

## Viewpoint

**To be, or not to be, a non-native species in non-English languages:  
gauging terminological consensus amongst invasion biologists**

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## Abstract

In invasion biology, terminological frameworks contribute to the improvement of effective communication among scientists, stakeholders, and policy-makers. This is important not only for informing policy decisions but also for engaging the broader public in understanding the risks associated with biological invasions. Meanwhile, the role of non-English languages in advancing knowledge in invasion biology has gained momentum in recent years. Building on the seminal contributions in this scientific discipline by Professor Gordon H. Copp, this paper examines the provision of three key terms defining species invasiveness in 28 non-English languages. We first define the three non-redundant terms “non-native species”, “established species”, and “invasive species”. Through a comparative analysis of the equivalent of these terms in the 28 non-English languages, as contributed by our panel of invasion biologists and native speakers, with those in a reference review paper, and following the diffusion-of-English versus ecology-of-language paradigms, we identify discrepancies and nuances reflecting the dynamic nature of terminology in invasion biology. While some languages showed consensus in terminology, others differed due to either the avoidance of a culturally or politically laden term for “non-native” or the achievement of greater precision in meaning. Our findings highlight the requirement for clear and precise terminology in invasion biology and suggest the adoption of multidisciplinary approaches to reach consensus and facilitate communication amongst scientists, policy-makers, and the general public in a globally interconnected and rapidly changing world. This will enhance international collaboration and accelerate knowledge exchange, leading to more effective management of biological invasions.

**Key words:** established species, invasive species, diffusion-of-English, ecology-of-language

## Introduction

*You taught me language, and my profit on't  
Is I know how to curse. The red plague rid you  
For learning me your language!  
(Shakespeare – The Tempest: 1.2.366–368)*

To echo the seminal paper by Professor Gordon H. Copp on terminology for non-native freshwater fish (Copp et al. 2005): To be, or not to be, a non-native species in non-English languages? That is the question. Whether 'tis nobler in the mind that a non-native species be referred to as “alien”, “exotic”, “foreign”, or “non-indigenous”, or rather as “allochthonous”, and by being one, avoid the slings and arrows of pronunciation of the latter term in another language? And what of this question, the essence of being an “established species” or an “invasive species”, or, perhaps redundantly, an “established non-native species” or an “invasive non-native species”? 'Tis simply the outcome of the diffusion-of-English or an informed balance between this and the ecology-of-language paradigm?

Biological invasions are recognized as a global issue (Seebens et al. 2017, 2021) resulting in major economic losses and causing extensive ecological damage to native biota (Early et al. 2016; Diagne et al. 2021). Given the widespread occurrence of biological invasions, effective communication within and across nations of the risk of invasiveness posed by non-native

species is paramount (Essl et al. 2018; Copp et al. 2021). This communication plays a pivotal role in shaping legislative frameworks and integrating policies into robust management strategies (Piria et al. 2017; Baquero et al. 2021). Meanwhile, increased emphasis in recent years has been placed on the importance of non-English languages in advancing knowledge in invasion biology (Amano et al. 2021, 2023; Angulo et al. 2021). This is especially relevant given the cultural and societal factors shaping linguistic diversity across countries.

In another seminal paper flagged as one of the “significant developments” in the field of ecolinguistics in 2021 (Zhang 2022), Professor Gordon H. Copp (alongside the first author and most of the co-authors of this paper) showed that addressing terminological uncertainty in communicating invasive species risks in non-English languages can be facilitated by seeking a balance between the diffusion-of-English and the ecology-of-language paradigms (Copp et al. 2021). The former denotes the dominance of English in multilingual work environments (Phillipson and Skuttnas-Kangas 1996), whereas the latter involves studying the interactions between a language and its environment (Haugen 1972). As non-English languages increasingly play a key role in scientific debate, there is an urgent need to establish cohesive terminological frameworks in invasion biology. This is crucial for reaching consensus amongst invasion biologists to better inform stakeholders and policy-makers, but also the general public, about the risks posed by non-native species, thereby facilitating collaborative efforts in the management of biological invasions (IPBES 2023).

An effort to provide a standardized terminological framework to promote more effective communication was recently made by Soto et al. (2024) in their other Shakespeare-inspired paper titled “Taming the terminological tempest in invasion science”. In their proposed streamlined framework, amongst the multitude of terms utilized in invasion biology, three were retained that are structured hierarchically and grounded in ecological principles: “non-native”, “established non-native”, and “invasive non-native”. Following the approach by Copp et al. (2021), to facilitate communication in invasion biology in languages other than English, the three proposed terms were translated in 28 non-English languages.

In this paper, we compare the three terms in the 28 languages as provided by our panel of experts and native speakers with the ones from the reference study by Soto et al. (2024). Our objective is to gauge the level of consensus amongst invasion biologists as to which term in their native language would “better” meet, in their informed opinion, the requirements of the proposed framework(s). In several cases, we suggest alternative terms not as a rebuttal or criticism, but to offer a broader perspective intended to stimulate constructive debate. This is especially important given the tendency by most invasion biologists, but also relevant authorities, to follow “old shibboleths” in the use of terminology in

invasion biology – as per the widely adopted and deeply rooted term “invasive alien species” (IPBES 2023). In doing so, we espouse throughout this study the diffusion-of-English versus ecology-of-language paradigms. Our expectation is to help contribute to clearer communication regarding the risks associated with biological invasions among scientists, competent authorities, and the general public, both locally and globally. Enhanced global communication will streamline efforts to inform about and mitigate the threats posed by invasive species to native ecosystems worldwide. This is particularly crucial for countries where the field of invasion biology is still in its infancy. For these countries, governance and policy options for the management of biological invasions will greatly benefit from improved communication in their official language (Copp et al. 2021).

## Methods

We focused on three key terms defining species invasiveness (Copp et al. 2005; Iannone et al. 2020): *non-native species*, *established species*, *invasive species*. These terms reflect the stages of a non-native species’ invasion process, including entry, establishment, dispersal, and impact (Blackburn et al. 2011). Unlike “alien”, “exotic”, “foreign”, and “non-indigenous”, the term *non-native species* does not carry politically or culturally laden connotation. For this reason, usage of the above terms in invasion biology has recently been discouraged (Iannone et al. 2020; Soto et al. 2024) – but with the exception of “allochthonous”. In our terminology, we favoured *established species* and *invasive species* over the somewhat redundant “non-native established species” and “non-native invasive species”. This is because usage of “established non-native species” and “invasive non-native species” may be more appropriate in the descriptive or pedagogic context of the biological invasion process when referring to the establishment and spread (and impact) phases of a non-native species, respectively. Also, usage of “invasive non-native species” may lead to confusion since all invasive species are inherently non-native – whereas a native species with invasive characteristics is generally referred to as a “native invader” (Carey et al. 2021). Using the term “invasive non-native species” may therefore result in stakeholders and policy-makers incorrectly equating non-native species with invasive ones, also considering that non-native species do not always exhibit invasive characteristics (Iannone et al. 2020).

The three terms *non-native species*, *established species*, and *invasive species* were contributed in the following 28 non-English languages: Arabic, Catalan, Chinese (Mandarin), Croatian, Czech, French, German, Greek, Hebrew, Hindi, Hungarian, Italian, Japanese, Kazakh, Lithuanian, Norwegian, Polish, Portuguese, Romanian, Russian, Serbian (Latin and Cyrillic), Slovak, Slovenian, Spanish, Turkish, Ukrainian, and Urdu. In total, 38 experts (the authors of this paper except for the first one), all of

whom are invasion biologists and native speakers of the assigned language(s), participated in the provision of the terminology. Some languages had two or three experts (Supplementary material Table S1).

A table with the three terms was circulated among the experts, accompanied by detailed instructions about the terminological context and definition as outlined above. Provision of the terms was based on an informed decision by the experts resulting from consultation of literature resources in their native language and personal knowledge (expert opinion) as to which terms would more closely match the English ones. The three terms as provided by the experts in the different languages were then improved and finalized iteratively (i.e. via email exchanges with L. Vilizzi), as part of a quality control process (see Copp et al. 2021). A consensus approach was used in case where multiple experts worked on the same assigned language(s). This involved reaching mutual agreement as to the most appropriate term(s) to use. During the study, the experts were instructed to follow the rationale and scope for the context and definition of the terms in the English language as above according to the diffusion-of-English paradigm. At the same time, they were encouraged to consider any language-specific nuances and constraints in their native language, hence abiding by the ecology-of-language paradigm. In case of discrepancies from the English-based rationale for choice of the terms, the experts were asked to provide an evidence-based explanation for their preference. All experts provided in support to their choice of terms the most relevant documentation about legislation of non-native (invasive) species in their own native language (Table S2), and following consultation of all relevant documents and resources as per the online searches described below. Additionally, they provided the most common term used in invasion biology to refer to *non-native species* in each language.

For each of the resulting 87 terms (i.e. 3 terms  $\times$  28 languages and with Serbian spelt in both Latin and Cyrillic) a standardized literature search (after Angulo et al. 2021) was performed using the Google search engine (<https://www.google.com/>) and the Google Scholar database (<https://scholar.google.com/>). For each term, the search was based on the entire string in the singular voice except when not applicable (i.e. Chinese, Japanese, Urdu). For the languages with declination, the nominative case was used. In Google, the terms were searched across pages in 26 non-English languages, hence with the exception of Kazakh and Urdu as not available. In Google Scholar, the terms were searched across articles published at any time and of any type, including citations. For each term, the number of results (as of 26/06/2024) from the two searchers was then summed up.

For the comparison with Soto et al. (2024: their Table S1), the experts were asked to provide an explanation in case of discrepancies between terms. For the terms showing discrepancies, and with “non-native” removed

**Table 1.** Terms defining species invasiveness in 28 non-English languages. For each language, terms are in the singular voice, except when not applicable (i.e. Chinese, Japanese, Urdu).

Language	Non-native species	Established species	Invasive species
Arabic		نوع غير أصلي	نوع مستقر
Catalan	Espècie no nativa	Espècie establerta	Espècie invasora
Chinese	非本地种	建群种	入侵种
Croatian	Nezavičajna vrsta	Uspostavljena vrsta	Invazivna vrsta
Czech	Nepůvodní druh	Etablovaný druh	Invazní druh
Dutch	Niet-inheemse soort	Gevestigde soort	Invasieve soort
French	Espèce non-native	Espèce établie	Espèce envahissante
German	Nicht einheimische Art	Etablierte Art	Invasive Art
Greek	Αλλόχθονο είδος	Εγκατεστημένο είδος	Εισβολικό είδος
Hebrew		מין לא מקומי	מין מבוסס
Hindi	गैर देशी प्रजाति	स्थापित प्रजाति	आक्रामक प्रजाति
Hungarian	Nem őshonos faj	Megtelepedett faj	Inváziós faj
Italian	Specie alloctona	Specie stabilizzata	Specie invasiva
Japanese	外来種	定着種	侵略的種
Kazakh	Бөгде түр	Қалыптасқан түр	Инвазивті түр
Lithuanian	Nevietinė rūšis	Įsitvirtinusi rūšis	Invazinė rūšis
Norwegian	Ikke-naturlig forekommende art	Etablert art	Invaderende art
Polish	Gatunek nierodzimy	Gatunek zadowowiony	Gatunek inwazyjny
Portuguese	Espécie não-nativa	Espécie estabelecida	Espécie invasora
Romanian	Specie alohtonă	Specie stabilită	Specie invazivă
Russian	Аллохтонный вид	Обосновавшийся вид	Инвазивный вид
Serbian (Latin)	Alohtona vrsta	Uspostavljena vrsta	Invazivna vrsta
Serbian (Cyrillic)	Алохтона врста	Успостављена врста	Инвазивна врста
Slovak	Nepôvodný druh	Etablovaný druh	Invázny druh
Slovenian	Tujerodna vrsta	Ustaljena vrsta	Invazivna vrsta
Spanish	Especie no nativa	Especie establecida	Especie invasora
Turkish	Yerli olmayan tür	Yerleşik tür	İstilacı tür
Ukrainian	Чужорідний вид	Укоріненний вид	Інвазивний вид
Urdu	غیر مقامی سپیشیز	مستحکم سپیشیز	تصرف پزیر سپیشیز

from the string of “non-native established species” and “non-native invasive species”, the standardized literature search described above was performed for each term in the singular voice except when not applicable. The number of results (as of 26/06/2024) from the two searches was then summed up and compared for each term differing between the two studies.

## Results

Provision of an equivalent term for *established species* and *invasive species* was straightforward in all 28 languages, unlike *non-native species* (Table 1). For 21 languages (Arabic, Catalan, Chinese, Croatian, Czech, Dutch, French, German, Hebrew, Hindi, Hungarian, Japanese, Lithuanian, Norwegian, Polish, Portuguese, Slovak, Slovenian, Spanish, Turkish, and Urdu), “non-native” translated as per the original English, and in five languages (Greek, Italian, Romanian, Russian, and Serbian) as “allochthonous” (Table 2). In Kazakh and Ukrainian, a term translating to “alien”, hence discouraged for use in English, was instead used (Table 2). In Ukrainian, this choice was justified as no semantic distinction seemingly exists with “non-native”; in Kazakh, this choice was due to the term “alien” being routinely employed in the country’s lexicon of invasion biology. For eight languages (Czech,

**Table 2.** Preferred (see Table 1) and most common term for *non-native species* (singular voice except when not applicable) in 28 non-English languages. Case (refers to Preferred term): A = translating to “Allochthonous species”; B = translating to “Non-native species” (as per the original English); C = translating to “Alien species”. In bold, preferred term same as most common term.

Language	Preferred	Case	Most common
Arabic	نوع غير أصلي	B	الأنواع الغريبة
Catalan	Espècie no nativa	B	Espècie invasora
Chinese	<b>非本地种</b>	B	<b>外来种</b>
Croatian	Nezavičajna vrsta	B	Strana vrsta
Czech	<b>Nepůvodní druh</b>	B	<b>Nepůvodní druh</b>
Dutch	Niet-inheemse soort	B	Exoot
French	Espèce non-native	B	Espèce exotique
German	Nicht einheimische Art	B	Neobiota
Greek	Αλλόχθονο είδος	A	Ξενικά είδη
Hebrew	מין לא מקומי	B	מין פולש
Hindi	गैर देशी प्रजाति	B	विदेशी प्रजाति
Hungarian	<b>Nem őshonos faj</b>	B	<b>Nem őshonos faj</b>
Italian	Specie alloctona	A	Specie aliena
Japanese	<b>外来種</b>	B	<b>外来種</b>
Kazakh	<b>Бөгде түр</b>	C	<b>Бөгде түр</b>
Lithuanian	Nevietinė rūšis	B	Svetimžemė rūšis
Norwegian	Ikke-naturlig forekommende art	B	Fremmed art
Polish	Gatunek nierodzimy	B	Gatunek obcy
Portuguese	<b>Espécie não-nativa</b>	B	<b>Espécie não-nativa</b>
Romanian	Specie alohtonă	A	Specie exotica
Russian	Аллохтонный вид	A	Чужеродный вид
Serbian (Latin)	Alohtona vrsta	A	Strana vrsta
Serbian (Cyrillic)	Алохтона врста	A	Страна врста
Slovak	<b>Nepôvodný druh</b>	B	<b>Nepôvodný druh</b>
Slovenian	<b>Tujerodna vrsta</b>	B	<b>Tujerodna vrsta</b>
Spanish	Especie no nativa	B	Especie exótica
Turkish	Yerli olmayan tür	B	Yabancı tür
Ukrainian	<b>Чужорідний вид</b>	C	<b>Чужорідний вид</b>
Urdu	غیر مقامی سپیشیز	B	ناگوار انواع

Hungarian, Japanese, Kazakh, Portuguese, Slovak, Slovenian, Ukrainian), the preferred term for *non-native species* was the same as the most commonly used one, whereas it differed for the other 20 languages (Table 2). The total number of search results for the three terms defining species invasiveness plus those for the most common term used for *non-native species* is given in Table 3 (see also Appendix 1). The number of results for the most common term for *non-native species* was from one to four orders of magnitude higher relative to the preferred term (Table 3).

Upon comparison of the three terms in the 28 languages (Table 4; Table S3; Appendix 2), 12 exhibited agreement (Arabic, Catalan, Czech, Dutch, French, Hebrew, Japanese, Polish, Portuguese, Slovak, Slovenian, and Spanish), three demonstrated overall equivalence (Chinese, Croatian, and German), and the remaining 13 differed in one or more terms (Greek, Hindi, Hungarian, Italian, Kazakh, Lithuanian, Norwegian, Romanian, Russian, Serbian, Turkish, Ukrainian, and Urdu). These discrepancies resulted either from choice of a term referring to *non-native species* deemed to be more appropriate to avoid politically or culturally laden content (Hindi, Hungarian, Lithuanian, Norwegian, Russian, Serbian, and Turkish) or from use of a term

**Table 3.** Total number of search results from a Google and Google Scholar search of the terms used to refer to species invasiveness in 28 non-English languages (see Tables 1 and 2). Results in bold when the preferred term is the same as the most common term. See Appendix 1 for breakdown of the number of search results and hyperlinks to online resources.

Language	Non-native species		Established species	Invasive species
	Preferred	Most common		
Arabic	7,420	28,511	5,893	3,360
Catalan	640	35,900	125	39,800
Chinese	3,126	69,100	103,900	130,890
Croatian	435	35,931	234	40,469
Czech	<b>29,704</b>	<b>29,704</b>	89	83,862
Dutch	2,670	178,800	456	30,553
French	1,426	94,700	5,090	70,760
German	1,373	166,300	3,329	165,400
Greek	340	13,880	83	450
Hebrew	137	11,805	433	9,275
Hindi	4,860	25,802	56	13,802
Hungarian	<b>5,026</b>	<b>5,026</b>	106	16,802
Italian	13,452	104,843	56	64,222
Japanese	<b>3,481,200</b>	<b>3,481,200</b>	7,058	2,246
Kazakh	<b>121</b>	<b>121</b>	470	908
Lithuanian	279	640	1	6,432
Norwegian	2	21,286	450	3,870
Polish	410	12,355	435	28,726
Portuguese	<b>4,058</b>	<b>4,058</b>	1,492	246,500
Romanian	830	5,796	79	21,825
Russian	293	41,025	4	65,180
Serbian (Latin)	4,630	28,931	180	12,600
Serbian (Cyrillic)	5,220	28,748	185	1,040
Slovak	<b>6,065</b>	<b>6,065</b>	16	22,167
Slovenian	<b>2,790</b>	<b>2,790</b>	89	35,269
Spanish	10,707	196,500	5,881	421,600
Turkish	297	19,280	1,419	35,189
Ukrainian	<b>1,577</b>	<b>1,577</b>	3	5,641
Urdu	1	604	0	0

deemed to be more precise (Greek, Italian, Kazakh, Romanian, Ukrainian, and Urdu). A language-wise explanation of the comparisons resulting in overall equivalence or discrepancy is provided below (see also Table S3).

### Chinese

Although **非本地** and **外来** are often used interchangeably, **非本地** is a more inclusive term that refers to species not naturally originating from the introduced area, whereas **外来** usually emphasizes species introduced by human action.

Both **建群** and **定居** are synonymous for “established”. However, **建群** emphasizes species whose populations have settled, reproduced, and developed over a long period of time, hence “established”. Conversely, **定居** more suitably describes species that have colonized a certain area after a short period of time and by a few individuals.



**Table 4.** Comparison of the terms defining species invasiveness in 28 languages differing between this study and those provided in Soto et al. (2024: their Table S1) with total number (*n*) of Google and Google Scholar search results. See Appendix 3 for breakdown of the number of search results and hyperlinks to online resources.

Language	Term (English)	This study		Soto et al. (2024)	
		Term	<i>n</i>	Term	<i>n</i>
Chinese	Non-native species	非本地种	3,126	外来种	69,100
	Established species	建群种	103,900	定居种	9,782
Croatian	Non-native species	Nezavičajna vrsta	435	Strana vrsta	35,931
German	Non-native species	Nicht einheimische Art	1,373	Nicht heimische Art	3,580
Greek	Non-native species	Αλλόχθονο είδος	340	Μη γηγενές είδος	11
	Established species	Εγκατεστημένο είδος	83	Εδραιωμένο είδος	11
Hindi	Non-native species	गैर देशी प्रजाति	4,860	विदेशी प्रजाति	25,802
Hungarian	Non-native species	Nem őshonos faj	5,026	Idegenhonos faj	5,220
Italian	Non-native species	Specie alloctona	13,452	Specie non nativa	869
	Established species	Specie stabilizzata	56	Specie stabilita	467
Kazakh	Non-native species	Бөгде түр	121	Бөтен түр	142
	Established species	Қалыптасқан түр	470	Негізделген түрі	424
Lithuanian	Non-native species	Nevietinė rūšis	279	Svetimkraštė rūšis	106
Norwegian	Non-native species	Ikke-naturlig forekommende art	2	Fremmed art	21,286
Romanian	Non-native species	Specie alohtonă	830	Specie non-native	107
Russian	Non-native species	Аллохтонный вид	293	Чужеродный вид	38,825
Serbian (Latin)	Non-native species	Alohtona vrsta	4,630	Vrsta stranog porekla	455
Serbian (Cyrillic)	Non-native species	Алохтона врста	5,220	Врста страног порекла	254
Turkish	Non-native species	Yerli olmayan tür	297	Yabancı tür	19,280
Ukrainian	Non-native species	Чужорідний вид	1,577	Чужоземний вид	3
	Established species	Укорінений вид	3	Закріплений вид	367
Urdu	Non-native species	غیر مقامی سپیشیز	1	غیر مقامی پر جاتیوں	233
	Established species	مستحکم سپیشیز	0	پر جاتیوں کو قائم کیا	3
	Invasive species	تصرف پریر سپیشیز	0	ناگوار انواع	408

### Croatian

Both **nezavičajna** and **strana** are correct and synonymous. However, **nezavičajna** carries a broader meaning than **strana**, encompassing both species that have expanded their distribution naturally and are not native to a newly colonized area and species that have been introduced into a different area within the same political boundaries or geographical region. Additionally, **nezavičajna** translates as “non-native”, unlike **strana**, which translates as “foreign”. This makes the former term not politically laden. Regardless, both terms are used interchangeably in invasion biology.

### German

The terms **nicht einheimische** and **nicht heimische** are synonymous and frequently used interchangeably.

### Greek

The terms **αλλόχθονο** and **μη γηγενές** are synonymous and widely used. Choice between the two terms depends on context and the nuance intended to be conveyed. **Αλλόχθονο** literally means “from another land”, emphasizing the non-native origin of a species. This term has been widely used in formal, informal, and general context. Conversely, **μη γηγενές** literally means “not born of the earth” or “not native to the land”. More

precisely, **μη γηγενές** means “non-indigenous” and is frequently confused with “non-endemic”, which does not necessarily mean “non-native”.

Regarding the term “established”, use of **εγκατεστημένο** may be preferable to **εδραιωμένο**. This is because, while both terms refer to something that has settled in an environment, **εγκατεστημένο** means “installed” or “established”, and typically refers to something that has been positioned or applied in a specific area or community. Conversely, **εδραιωμένο** means “entrenched” or “strengthened”, and usually refers to something deeply ingrained.

#### *Hindi*

Unlike **गैर देशी**, the term **विदेशी** means “foreign”, hence it may not be the most appropriate translation for “non-native” to avoid politically laden connotation. Regardless, both terms overall convey the same meaning.

#### *Hungarian*

The terms **nem őshonos** and **idegenhonos** are used interchangeably. However, **nem őshonos** may be preferable because it means “non-native”. On the contrary, **idegenhonos** means “alien” or “foreign”, hence carries a politically laden connotation.

#### *Italian*

The term **alloctona** is preferred for “non-native” rather than the more literal translation **non nativa**. **Alloctona** is also the term more widely used and accepted in invasion biology.

The term “established” is better rendered with **stabilizzata** (i.e. “non-native”, “self-sustaining”) rather than **stabilita**, which means “set” or “sanctioned” in Italian, hence not quite suitable in the context of invasion biology.

#### *Kazakh*

While **бөгде** and **бөтен** are synonymous, **бөгде** (“foreign”) is commonly used to refer to any item, including animals, whereas **бөтен** is typically used to refer to a person, such as a stranger.

The term **қалыптасқан** more accurately means “established” compared to **негізделген**, which means “based”.

#### *Lithuanian*

Preference for **nevietinė** is based on the somewhat negative geopolitical connotations associated with **svetimkraštė**. The latter term is compound word of **svetimas** (“alien”, “foreign”) and **kraštas** (“region”). Although **svetimžemė** is an approved term utilized in official government documents and various publications, in Lithuanian terms such as “alien” and “foreign” apply more commonly to people from other countries than to species.

### *Norwegian*

The term **ikke-naturlig forekommende** means “not naturally occurring”, hence it may be a more preferable, politically neutral term to refer to ‘non-native’ compared to **fremmed**, which, albeit more commonly used in invasion biology, means “foreign” or “alien”.

### *Romanian*

The term **alohtonă** is used in both national legislation and scientific publications. Neither of these documents seems to use consistently the term **non-native**.

### *Russian*

The term **аллохтонный** does not carry a politically laden connotation, unlike **чужеродный**, which means “alien”.

### *Serbian*

The term **alohtona/алохтона** is already adopted in the Serbian language, unlike **stranog porekla/страног порекла**, which literally means “of foreign (alien) origin”, hence carries a politically laden connotation.

### *Turkish*

In the term “non-native”, “non” acts as a prefix denoting negation, which can be translated into Turkish as **olmamak**. The direct counterpart of “native” in Turkish is **yerli**, which is widely accepted and used in ecological context. Thus, translating “non-native” as **yerli olmayan** precisely conveys the intended negation. In contrast, **yabancı** means “foreigner”, “stranger”, or “alien”, hence carries broader connotations that extend beyond the scientific context of invasion biology. This term implies foreignness in a general sense, including cultural or national differences, and even refers to extraterrestrial beings, thus introducing ambiguity in the ecological context of “non-native”.

### *Ukrainian*

Although **чужорідний** means “alien”, it is a more appropriate term to use for *non-native species*, unlike **чужоземний**, which means “foreigner” and is not generally used to refer to *non-native species* but rather to people.

Despite its more common usage in invasion biology compared to **укорінений**, the term **закріплені** has several meanings including “fixed”, “attached” or “fastened”. The former term is therefore to be considered more grammatically correct.

### *Urdu*

The term **سپیشیز** is commonly used in Pakistani textbooks for “species”, unlike **پر جاتیوں**, which comes from Hindi.

The term **مستحکم** covers the meanings of arrival, spread, and establishment (hence, “established”), unlike **قائم کیا**. The latter term is generally used to refer to objects for building or recurring events and cannot be used as standalone terminology, as it conveys its meaning only when used in a sentence. Overall, it is common practice to use English words in Urdu rather than Hindi words. This is because many words now obsolete in Hindi come from Sanskrit – the main source language for Hindi that is no longer in practice in India these days.

The term **تصرف پزیر** refers to the arrival, establishment, and spread typical of an *invasive species* (hence, “invasive”), whereas **ناگوار** literally means “undesired”. Furthermore, the latter term carries a somewhat politically laden connotation.

## Discussion

To quote Copp et al. (2021, p. 6), the provision in this paper of the three terms defining species invasiveness in 28 non-English languages “has effectively been a study of environmental interactions between any given language and its user. These interactions combine the various factors that make up national culture, including geography, history, climate, religion and language”.

In most languages, efforts were made to use a term for “non-native” that avoids politically or culturally laden content, often diverging from current usage. In other languages, choice to retain one of those terms was often contextual given the lack of semantic distinction with reference to *non-native species*. One language, Kazakh, retained a term translating as “alien”. While this might suggest “resistance” to change, it may not fully represent the stance of the entire scientific or legislative community in that country, as our study engaged one to three experts for each language from the same country (with the exception of Russian: see Table S1). A broader consensus-based approach involving a panel of experts from academic and governmental institutions from a certain country (or more countries, in case of widely spoken languages) would therefore provide further insights into the adoption of an equivalent term to “non-native” in the local language – even if as a neologism or as a less commonly used term in the local lexicon. Here, this was achieved in some languages by rendering “non-native” as the equivalent of “allochthonous”. Incidentally, pronunciation of this word, though somewhat challenging in English due to its Greek origin (Soto et al. 2024), would not pose the same difficulty in non-English languages lacking the “chth” consonant cluster (cf. Italian, Romanian, Russian, and Serbian), which is an English transliteration from Greek.

The discrepancies observed in the terms defining species invasiveness in nearly half of the languages in the comparative evaluation are indicative of the dynamic nature of terminology in invasion biology as a scientific

discipline under development. However, it may also represent a potential gauge of the experience of the contributors involved. This is because most of the experts in this study (see Tables S1 and S3) are not only native speakers of the assigned language(s) but also have long-term experience in the translation of the questionnaire and graphical user interface of the three currently available, state-of-the-art, second-generation decision support tools for risk screening: the Aquatic Species Invasiveness Screening Kit (AS-ISK), the Terrestrial Animal Species Invasiveness Screening Kit (TAS-ISK), and the Terrestrial Plant Species Invasiveness Screening Kit (TPS-ISK) (Copp et al. 2016, 2021; Vilizzi et al. 2022, 2024a, b).

Overall, the findings of our study confirm the need of detailed linguistic analysis and clear definition of terminologies in invasion biology. Although the three terms related to species invasiveness as proposed in this study inherit in definition and context from Soto et al. (2024), they are intended to eliminate redundancy by the omission of “non-native” in *established species* and *invasive species*. Our comparative evaluation has also indicated unavoidable disagreements amongst invasion biologists on how some terms should be rendered in their native language. As properly stated by Soto et al. (2024, p. 8): “We therefore acknowledge that even among ourselves, there remains disagreement about how some terms should be defined, reflecting the diversity of opinions within our evolving field and demonstrating the importance of international and multidisciplinary discussions on how to clarify terminology”. This is especially relevant given that five authors of this paper (L. Vilizzi, MP, HV, BY and DG) were part of that study, with two of them (MP and HV) being responsible for the translations in Croatian and Dutch, respectively, also in the present study (Table S3). Whilst the terms provided in Dutch were the same between the two studies, those in Croatian intentionally differed. Rationale for the latter choice was to propose in the present study a different term for “non-native” that would emphasize the current “state of flux” in terminology for invasion biology in Croatian, but also to offer an alternative perspective in the usage of a non-politically laden term despite its more limited occurrence in the supporting literature.

The latter approach was also adopted in other languages to mirror the translation of the term “non-native” in a similar, non-politically or culturally laden connotation as in English, including using the equivalent for “allochthonous”. However, whilst in the case of Greek, Lithuanian, and Serbian this choice for a more “neutral” term reflected its wider usage (as indicated by the corresponding number of search results), the opposite was true for Russian and Turkish, and especially for Norwegian. In these cases, this was the result of an informed decision to propose a somewhat “novel” term for prospective adoption in invasion biology in the local language, hence despite the widely accepted usage of the far more common term translating as “foreign” or “alien”. Usage of the latter terms could

inadvertently shape public perception, leading to either heightened fear or lack of awareness regarding the risks of certain species introductions.

In the case of Urdu almost no results for the proposed terms were found (Table 3). This outcome is not surprising, as English is the other official language widely spoken in Pakistan, with the vast majority of the scientific literature published in this language (Angulo et al. 2021). However, the larger number of results for the rendition in Urdu of the term *invasive species* in Soto et al. (2024) compared to that proposed in the present study ( $n = 0$ ) deserves a more in-depth explanation. The large number of search retrievals of scientific terms in Urdu is often the result of online translators, which are largely developed by Indians who use their own terminology. Also, Urdu mostly borrows words from Arabic and Persian, resulting in terminology not used in those languages. In fact, the alternative translation for “invasive” provided in the reference study to the one proposed in the present one can be retrieved from Persian web pages in which various authors have used this word in an entirely different context.

In conclusion, establishing consistent terminologies across multiple languages is essential to promote consensus and facilitate effective global communication among researchers, stakeholders, and policy-makers, but also the general public as part of citizen science initiatives (Theobald et al. 2015; Encarnação et al. 2021; Verbrugge et al. 2021). We, therefore, advocate for (i) a concerted effort in achieving precision in terminology to resolve any ambiguities, particularly in languages where the lexicon of invasion biology is still in its infancy, and (ii) the adoption of a multidisciplinary approach that combines invasion biology principles with insights from humanistic disciplines and linguistics, cast within the diffusion-of-English versus ecology-of-language paradigms. Addressing these challenges will require sustained and constructive international dialogue. This is pivotal to improve communication in invasion biology both locally and globally in a rapidly changing world. Failure to do so could impede the development of collaborative management strategies and research initiatives aimed at mitigating the impacts of biological invasions.

### Authors' contribution

L. Vilizzi, MP, DP and BY designed the concept; All authors contributed the data; L. Vilizzi analyzed the data; DG organized the logistics; L. Vilizzi wrote the first draft of the manuscript; All authors inspected and approved the final version of the manuscript prior to submission.

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### Supplementary material

The following supplementary material is available for this article:

**Table S1.** Contributors (and authors of this paper) of the terms defining species invasiveness in 28 non-English languages (see Table 1).

**Table S2.** Main reference documentation about legislation for non-native (invasive) species in each of the 28 languages for which the terms defining species invasiveness were provided in this study.

**Table S3.** Comparison of the terms (Terminology) defining species invasiveness in 28 languages between this study and Soto et al. (2024).

**Appendix 1.** Number of search results and hyperlinks to online resources for the four terms defining species invasiveness in 28 non-English languages.

**Appendix 2.** Number of search results and hyperlinks to online resources for the terms defining species invasiveness in 28 non-English languages differing between this study and Soto et al. (2024).

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