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Risk Assessment

Questionnaire improvements in second-generation, multilingual decision support tools for invasion risk screening of non-native taxa

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Abstract

As a result of the increasing threats posed by non-native species invasions, there has been a rise in the demand for decision support tools that can more efficiently identify those non-native species likely to become invasive. As part of the risk screening (first) step in the environmental risk analysis process, three multilingual decision support tools are currently available for the screening of aquatic and terrestrial organisms: 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). Here, we describe the recent improvements to the questionnaire that forms the base of these second-generation Weed Risk Assessment-type tools. We subjected the AS-ISK and TAS-ISK questionnaires to a thorough revision and extended these improvements for the development of the TPS-ISK. Overall, this involved an improvement of the AS-ISK and TAS-ISK questionnaires, an alignment of the questionnaires across the three toolkits, and the translation of the three resulting questionnaires in all 30 non-English languages supported by the toolkits. Given the most extensive usage of the AS-ISK and, in perspective, of the recently released TAS-ISK and TPS-ISK, it is timely to provide researchers and decision-makers in the field of invasion biology with a suite of updated toolkits designed to streamline and improve the risk screening process. These enhancements will be crucial for the delivery of reports to stakeholders and decision-makers also in the languages supported by the toolkits as applicable, and in line with the ecology-of-language paradigm at the base of the toolkits' multilingual interface development.

Key words: biological invasions, risk analysis, Aquatic Species Invasiveness Screening Kit (AS-ISK), Terrestrial Animal Species Invasiveness Screening Kit (TAS-ISK), Terrestrial Plant Species Invasiveness Screening Kit (TPS-ISK)

Introduction

The global introduction and establishment of non-native species has experienced a significant surge over the past two centuries (Bailey et al. 2020; Pyšek et al. 2022) and has resulted in substantial ecological damage and economic losses to the native biota (Pimentel et al. 2000; Bradshaw et al. 2021). Consequently, there is a demand for decision support tools that can more efficiently identify those non-native species likely to become invasive (Srėbalienė et al. 2019). The identification of species carrying a higher risk of invasiveness is a crucial aspect in environmental risk analysis, which consists of three sequential components: risk screening, risk assessment, and risk management and communication. Risk screening assists in identifying those non-native species with the higher invasive potential within a predetermined risk assessment area, which would then qualify for follow-up risk assessment (Copp et al. 2016a). Therefore, clear and detailed risk screening outcomes are essential to inform decision-makers and stakeholders about the prioritisation of measures for prevention and management strategies to counteract biological invasions (Copp et al. 2021).

Among the most widely applied screening tools is the Australian Weed Risk Assessment (WRA) for terrestrial and aquatic plants (Pheloung et al. 1999; Gordon et al. 2008). The WRA is a semi-quantitative scheme based on a questionnaire consisting of 49 questions, which is made available as a self-automated workbook. The WRA formed the basis for the Fish

Invasiveness Screening Kit (FISK: Copp et al. 2005a, 2005b; Lawson et al. 2013) and related taxon-specific toolkits (Copp 2013). These first-generation WRA-type tools have been widely applied worldwide (Vilizzi et al. 2019) and were eventually replaced by the taxon-generic, multilingual Aquatic Species Invasiveness Screening Kit (AS-ISK: Copp et al. 2016b, 2021), which is designed as a turnkey application. Following the successful uptake and implementation by the scientific community worldwide of the AS-ISK for screening aquatic organisms (see Vilizzi et al. 2021, 2022a, b; Vilizzi and Piria 2022), the Terrestrial Animal Species Invasiveness Screening Kit (TAS-ISK: Vilizzi et al. 2022c) and the Terrestrial Plant Species Invasiveness Screening Kit (TPS-ISK: Vilizzi et al. 2024) were recently developed as "siblings" of the AS-ISK. Together, the AS-ISK, TAS-ISK and TPS-ISK are second-generation WRA-type tools that allow the screening of all non-native taxa (i.e. aquatic and terrestrial animals and plants).

The aim of this paper is to describe the recent improvements to the questionnaire of the second-generation WRA-type tools relative to the previous versions of the AS-ISK and TAS-ISK, and with reference to the recently released TPS-ISK. Given the most extensive usage of the AS-ISK and the prospect of a similar fate by the TAS-ISK and TPS-ISK, we thought it timely to provide researchers and decision-makers in the field of invasion biology with a suite of updated toolkits designed to streamline and improve the risk screening process. To achieve this objective, we subjected the AS-ISK and TAS-ISK questionnaires to a thorough revision and extended these improvements to the development of the TPS-ISK. Overall, this joint effort involved an improvement of the AS-ISK and TAS-ISK questionnaires, an alignment of the questionnaires across the three toolkits (i.e. including the TPS-ISK), and the updated translation of the three resulting questionnaires in all 30 non-English languages supported by the toolkits.

Methods

The second-generation WRA-type tools AS-ISK, TAS-ISK and TPS-ISK comply with the "minimum standards" for screening non-native species under EC Regulation No. 1143/2014 on the prevention and management of the introduction and spread of invasive alien species (Roy et al. 2018). The questionnaire in these toolkits comprises 55 questions in total (Copp et al. 2016b; Vilizzi et al. 2022a) with the text for each question consisting of two components: Text and Guidance (note the capitalisation of the term Text with reference to the first component of a question). The Text represents the actual question, whereas the Guidance provides an explanation on how to respond correctly to the question. The first 49 questions, which have been adapted from those of the WRA through the first-generation ISK tools, comprise the Basic Risk Assessment (BRA), and the last six questions the Climate Change Assessment (CCA). The BRA part of the questionnaire consists of two sections with eight categories: Section A

Biogeography/Historical including Categories *Domestication/Cultivation*, *Climate, distribution and introduction risk*, and *Invasive elsewhere*; Section B *Biology/Ecology*, including Categories *Undesirable (or persistence) traits*, *Resource exploitation*, *Reproduction*, *Dispersal mechanisms* and *Tolerance attributes*. The CCA part of the questionnaire consists of Section C (and Category) *Climate change*. To achieve a valid screening, the assessor must provide for each question a response, a confidence level and a justification based on literature sources (Vilizzi and Piria 2022). Upon completion of a screening, a BRA score and a BRA+CCA score are computed by which a species is ranked as low, medium or high risk based on threshold values (Vilizzi et al. 2022b).

Improvement of the AS-ISK, TAS-ISK and TPS-ISK questionnaires in their new v2.4 was the outcome of a four-stage process. Firstly, the questionnaires of the AS-ISK and TAS-ISK in their v2.3.3 were upgraded to v2.4 by revising both Text and Guidance for all 55 questions. Secondly, the TAS-ISK questionnaire was adapted to terrestrial plants to develop the TPS-ISK. Thirdly, the questionnaires for the three toolkits were "aligned" in terms of both structure and consistency. Lastly, the translation of the three resulting questionnaires into the languages supported by the toolkits was updated mirror exactly the improvements in the English language. In this last process, 37 native speakers (and authors of this study) of each language with expertise in invasion biology were involved. Of note, the adaptation of the TAS-ISK to develop the TPS-ISK as part of the second stage of the process is described elsewhere (Vilizzi et al. 2024). The AS-ISK, TAS-ISK and TPS-ISK in their v2.4 are available for free download at http://www.cefas.co.uk/nns/tools/, where full details can be found in the corresponding User Guide of each toolkit.

Results

Upgrade

Changes in the questionnaire from v2.3.3 to v2.4 involved 50 questions for the Text and 54 for the Guidance in the AS-ISK (Supplementary material Tables S1 and S2), and 49 questions for the Text and 52 for the Guidance in the TAS-ISK (Tables S3 and S4). These changes could be grouped into five categories: (i) improved text, (ii) removed text relevant to the question Guidance so that only text applicable to the question Text category remained, (iii) consistent usage of the term "taxon", (iv) improved grammar, (v) removal of acronym.

Text improvements were made in 24 questions for the Text and 34 questions for the Guidance in the AS-ISK, and in 22 questions for the Text and 31 questions for the Guidance in the TAS-ISK. These improvements consisted in ensuring across-questionnaire consistency when formulating a question (i.e. replacement in the Text for Qs 14, 15, 20, 21, 22 of "Is it likely

that the taxon will" with "Is the taxon likely to" in line with Qs 18, 19, 25–31, 47), increased thoroughness of a question (e.g. addition of "by the taxon" in the Text for Qs 51, 53–55), usage of more appropriate terminology (e.g. "pathogens" instead of "infectious agents" in both Text and Guidance for Qs 20, 21, 49; "suppress the growth" instead of "smother" in AS-ISK Text for Q 15; "generalist" instead of "eurybionts" in TAS-ISK Guidance for Q 23), removal of unnecessary text or locally relevant species lists in parentheses (i.e. Text for Qs 15, 33, 36, 44, 45; Guidance for Qs 16, 26), provision of both more detailed (e.g. Guidance for Qs 8, 12, 37) and more generalised and simplified examples (e.g. Guidance for Qs 4, 11, 15, 42), inclusion of DOIs for references (Guidance for Qs 4, 27), and capitalisation of the term "Response" throughout as a graphical user interface keyword (Guidance for Qs 10, 16, 19, 23, 26, 27, 35, 49).

The question Text was modified to remove any text that was relevant to the Guidance only for five (albeit not all the same) questions in both AS-ISK and TAS-ISK. Specifically, AS-ISK and TAS-ISK Qs 9, 24, 37, 49, AS-ISK Q 23 and TAS-ISK Q 27 were simplified by removal of text in parentheses relevant to the corresponding Guidance. In this way, the Text and Guidance for all questions in both toolkits was made consistent by ensuring that no redundant information would be provided in the Text and that the Guidance would include all necessary details relevant to the specific question.

The consistent usage of the term "taxon" involved changes in six questions for their respective Text and 31 questions for their respective Guidance in the AS-ISK, and changes in six questions for their respective Text and 28 questions for their respective Guidance (same questions as for the AS-ISK) in the TAS-ISK. Usage of the term taxon was limited to reference to the taxonomic entity under screening (i.e. noting that the ISK tools are by definition "taxon-generic"), whereas the term "species" was restricted to the native organism(s) that the taxon may impact.

Improvements to the grammar involved changes in 20 questions for their respective Text and 24 questions for their respective Guidance in the AS-ISK, and changes in 21 questions for their respective Text and 22 questions for their respective Guidance in the TAS-ISK. These improvements consisted of grammar corrections (i.e. "enter" instead of "enter in/into" in Qs 7 and 8 Text; "are there any known" instead of "are there known" in Qs 11–13 Text; "persist" instead of "persisting" in Q 25 Text; "the data used are" instead of "are the data used" in Q5 Guidance; "freshwater" instead of "freshwaters" in Q 22 Text for AS-ISK; "grown" instead of "grown on" in Q 2 Guidance for AS-ISK), replacement of slashes (/) throughout with "and", "or" or a comma (,), and removal of unnecessary hyphens (-).

Acronym removal involved changes in 21 questions for their respective Text and 16 questions for their respective Guidance in the AS-ISK, and changes in 21 questions for their respective Text and 15 questions for their

respective Guidance in the TAS-ISK. Specifically, the term "risk assessment area" was used throughout in lieu of "RA area". This was to avoid the unnecessary use of "technical" (or "report-like") terms in the English language and to make translation consistent across all other languages for most of which no acronym was previously used. In the case of those languages that previously used the acronym (i.e. Filipino, Swedish, Turkish and Greek), this also was removed from the updated translations.

Alignment

Upon comparison of the questionnaires across the three toolkits, the Text differed for 14 (25.5%) questions and was the same for the other 41 (74.5%) (Table 1; Table S5), whereas the Guidance differed for 28 (50.9%) questions and was the same for the other 27 (49.1%) (Table 1; Table S6). In both cases and in all languages (see Tables S7 and S8 for an example in the Polish language), differences were limited to key terms and parts of text specific to the organism group pertaining to the toolkit and could be categorised based on their relevance to (i) aquatic organisms (AS-ISK) *vs* terrestrial animals and plants (TAS-ISK and TPS-ISK), (ii) aquatic organisms and terrestrial animals (AS-ISK and TAS-ISK) *vs* plants (TPS-ISK), and (iii) aquatic organisms (AS-ISK) *vs* terrestrial animals (TAS-ISK) *vs* terrestrial plants (TPS-ISK).

For the Text, the number (and proportion) of questions with differences in the three categories was 3 (5.5%), 4 (7.3%) and 7 (12.7%), respectively. In the first case (i.e. AS-ISK *vs* TAS-ISK and TPS-ISK), differences were related to impacts to aquaculture *vs* agriculture or forestry (Q 11), and to the taxon being out of water *vs* in water (Q 44) and tolerant of a range of water *vs* soil or air quality conditions (Q 45). In the second case (i.e. AS-ISK and TAS-ISK *vs* TPS-ISK), differences were related to the taxon's captivity *vs* cultivation status (Qs 6 and 22), predation or competitive pressure *vs* competitive pressure only (Q 26), and production of gametes or propagules *vs* propagules only (Q 29). In the third case (i.e. AS-ISK *vs* TAS-ISK *vs* TPS-ISK), differences were related to the disruption of food-web structure or ecosystem function (Q 18), production of offspring or propagules (Q 33), means of hiding or attachment (Q 37), dispersal as eggs, seeds or spores (Q 38), larvae, juveniles, fragments or seedlings (Q 39) and propagules or eggs (Q 41), and to tolerance of salinity, soil acidity or other parameter levels (Q 48).

For the Guidance, the number (and proportion) of questions with differences in the three categories was 5 (9.1%), 5 (9.1%) and 18 (32.7%), respectively. Differences applied to all questions for which the Text differed as above except for Q 29 for which the Guidance remained the same across the three toolkits. However, when differences for the Guidance were categorised based on their relevance to aquatic organisms, terrestrial animals and terrestrial plants, there was not always a one-to-one correspondence relative to the differences in the Text. This was because of

Table 1. Comparison of differences in question (Q) Text and Guidance for the Aquatic Species Invasiveness Screening Kit (AS-ISK), Terrestrial Animal Species Invasiveness Screening Kit (TAS-ISK) and Terrestrial Plant Species Invasiveness Screening Kit (TPS-ISK). AO = Aquatic organisms (AS-ISK); TA = Terrestrial animals (TAS-ISK); TP = Terrestrial plants (TPS-ISK).

	Q	AO *vs* (TA, TP)	(AO, TA) *vs* TP	AO vs TA *vs* TP
Text				
	6		√	
	11	√		
	18			√
	22		√	
	26		√	
	29		√	
	33			√
	37			√
	38			√
	39			√
	41			√
	44	√		
	45	√		
	48			√
Guidance				
	1			√
	2			√
	6		√	
	8	√		
	9		√	
	11	√		
	12			√
	18		√	
	19			√
	22			√
	23			√
	24			√
	26			√
	28	√		
	32			√
	33			√
	34			√
	36			√
	37			√
	38			√
	39			√
	40		√	
	41			√
	44			√
	45	√		
	47	√		
	48			√
	49		√	

the provision of examples that were specific to the different types of taxa. As a result, the Guidance differed for an additional 14 questions (i.e. Qs 1, 2, 8, 9, 12, 19, 23, 24, 28, 32, 34, 36, 40, 47, 49) whose Text remained unchanged.

Translation update

The translation update process involved 30 languages in total: Albanian, Arabic, Bulgarian, Chinese (simplified), Croatian, Czech, Dutch, Filipino, French, Georgian, German, Greek, Hebrew, Hungarian, Italian, Japanese, Korean, Macedonian, Persian, Polish, Portuguese, Romanian, Russian, Slovak, Slovenian, Spanish, Swedish, Thai, Turkish, Vietnamese. Of note, the pooled "Croatian, Serbian and related languages" option in v2.3.3 was restricted to Croatian only. A multi-stage quality-control check ensured that the final translation of the three questionnaires mirrored exactly the

original English text in terms of keywords (both specific to the questionnaire and pertaining to the graphical user interface: i.e. "taxon", "species", "risk assessment area", "native range", "introduced range", "justification", "response") and consistency in the structure of the questions' Text and Guidance. As per the English, consistency was ensured also between and among related questions as well as in terms of keywords between Text and Guidance for all questions (e.g. "establishment", "naturalised", "pathogens", "pathways", "pests", "vectors"). Grammatically, for all 30 languages in which the questionnaires were translated, the format of quotation marks (as in e.g. "best estimate") followed that specific to each language (see https://en.wikipedia.org/wiki/Quotation_mark).

Discussion

Since its release (Copp et al. 2016b), the AS-ISK has been applied worldwide to screen non-native aquatic taxa for a total of almost 100 published applications (as of 29/06/2024). These applications by far outnumber those of the other available screening toolkits *Harmonia+* for plants, animals and their pathogens (D'hondt et al. 2015; 15 published applications) and Canadian Marine Invasive Screening Tool for aquatic invertebrates (Drolet et al. 2016; six published applications). The strengths of the second-generation WRA-type tools are numerous and can be summarised into: (i) compliance with the minimum standards against which a protocol should be evaluated for invasion process and management approaches (Roy et al. 2018), (ii) questionnaire comprehensiveness with inclusion of a climate change component (Copp et al. 2016b), (iii) provision of a level of confidence (Copp et al. 2016b), (iv) multilingual support (Copp et al. 2021), (v) possibility for across-study comparisons of screening outcomes (Vilizzi et al. 2021), and (vi) a powerful graphical user interface coupled with seamless software deployment and accessibility and with improved data exchange (Copp et al. 2016b).

As a result of the upgrade from v2.3.3 to v2.4, the changes in the AS-ISK and TAS-ISK questionnaires involved almost all questions. However, these improvements are not expected to affect substantially a species' screening outcomes in terms of the resulting BRA and BRA+CCA scores and related risk ranks, even for the same species and risk assessment area. This is because the foundation of all questions in terms of rationale, scope and applicability has been fully preserved in this upgrade, thereby ensuring full compatibility of v2.4 with previous versions. These improvements, albeit substantial, have been in terms of enhanced clarity, correctness and consistency of each question both within and between its corresponding Text and Guidance, and of repartitioning of information across the latter (i.e. with examples provided exclusively in the Guidance). It is therefore envisaged that assessors will be able to conduct their screenings more

efficiently by taking advantage of the more streamlined and accurate questionnaires provided by the latest version of the toolkits. These enhancements will also be crucial for the delivery of reports to stakeholders and decision-makers in the languages supported by the toolkits as applicable, hence in line with the ecology-of-language paradigm at the base of the AS-ISK, TAS-ISK and TPS-ISK multilingual interface (Copp et al. 2021).

The alignment across the toolkits questionnaires, where differences are limited to key terms and parts of text specific to the organism under screening, highlights both the parsimonious approach that was followed in the development of the questionnaires themselves and their versatility in terms of adaptation to the different types of taxa (i.e. aquatic organisms, terrestrial animals and terrestrial plants). This versatility was already shown by the development of the FISK for freshwater fishes as an adaptation of the WRA for plants (Copp et al. 2005a, 2005b), by the further adaptation of the FISK into its "sister" toolkits for the screening of amphibians, freshwater invertebrates, marine fishes and marine invertebrates (Copp 2013), and, more recently, by the adaptation of the AS-ISK to the screening of terrestrials animals with the TAS-ISK (Vilizzi et al. 2022c).

The questionnaires in the 30 languages of the second-generation WRA-type tools in their v2.4 have undergone meticulous quality-control checks to ensure compliance with the highest standards expected of this state-of-the-art suite of electronic decision support tools (see also Srėbalienė et al. 2019). This reinforces the recent evaluation of the multilingual AS-ISK as one of the "significant developments" in the field of ecolinguistics in 2021 (Zhang 2022). The removal of 'Serbian and related languages' from the Croatian language interface during the recent development of the AS-ISK, TAS-ISK and TPS-ISK indicates the evolution of each language identity after the breakup of Yugoslavia, particularly in Croatia and Serbia but also in Bosnia-Herzegovina and Montenegro (Greenberg 2004). This highlights the need to follow specificities and development of new terms, especially in invasion biology where terminology is still in a developmental phase. Finally, there is still potential for inclusion of additional languages not currently supported by the toolkits (see Copp et al. 2021), noting that any contribution in this regard will have to include the AS-ISK, TAS-ISK and TPS-ISK questionnaire as a joint "package".

In conclusion, the transition from v2.3.3 to v2.4 brought modifications to both the AS-ISK and TAS-ISK, encompassing improvements in questions' content and language structure. Enhancements to the text were substantial, involving modifications to a considerable number of questions across both their Text and Guidance. These improvements were aimed at achieving consistency in question formulation, enhancing question thoroughness, adopting a more appropriate terminology and removing unnecessary details. The translation process involved a meticulous effort by author-translators across 30 languages, ensuring consistency with the original English text in

terms of keywords and structural elements. The transition to version v2.4 represents therefore a comprehensive refinement of the second-generation WRA-type tools that is expected to enhance their effectiveness and global applicability.

Author's contribution

LV, MP and DP designed the concept; LV and MP wrote the first draft of the manuscript; MP, GH, DA, ZA-W, RB, AB, RC, DD, MDZ, ASG, PG, EI, OK, NK, AK, PK, SL, JL, SDM, JGM, LM, CO, KHO, RTP, CPe, RP, CPr, MR, KSŠ, BŠ, KATT, EU, LVa, HV, HW, BY and DP contributed the translations in their corresponding language; DG coordinated several logistical aspects of the study; 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. Improvements to the Text for the 55 questions (Q) of the Aquatic Species Invasiveness Screening Kit (AS-ISK) from v2.3.3 to v2.4.
Table S2. Improvements to the Guidance for the 55 questions (Q) of the AS-ISK from v2.3.3 to v2.4.
Table S3. Improvements to the Text for the 55 questions (Q) of the Terrestrial Animal Species Invasiveness Screening Kit (TAS-ISK) from v2.3.3 to v2.4
Table S4. Improvements to the Guidance for the 55 questions (Q) of the TAS-ISK from v2.3.3 to v2.4.
Table S5. List of the Text for the 55 questions (Q) comprising the questionnaire of the three toolkits AS-ISK, TAS-ISK and Terrestrial Plant Species Invasiveness Screening Kit (TPS-ISK).
Table S6. List of the Guidance for the 55 questions (Q) comprising the questionnaire of the three toolkits AS-ISK, TAS-ISK and TPS-ISK.
Table S7. List of the Text for the 55 questions (Q) comprising the questionnaire in the Polish language of the three toolkits AS-ISK, TAS-ISK and TPS-ISK.
Table S8. List of the Guidance for the 55 questions (Q) comprising the questionnaire in the Polish language of the three toolkits AS-ISK, TAS-ISK and TPS-ISK.

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