language studies**
959 **testing the effectiveness of conservation interventions published in each journal.** Only
960 journals with ten or more eligible studies are shown (colours indicate different journals) and
961 thus four languages for which there were no such journals are omitted. Black lines represent
962 regression lines for each journal (solid lines: significant slopes, dashed lines: non-significant
963 slopes) based on Poisson generalised linear models with journals as a fixed factor. Languages
964 with a statistically significant positive slope are shown with blue background. Vertical lines
965 indicate the year 2000.

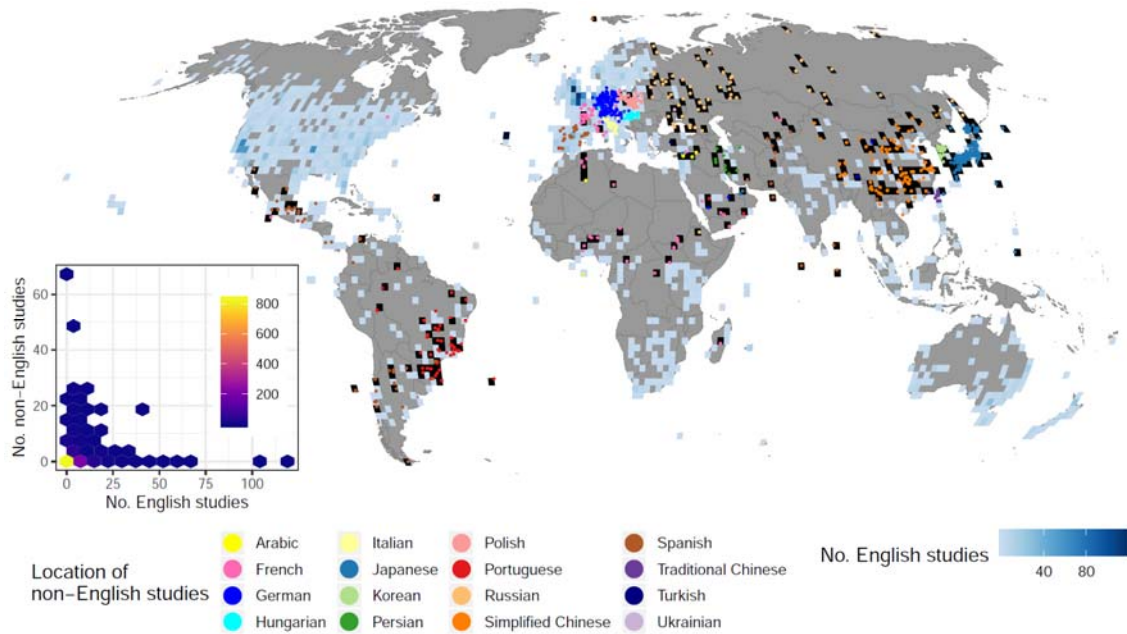


966

967

968 **Fig. 2. The proportion of studies in different languages that tested the effectiveness of**
 969 **conservation interventions with different study designs.** Designs in the order of increasing
 970 robustness: After, Before-After (BA), Control-Impact (CI), Before-After-Control-Impact
 971 (BACI), or Randomised Controlled Trial (RCT). English – others: English-language studies
 972 conducted in countries where English is not an official language. English – official:
 973 English-language studies conducted in countries where English is an official language.
 974 Languages with statistically less robust designs compared to English – others are shown with
 975 pink background, those with statistically more robust designs with blue background, and
 976 those with a non-significant difference with grey background. The numbers above bars
 977 represent the number of studies in each taxon (i.e., amphibians, birds, mammals or others) –
 978 language group. Only groups with at least ten studies are shown. Studies in five languages
 979 (Arabic, Persian, traditional Chinese, Turkish, and Ukrainian) are not shown as no taxon –
 980 language group had ten or more studies.

981



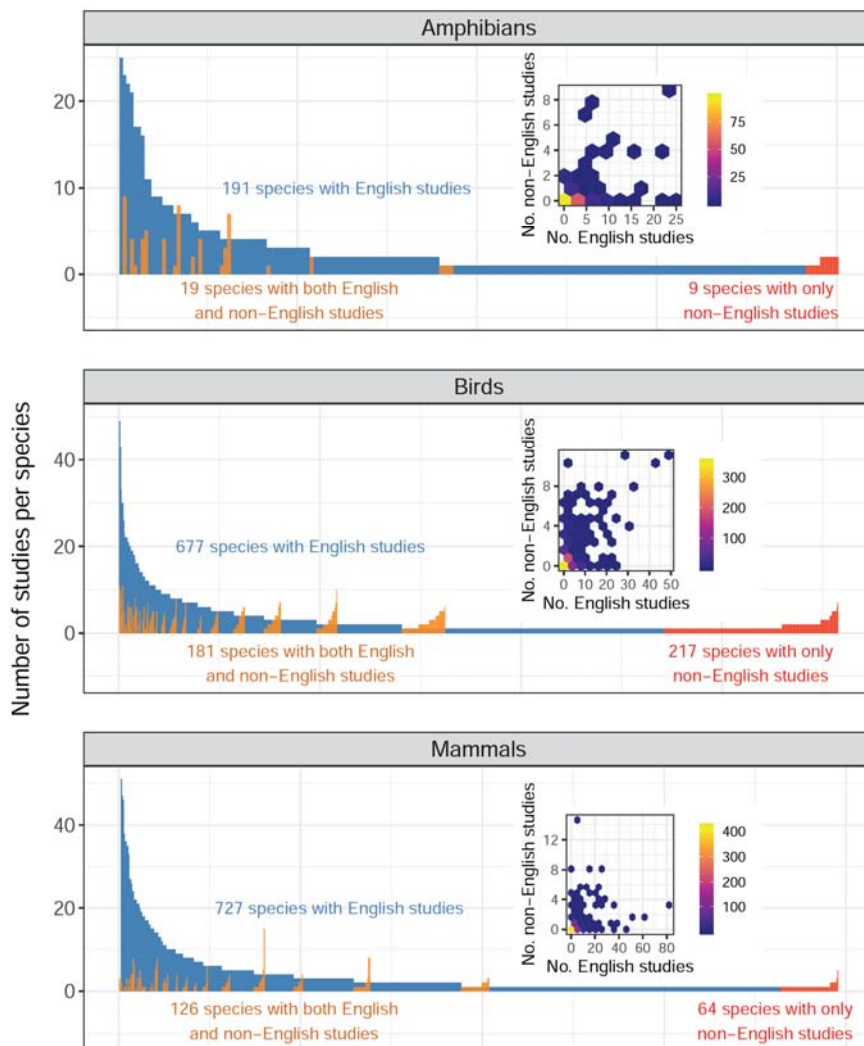
982

983

984 **Fig. 3. The location of 1,203 non-English-language studies with coordinate information,**
985 **compared to the number of English-language studies testing the effectiveness of**
986 **conservation interventions within each 2° × 2° grid cell (952 grid cells in total).**

987 Non-English-language studies were found in 353 grid cells, 238 of which were without any
988 English language studies (grid cells in black). The inset is a hexbin chart showing a negative
989 (although non-significant) relationship between the number of English-language studies and
990 the number of non-English-language studies (No. non-English studies) within each grid cell.
991 Brighter colours indicate more grid cells in each hexagon.

992



Species in order of decreasing English studies

993

994

Fig. 4. The number of English- and non-English-language studies testing the

995

effectiveness of conservation interventions for each amphibian, bird, and mammal

996

species. The number of English-language studies for each species (blue), with species ranked

997

on the x axis in order of decreasing English-language studies per species, and the number of

998

non-English-language studies per species for those species studied by both English- and

999

non-English-language studies (orange), and those studied only by non-English-language

1000

studies (red). Note that two mammal species with 82 and 63 English-language studies are not

1001

shown as outliers. The insets are hexbin charts showing significantly positive relationships

1002

between the number of English-language studies (No. English studies) and the number of

1003

non-English-language studies (No. non-English studies) per species. Brighter colours indicate

1004

more species in each hexagon.

1005 **Supporting information**

1006

1007 **Supplementary Text**

1008 In this study we screened 419,680 peer-reviewed papers in 326 journals, published in 16
1009 languages, to identify non-English-language studies testing the effectiveness of interventions
1010 in biodiversity conservation. This enabled us to test four commonly held perceptions that: (i)
1011 the amount of relevant scientific evidence that is available only in non-English languages is
1012 negligible; (ii) the number of relevant studies being published in non-English languages has
1013 been decreasing over time; (iii) non-English-language studies are often based on less robust
1014 study designs than English-language studies; (iv) there is no bias in the scientific evidence
1015 provided between English-language studies and non-English-language studies, in terms of
1016 geographical and taxonomic coverage. Our findings provide novel, quantitative insights into
1017 how non-English-language scientific knowledge can contribute to environmental evidence
1018 syntheses and the implementation of much-needed evidence-based conservation globally.

1019 The potential importance of non-English-language studies in evidence synthesis has long
1020 been explored in healthcare, where studies have reported systematic biases in statistical
1021 results between English- and non-English-language studies [59, 60], tested differences in
1022 study quality between languages [7], and assessed the effects of excluding
1023 non-English-language studies on the outcomes of meta-analyses [10, 11]. These attempts
1024 were focused almost exclusively on how including non-English-language studies might
1025 change the statistical results of meta-analyses, and have neither investigated temporal
1026 changes in relevant non-English-language evidence nor compared the characteristics of
1027 evidence provided between languages. However, non-English-language studies are also
1028 expected to provide scientific information that is not available in English-language studies,
1029 and thus expand the coverage of evidence that can be incorporated, especially in disciplines
1030 dealing with more geographically and taxonomically diverse targets and phenomena than
1031 healthcare [12].

1032 Earlier studies have also attempted to quantify the importance of non-English-language
1033 scientific knowledge in ecological evidence syntheses. For example, 67% of the scientific

1034 literature identified in a systematic review on Japanese bats including many endemic and
1035 threatened species was in Japanese [61], literature searches in Spanish increased the amount of
1036 scientific literature on interactions between birds and wind farms by 11% [62], and 65% of the
1037 literature included in a systematic review on China's Belt and Road Initiative, a
1038 continental-scale infrastructure development that potentially has disastrous consequences for
1039 biodiversity in the region, was in Chinese [63]. Despite the importance of their findings, most
1040 studies are limited only to a specific research topic and a single non-English language,
1041 restricting the generalizability of their findings.

1042 A few studies have also investigated the availability of ecological knowledge published in
1043 multiple non-English languages. Amano et al. [16] showed that up to 35% of scientific
1044 documents on biodiversity conservation published in 2014 were in 15 non-English languages;
1045 however the study did not investigate and compare the detail of those scientific documents
1046 published in different languages. Another example is the study conducted by Angulo et al [64],
1047 which compiled data on the global economic costs of invasive alien species reported in 15
1048 non-English languages, and showed that non-English-language sources (i) capture a greater
1049 amount of data than English-language sources, (ii) fill in geographic and taxonomic gaps in
1050 English-language sources, and (iii) increase the global cost estimate of invasions by 16.6%.
1051 This study, while providing important insights into the role of non-English-language sources in
1052 developing a specific database, lacks assessments of (i) temporal changes in
1053 non-English-language sources, and (ii) differences in study quality between languages. These
1054 limitations are critical in rigorously testing the role of non-English-language knowledge in
1055 evidence synthesis, as the importance of non-English-language knowledge could wrongly be
1056 overstated if (i) the amount of newly published non-English-language knowledge is decreasing
1057 (as is argued in [19]), or (ii) the quality of non-English-language knowledge is lower than that
1058 of English-language knowledge (as is shown in several healthcare studies [7]).

1059 In contrast, our study revealed that the number of relevant non-English-language studies is
1060 increasing in many languages, showing that non-English-language science will continue
1061 playing a crucial role, while there seems to be a trade-off between evidence quality and
1062 availability in regions and species with little English-language evidence, highlighting a future

1063 research priority for making the best use of evidence with varying qualities and degrees of
1064 relevance to a specific context.
1065

1066 **Table S1.** Results of a cumulative link model aimed at testing the association between ordered
 1067 study designs (with Randomised Controlled Trial as the least biased design, followed by
 1068 Before-After-Control-Impact, Control-Impact, Before-After, and After) in each study as the
 1069 response variable, and languages (16 non-English languages and “English – official”
 1070 (English-language studies conducted in countries where English is an official language),
 1071 compared to “English – others” (English-language studies conducted in the other countries) as
 1072 the reference category) and taxa (birds, mammals, and others, compared to amphibians as the
 1073 reference category) as the explanatory variables. Significant results are shown in bold.

Coefficients	Estimate	Standard error	<i>z</i>	<i>p</i>
Arabic	-3.14	1.08	-2.92	0.0035
English – official	0.18	0.055	3.32	0.00091
French	-0.60	0.20	-2.93	0.0034
German	-1.34	0.13	-10.47	1.16×10^{-25}
Hungarian	-0.57	0.24	-2.39	0.017
Italian	-2.42	0.49	-4.91	9.15×10^{-7}
Japanese	-0.91	0.11	-8.16	3.31×10^{-16}
Korean	-2.56	0.37	-6.85	7.44×10^{-12}
Persian	0.067	0.53	0.13	0.90
Polish	-0.99	0.22	-4.44	8.97×10^{-6}
Portuguese	0.49	0.26	1.90	0.057
Russian	-1.64	0.24	-6.84	7.67×10^{-12}
Simplified Chinese	-0.67	0.18	-3.79	0.00015
Spanish	-0.33	0.17	-1.87	0.061
Traditional Chinese	0.16	0.38	0.42	0.67
Turkish	0.69	1.08	0.64	0.52
Ukrainian	0.52	1.10	0.47	0.64
Taxa – Birds	-0.13	0.11	-1.22	0.22
Taxa – Mammals	-0.15	0.11	-1.35	0.18
Taxa – others	0.83	0.10	7.95	1.83×10^{-15}

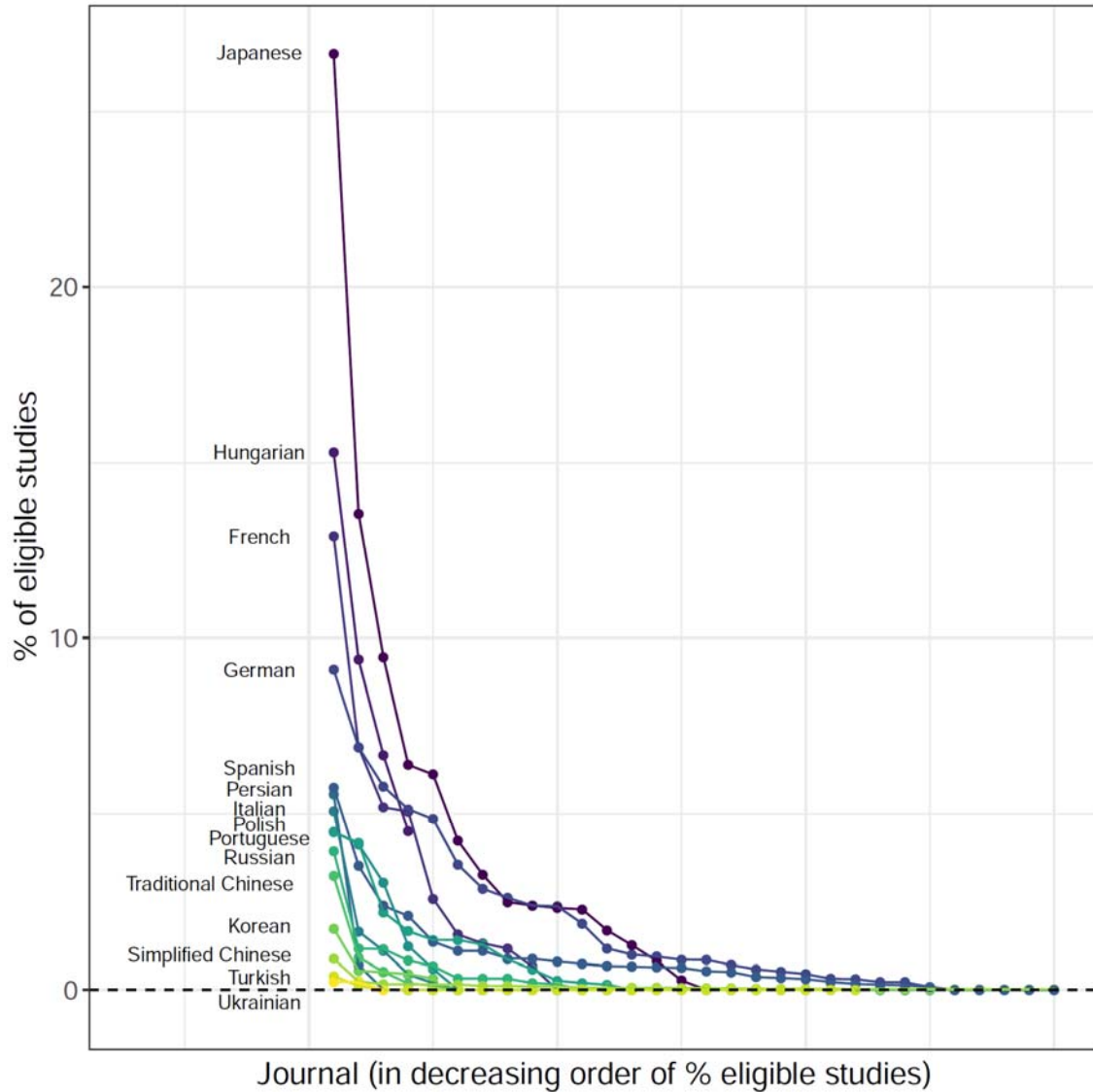
1074

1075 **Table S2.** List of those involved in searches and their roles for each language covered in this
 1076 study.

Language	Name	Journal listing	Searches	Data coding	Validation n
Arabic	Perla Farhat	1	1	1	0
Arabic	Magda Bou Dagher Kharrat	1	0	0	0
French	Ingrid Pollet	1	1	1	0
French	Marie-Morgane Rouyer	1	1	1	0
French	Ana Reboredo Segovia	0	1	1	0
German	Dominik Schwab	1	1	1	0
German	Kerstin Jantke	1	1	1	0
German	Isabel Mangold	1	1	1	0
German	Horst Korn	1	0	0	0
German	Richard Schuter	0	0	1	0
German	Matthias-Claudio Loretto	0	0	1	0
Hungarian	Flóra Vajna	1	1	1	0
Hungarian	András Báldi	1	0	0	0
Italian	Sandro Bertolino	1	1	1	0
Italian	Valentina Marconi	0	1	1	0
Japanese	Ko Konno	1	1	1	0
Japanese	Munemitsu Akasaka	1	0	0	0
Japanese	Yushin Shinoda	1	1	1	0
Japanese, simplified Chinese	Tatsuya Amano	1	1	1	1
Japanese	Kensuke Kito	0	0	1	0
Korean	Hemin Seo	1	1	1	0
Korean	Chang-Yong Choi	1	0	0	0
Persian	Elham Nourani	1	1	1	0

Polish	Joanna Kajzer-Bonk	1	1	1	0
Polish	Pawel Waryszak	0	1	1	0
Portuguese	Ana Cláudia Piovezan	1	1	1	0
	Borges				
Portuguese	Rafael D. Zenni	0	1	1	0
Portuguese	Danielle Ramos	1	1	1	0
Portuguese	Jose Manuel Ochoa	1	0	0	0
	Quintero				
Portuguese	Juan Pablo	0	1	1	0
	Narváez-Gómez				
Portuguese	Luis Gustavo de Oliveira	0	0	1	0
Portuguese and	Ricardo Rocha	1	1	1	1
Spanish					
Russian	Igor Khorozyan	1	1	1	0
Russian	Svetlana Vozykova	0	1	1	0
Simplified Chinese	Yifan Liu	1	1	1	0
Simplified Chinese	Min Chen	1	1	1	0
Simplified Chinese	Wenjun Zhou	1	1	1	0
Simplified Chinese	Yang Liu	1	1	1	0
Simplified Chinese	Rachel Oh	0	0	1	0
Spanish	Jose Valdebenito Chavez	1	1	1	0
Spanish	Nataly Hidalgo	1	1	1	0
	Aranzamendi				
Spanish	Nayelli Rivera	0	1	1	0
Spanish	Veronica Zamora	1	0	0	0
Spanish	Pablo Jose Negret	0	0	1	0
Traditional Chinese	Ming-shan Tsai	1	1	1	0
Traditional Chinese	Shan-dar Tao	1	1	1	0
Traditional Chinese	Da-Li Lin	0	1	1	0

Turkish	Çisel Kemahlı	1	1	1	0
Turkish	Çağan Hakkı Şekercioğlu	1	0	0	0
Ukrainian	Marina Golivets	1	1	1	0
Arabic, French, German, Italian, Korean, Polish, Spanish, Russian, Ukrainian	Kate Willott	0	0	0	1
Traditional Chinese, French	William Morgan	0	0	0	1
French, Portuguese	Philip Martin	0	0	0	1
French, German, Hungarian	Katie Sainsbury	0	0	0	1
German, Simplified Chinese	Elizabeth Tyler	0	0	0	1
French, Hungarian, Spanish	Andrew Bladon	0	0	0	1
Japanese, Korean, Persian, Polish, Simplified Chinese	Rebecca Smith	0	0	0	1
Japanese, Simplified Chinese	Nancy Ockendon	0	0	0	1
Japanese	Gorm Shackelford	0	0	0	1
Japanese, Simplified Chinese	Nick Littlewood	0	0	0	1
Japanese, Polish, Simplified Chinese, Turkish	Silviu Petrovan	0	0	0	1
Spanish	Anna Berthinussen	0	0	0	1

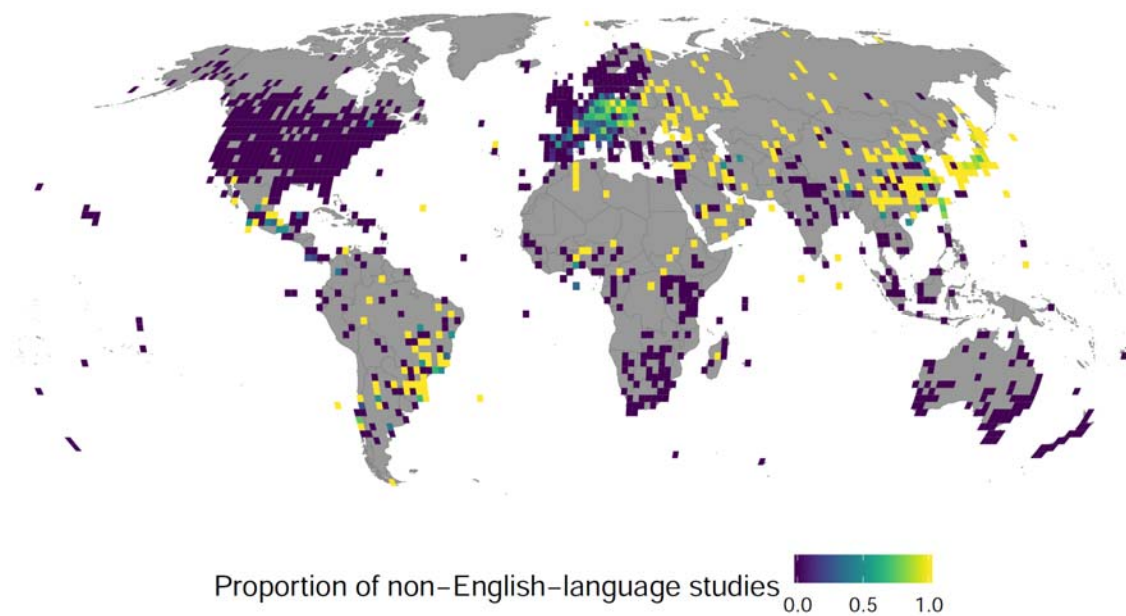


1078

1079

1080 **Fig. S1.** The proportion (%) of eligible studies testing the effectiveness of conservation
1081 interventions in each journal in 16 non-English languages. Coloured dots connected with a
1082 line represents all journals screened for each language, in decreasing order of % eligible
1083 studies; the journal with the highest % eligible studies is shown on the far left, while the
1084 journal with the lowest % eligible studies is on the far right.

1085

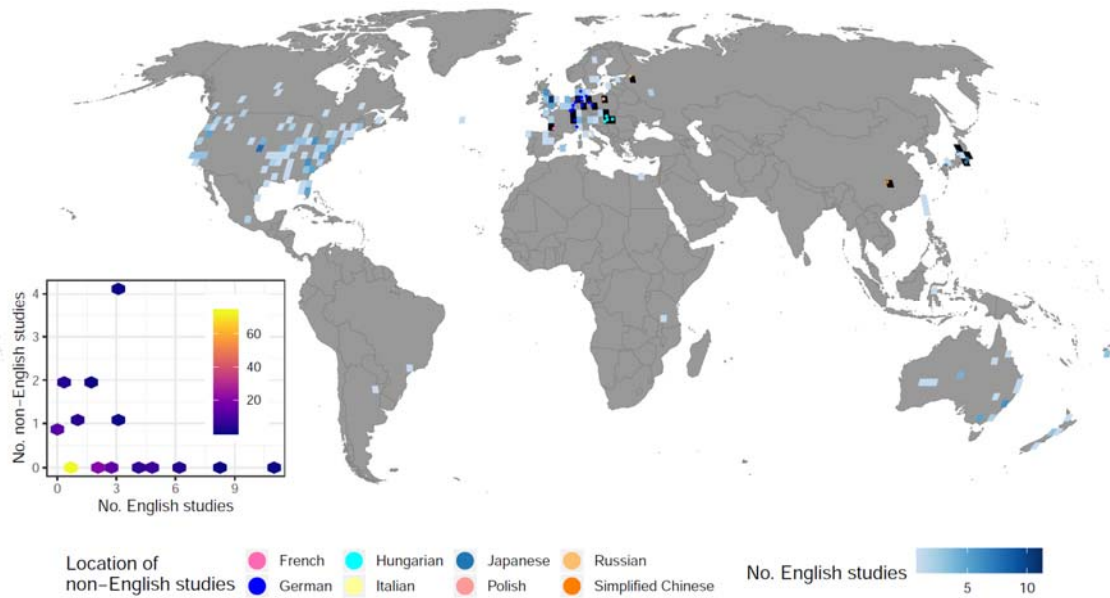


1086

1087

1088 **Fig. S2.** The proportion of non-English-language studies (all 16 languages combined) to all
1089 studies (i.e., non-English and English-language studies combined) testing the effectiveness of
1090 conservation interventions within each $2^\circ \times 2^\circ$ grid cell.

1091

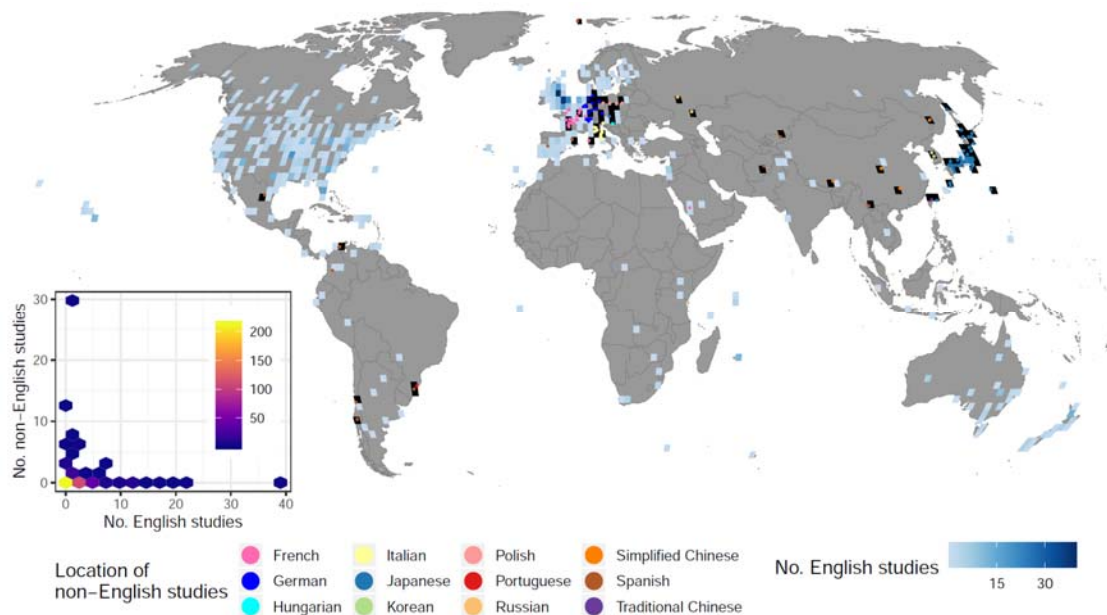


1092

1093

1094 **Fig. S3.** The location of 31 non-English-language studies testing the effectiveness of
1095 conservation interventions for amphibian species (published in 2012 or earlier), compared to
1096 the number of English-language studies on amphibians within each $2^\circ \times 2^\circ$ grid cell (133 grid
1097 cells in total). Non-English-language studies were found in 23 grid cells, 16 of which were
1098 without any English language studies (grid cells in black). The inset is a hexbin chart
1099 showing a significantly negative relationship between the number of English-language
1100 studies (No. English studies) and the number of non-English-language studies (No.
1101 non-English studies) within each grid cell. Brighter colours indicate more grid cells in each
1102 hexagon.

1103

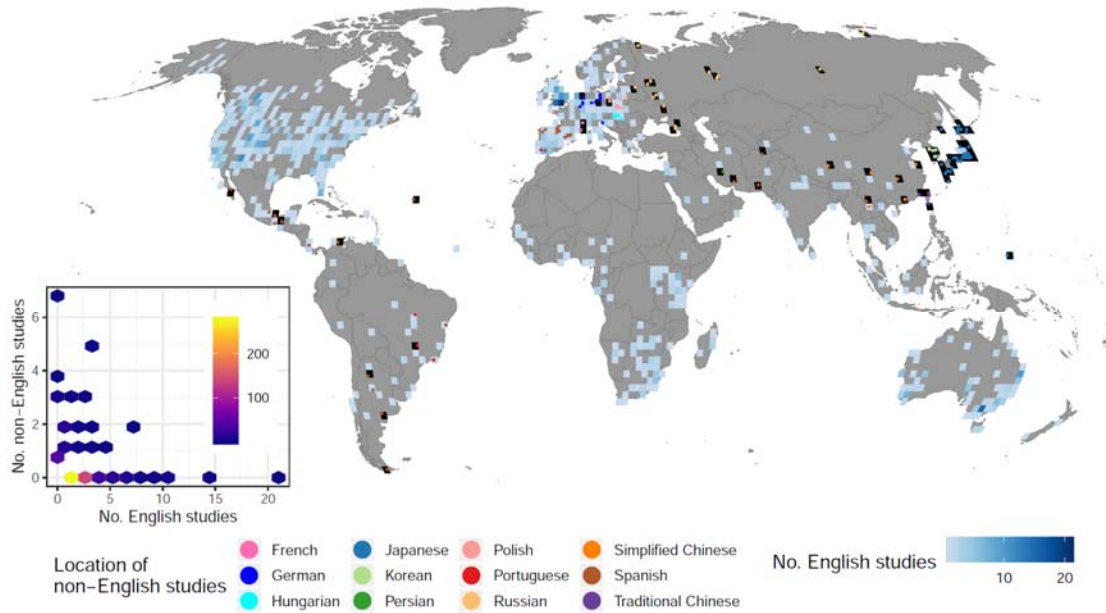


1104

1105

1106 **Fig. S4.** The location of 182 non-English-language studies testing the effectiveness of
1107 conservation interventions for bird species (published in 2011 or earlier), compared to the
1108 number of English-language studies on birds within each $2^\circ \times 2^\circ$ grid cell (373 grid cells in
1109 total). Non-English-language studies were found in 75 grid cells, 59 of which were without
1110 any English language studies (grid cells in black). The inset is a hexbin chart showing a
1111 significantly negative relationship between the number of English-language studies (No.
1112 English studies) and the number of non-English-language studies (No. non-English studies)
1113 within each grid cell. Brighter colours indicate more grid cells in each hexagon.

1114

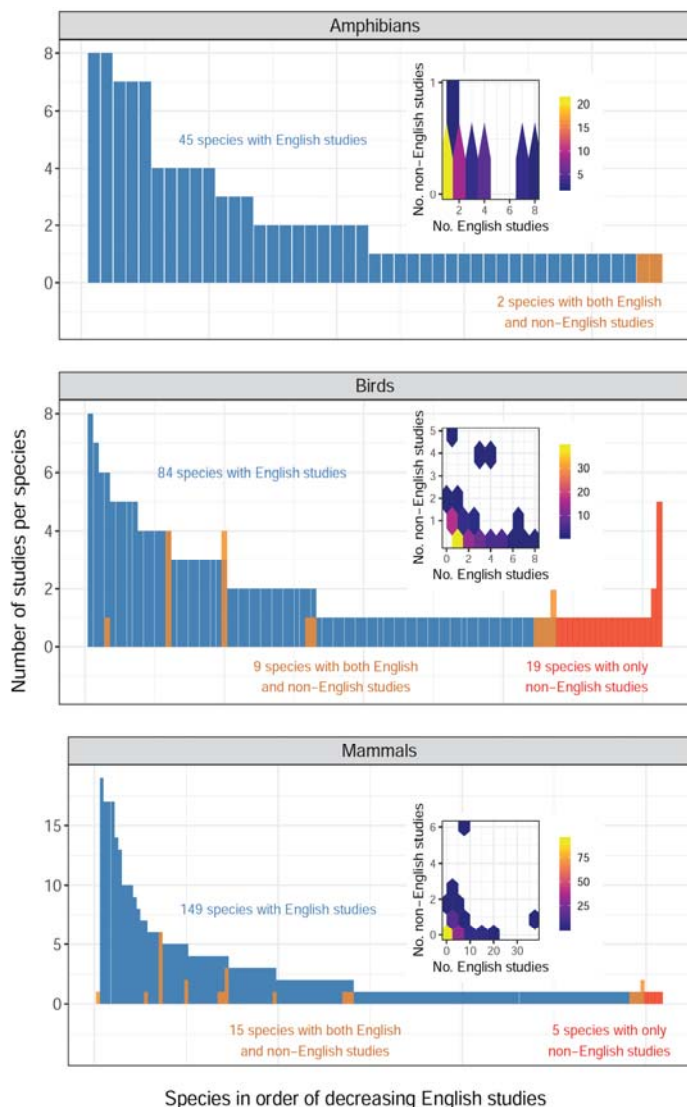


1115

1116

1117 **Fig. S5.** The location of 146 non-English-language studies testing the effectiveness of
1118 conservation interventions for mammal species (published in 2018 or earlier), compared to
1119 the number of English-language studies on mammals within each $2^\circ \times 2^\circ$ grid cell (514 grid
1120 cells in total). Non-English-language studies were found in 89 grid cells, 61 of which were
1121 without any English language studies (grid cells in black). The inset is a hexbin chart
1122 showing a significantly negative relationship between the number of English-language
1123 studies (No. English studies) and the number of non-English-language studies (No.
1124 non-English studies) within each grid cell. Brighter colours indicate more grid cells in each
1125 hexagon.

1126



1127

Species in order of decreasing English studies

1128 **Fig. S6.** The distribution of the number of English-language studies for each threatened
1129 amphibian, bird and mammal species (blue), with species ranked on the x axis in order of
1130 decreasing number of English-language studies, and the number of non-English-language
1131 studies per species for those threatened species studied by both English- and
1132 non-English-language studies (orange), and those studied only by non-English-language
1133 studies (red). Note that a threatened mammal species with 38 English-language studies is not
1134 shown as an outlier. The insets are hexbin charts showing the relationship between the
1135 number of English-language studies (No. English studies) and the number of
1136 non-English-language studies (No. non-English studies) for each threatened species. Species
1137 classified as threatened (Critically Endangered, Endangered or Vulnerable) based on IUCN.
1138 Brighter colours indicate more species in each hexagon.

1139 **Supplementary Data** (available at: <http://doi.org/10.17605/OSF.IO/Y94ZT>)

1140

1141 **Data S1**

1142 The list of non-English-language peer-reviewed journals related to biodiversity conservation
1143 identified in this study. The explanations of column names are as follows: Language: journal
1144 publication language, Country: journal publication country, Journal title in English: journal
1145 title in English, Journal title in non-English language: journal title in the non-English
1146 language, First publication year: the first publication year, Latest publication year: the latest
1147 publication year (as of March 2021), Link (URL): link to the journal website, Research
1148 areas/taxa: broad research area and taxa covered in the journal, Searcher: searcher name,
1149 Years screened first: the publication year of the first volume screened, Years screened last:
1150 the publication year of the last volume screened, Years screened total: the number of years
1151 screened, Volumes screened: the number of volumes screened, Number of papers screened:
1152 the number of studies screened, Number of papers id as relevant by collaborators: the number
1153 of studies initially identified as eligible by searchers, Number of papers validated as relevant:
1154 the number of studies validated as eligible, Number of papers added ad hoc from CE dataset:
1155 the number of studies added from the Conservation Evidence database, Total relevant: the
1156 total number of eligible studies, Comments: any other relevant notes.

1157

1158 **Data S2**

1159 The list of 1,234 non-English-language studies identified as eligible in this study. The
1160 explanations of column names are as follows: Paper ID: study ID, Translator Name: searcher
1161 name, Language: study publication language, Journal Country: journal publication country,
1162 Reference Type: the type of publications (e.g., journal article, review, etc), Authors (separate
1163 with//): the name of authors, Year: publication year, Title – English: title in English, Title -
1164 non-English language: title in the non-English language, Journal: journal name, Volume:
1165 volume, Issue: issue, Pages: pages, Abstract – English: abstract in English, Abstract -
1166 non-English: abstract in the non-English language, Keywords – English: keywords in English,
1167 Keywords - non-English: keywords in the non-English language, Broad species group(s)/
1168 habitat(s)/ ecosystem service(s): broad species group(s) / habitat(s) studied, Species Scientific

1169 Name: scientific name of study species, Species English Name: common name of study
1170 species in English, Species No-English Name: common name of study species in the
1171 non-English language, Study design: study design adopted, Mean Lat: mean latitude of the
1172 study site(s), Mean Long: mean longitude of the study site(s), City/state or province/country:
1173 city/state/province/country of the study site(s), DOI: Digital Object Identifier, Link (URL):
1174 link to the paper.

1175

1176 **Data S3**

1177 The list of species studied in the 1,234 non-English-language eligible studies. The
1178 explanations of column names are as follows: Paper ID: study ID, Language: study
1179 publication language, IUCN: scientific name of study species used by the International Union
1180 for Conservation of Nature (IUCN name), Species Scientific Name: scientific name of study
1181 species recorded by searchers, Common name: common name of study species identified
1182 with the package ‘taxize’ in R, Species English Name: common name of study species in
1183 English recorded by searchers, Species Non-English Name: common name of study species
1184 in the non-English language recorded by searchers, Taxa: taxonomic group identified based
1185 on the IUCN name, Broad species group(s)/ habitat(s)/ ecosystem service(s): broad species
1186 group(s) / habitat(s) studied, Study design: study design adopted, Mean Lat: mean latitude of
1187 the study site(s), Mean Long: mean longitude of the study site(s), City/state or
1188 province/country: city/state/province/country of the study site(s), Journal: journal name,
1189 Journal Country: journal publication country, Source: the method of identifying the study
1190 (systematic review: discipline-wide literature searching, Ad hoc: identified in the
1191 Conservation Evidence database) Year: publication year.

1192

1193 **Data S4**

1194 The list of species studied in the 4,412 English-language studies stored in the Conservation
1195 Evidence database. The explanations of column names are as follows: rowed: record ID,
1196 pageid: study ID, journal_match_scimago: journal name used in the Scimago Journal Rank,
1197 journal: journal name, syn: Conservation Evidence synopsis including the study, int:
1198 conservation intervention tested, before: if the study has a Before element, controlled: if the

1199 study has control(s), randomized: if replications are randomized, review: if the study is based
1200 on a review or not, pubdate: publication year, lat: latitude of the study site(s), long: longitude
1201 of the study site(s), country: country of the study site(s), species: specific name of the study
1202 species, genus: generic name of the study species, family: family of the study species, order:
1203 order of the study species, class: class of the study species, binom: scientific name of the
1204 study species, subtype: study publication type, original_title: paper title, ref_startpage: start
1205 page of the paper, ref_endpage: end page of the paper, ref_vol: volume published, ref_issue:
1206 issue published, ref_doi: Digital Object Identifier, ref_citation: paper citation,
1207 ref_authorstring: authors.

1208

1209 **Data S5**

1210 The list of amphibian, bird and mammal species studied in the English-language studies
1211 stored in the Conservation Evidence database. The explanations of column names are as
1212 follows: pageid: study ID, syn: Conservation Evidence synopsis including the study, int:
1213 conservation intervention tested, before: if the study has a Before element, controlled: if the
1214 study has control(s), randomized: if replications are randomized, review: if the study is based
1215 on a review or not, pubdate: publication year, lat: latitude of the study site(s), long: longitude
1216 of the study site(s), country: country of the study site(s), species: specific name of the study
1217 species, genus: generic name of the study species, family: family of the study species, order:
1218 order of the study species, class: class of the study species, binom: scientific name of the
1219 study species (standardised based on the names used by the International Union for
1220 Conservation of Nature), habitat: broad habitat type studied, authors: authors, journal: journal
1221 name.