The Pest Management Attitude scale: a tool for measuring consensus between experts and practitioners in invasion biology

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Abstract Quantifying attitudes towards invasive alien species (IAS) is fundamental to understand the extent to which conservation scientists agree and can collaborate in their management. We tested the Pest Management Scale (PMS), originally invented to quantify attitudes towards invasive alien mammals in New Zealand, as a tool to quantify broader attitudes towards IAS among bioinvasion experts in Italy.

In autumn 2020 we administered an online questionnaire to a sample of 525 experts, representing almost all people working on biological invasions in Italy, that contained a subset of 7 questions from the PMS. We collected 316 answers, both from conservation practitioners (26.6%) and researchers (73.4%), and we used structural equation modeling to test for the psychometric properties of the scale and compare attitude scores between groups.

The PMS showed both a good reliability (Cronbach's alpha = 0.7), validity (CFI = 0.99, TLI = 0.99, SRMR = 0.03, RMSE = 0.02) and measurement invariance, when comparing researchers and practitioners, as well as when comparing respondents working on different invasive taxa. Both researchers and practitioners, as well as respondents with a different background, and respondents of a different age, had similar attitudes about IAS and their management.

Out study shows that the PMS, a simple scale originally conceived to measure attitudes towards invasive alien mammals, could indeed be used to quantify the attitudes of experts towards IAS. Even in countries where the public debate about biological invasions is much more recent than in New Zealand. The PMS scale could potentially be used both for large-scale and long-term research about the attitudes of experts about IAS.

Warning

Introduction

Invasive alien species (hereafter, IAS) are one the fundamental conservation threats worldwide, yet their management is complex, as it requires collaboration between different stakeholders [1][2][3]. For instance, it often requires a sound agreement between experts, which can be researchers, practitioners or policymakers [4]. Like laypersons, experts agree, and eventually decide to collaborate about a certain issue, due to important and interdependent intrinsic factors, such as anthropomorphism, ideology, perceived moral obligations, value orientations or trust [5][6][7][8][9][10], or because of extrinsic factors, such as their affiliation to different agencies and institutions.

Collaboration is also driven by individual thoughts about a specific issue. Explicit attitudes (hereafter, attitudes), are a parsimonious and clear approach to summarize these thoughts. Attitudes are an association, in memory, of an evaluation with an object: if people have a positive evaluation when asked about a certain issue, we would say that they have a positive attitude towards it. Attitudes allow people *i)* to understand if a certain object is consistent with their own goals, *ii)* to express their own values and *iii)* to facilitate social relationships, three scopes that are fundamental for collaboration [11].

In research about personal networks, which can also be used to represent professional collaboration, attitudes are recognized as a key component of value homophily [12]. For example, research conducted in healthcare demonstrated that experts holding similar attitudes towards a certain issue have been found to be more willing to collaborate, even when they are from different backgrounds [13][14]. Therefore, in conservation biology developing reliable, and widely applicable, attitudinal scales is paramount for measuring a key driver of collaboration between experts over a specific topic.

To date, various studies have developed psychometric scales to measure attitudes towards one or more IAS in specific circumstances, often within management or eradication programs. However, fewer tried to develop broadly-applicable attitudinal scales, to measure overall beliefs about IAS and their management, similarly to what has been done for other psychological constructs (e.g., wildlife value orientations)[15]. This gap needs to be addressed: biological invasions are one of the most important, and fastest-evolving, conservation issues globally [16] and there is a growing need for studies mapping what conservation actors think about IAS across large spatial scales, and even how these thoughts evolved through time.

Aley et al. (2020)[17] proposed the Pest Management Attitude (hereafter, PMA) scale as a reliable and valid tool to quantify attitudes towards pest species and their management, among the general public in New Zealand. The 12-items scale is based on the new ecological paradigm (hereafter, NEP) scale [18][19] and on a literature review about pest management, and it was initially conceived for measuring support towards the control of vertebrate pests, a widely popular IAS in New Zealand [20]. However, the scale covers many key issues related to the management of biological invasions and its application could become a valuable tool to measure attitudes about IAS and their control across experts in biological invasions worldwide.

In this study we provided the first application of the PMA scale in a European country. We administered the scale to a sample of experts (n = 322) working on IAS in Italy and tested its reliability and validity, altogether with its measurement invariance between different groups of respondents (researchers versus practitioners, and respondents that had worked on a single group of IAS versus those that had worked with multiple taxonomic groups). Then we also tested if the age of respondents, a potential antecedent of attitudes towards IAS, which are a relatively new topic in conservation biology [21], was associated with attitude scores.

Materials and methods

We identified a sample of experts working on IAS in Italy as it follows. In Italy, attention towards biological invasions, as well management initiatives and research, increased steadily over the last few years, with the approval of the first national legislative decree about IAS in 2017 (Legislative Decree no. 230/2017). Experts were identified by *i)* by checking available studies carried out on IAS, since the early 2000s, *ii)* by controlling people involved in major conservation projects about IAS that were carried out in Italy (e.g., LIFE ASAP LIFE15 GIE/IT/001039; e.g., LIFE STOPVESPA, LIFE14/NAT/IT/001128; e.g., Interreg Maritime ALIEM https://interreg-maritime.eu/web/aliem), *iii)* from personal knowledge of authors of the study and iv) by asking other researchers to nominate some colleagues. This led to a final list of 580 experts that included both people within the research community (which were classified as "researchers"), as well as people working in private companies for environmental consulting and pest control, or in environmental agencies (classified as "practitioners").

Then, 525 experts were invited, between November and December 2020, to complete an online questionnaire on GoogleForms (see Appendix 1 in the Supplementary Information). The questionnaire was confidential and asked them 7 questions from the PMA scale that had been selected as they were
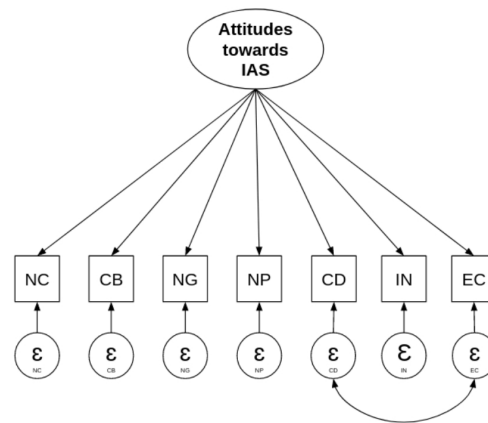
Figure 1: Overview of the latent variable model. Acronyms are explained in Table 1. Observed variables CD and EC are assumed to be correlated. A complete overview of model selection is given in Appendix 2.

deemed to be suitable for measuring attitudes about IAS management in Italy (Table 1). Answers were based on 7-points bipolar scales, asking respondents to indicate the extent to which they agreed with a series of statements, from "totally disagree" to "totally agree".

To better identify the professional background of respondents, the questionnaire also asked participants to indicate whether they had worked on invasive alien mammals, birds, amphibians, reptiles, freshwater fish, freshwater invertebrates, terrestrial invertebrates, plants or marine organisms through a series of dichotomous questions. Finally, the questionnaires also asked respondents if they had participated in some specific conservation project for IAS. Questionnaires took about 5-7 minutes to complete. We also collected age of each respondent based on publicly available information, or private knowledge.

We used the Cronbach's alpha to measure the reliability of the PMA scale, and confirmatory factor analysis to assess its validity. We tested if a solution with a single latent variable showed a good fit to the data, expressing overall attitudes towards IAS, as suggested by Aley et al. (2020)[17], through modification indexes and chi-square testing of nested models [22]. Due to the non-normal distribution of item scores, we used a robust Satorra-Bentler estimator. Moreover, we also tested measurement invariance (configural, weak and strong invariance) to see whether the scale had the same structure between different groups of experts, and could be used to really compare attitudes between groups.

We compared PMA scores of researchers versus practitioners, as these two groups sometimes have different backgrounds and personal experiences that, sometimes, could lead them to diverge in their attitudes towards wildlife. We also compared respondents that had worked on a single taxonomic group of IAS, versus respondents that had worked on different taxonomic groups. This distinction was made because respondents working on a single group of IAS could have worked on the topic for a short period of time and therefore have evolved different attitudes, from people with prolonged professional experience of biological invasions. Due to the low number of responses (see the Results), it was not possible to compare experts that had worked on different taxonomic groups (e.g. terrestrial vertebrates versus plants).

Finally, we also tested, through structural equation models, if the age of respondents affected their PMA score. As conservation topics have a somewhat transient importance [23][24], and IAS are a relatively new topic for Italian conservationists, we hypothesized that younger respondents could have had higher PMA scores than older ones.

Results

We collected answers from 316 respondents (60% response rate). Most respondents worked on invasive alien plants (52.7%), mammals (44.1%), terrestrial (38.8%) and freshwater invertebrates (34.8%), freshwater fish (32.3%), marine organisms (26.7%), birds (22.7%), reptiles (20.1%) and amphibians (15.8%). 73.4% respondents were researchers, while 26.6% of them worked as conservation practitioners in private companies or environmental agencies. Respondents had an age of 44.04 ± 12.97 years (mean ± s.d.).

The PMA scale showed good reliability (Cronbach's alpha = 0.7). Confirmatory factor analysis also showed a good fit to the data, already when a basic model without groups was specified (CFI = 0.99, TLI = 0.99, SRMR = 0.03, RMSE = 0.02). Moreover, the PMA scale showed strong measurement

invariance, both when comparing researchers to conservation practitioners, and when comparing respondents that had worked on different taxa with respondents that had focused on one single taxonomic group. A model without constraints on its parameters performed just as good as a model with constrained loadings between groups (weak invariance) and a model with constrained loadings and intercepts (strong invariance), both when we compared the difference in the T-statistics of nested models and when we compared alternative fitness indexes (Fig. 1, See the Supplementary Information, Appendix 2).

When we compared PMA scores between groups, we did not notice differences between the attitudinal score of practitioners and that of researchers, nor between the score of experts that had worked on a single taxonomic group and those working on different taxonomic groups of IAS (Fig. 2). This lack of difference was confirmed by the fact that multi-group CFA models were not significantly different from a basic CFA without groups, both in their t-statistics and their fitness indexes. Moreover, factor loadings of the various items were quite similar between groups (Fig. 3). Overall, beliefs about the importance of IAS control in conservation, and the importance of IAS control as an action capable to benefit future generations, were the items most strongly associated with PMA scores. Conversely, beliefs about the possibility of collateral damages from IAS control were the least predictive item (Fig. 3).

Finally, age did not seem to affect attitude scores. A model where age predicted PMA scores was not better than the basic CFA model, and the slope of age in the SEM model had a small effect size (Appendix 2).
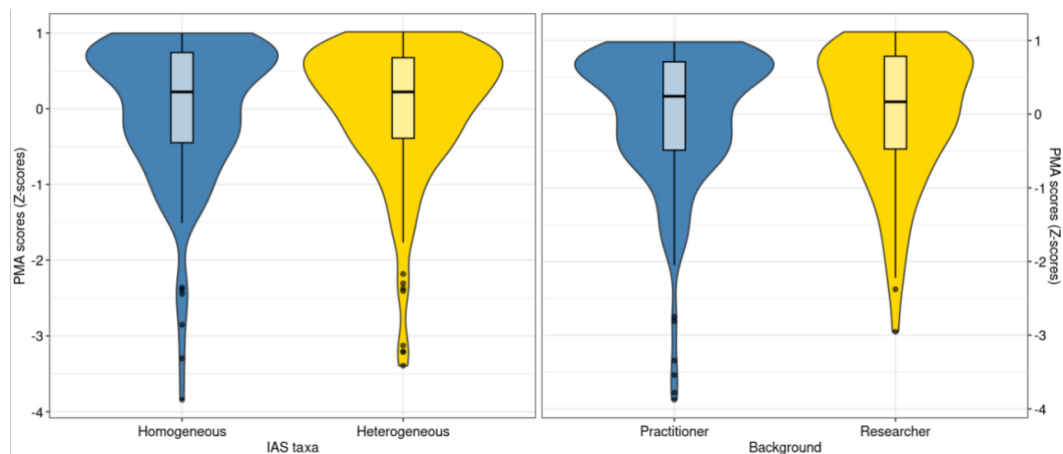

Figure 2: Comparison of latent scores of the PMA scale. Left: between respondents working on a single taxonomic group of IAS ("Homogeneous") or on multiple taxonomic groups ("Heterogeneous"). Right: between respondents with a different background, namely conservation practitioners ("Practitioner") and researchers ("Researcher").

Discussion

Our study was the first one testing for the applicability of a general attitudinal scale, the PMA scale, to quantify attitudes towards IAS in a geographical context which is very different from the one where such scale was originally proposed [17].

The PMA scale was originally designed to measure attitudes towards invasive alien pests in New Zealand, a country where the control of invasive alien vertebrates is well-integrated into the political agenda [20]. We showed that the PMA scale could also be used to measure attitudes towards IAS from experts in biological invasion research living in a European country, where the history of biological invasion management is much more recent, a finding that we deem both encouraging and important.

Our results indicated that the PMA scale was both valid and reliable for our respondents. Even if our sample included experts in biological invasions, attitudes are often context-dependent and embedded into a certain culture and geographic context [11][25]. Therefore, experts in IAS control working in Europe could well have had partially different beliefs from people in New Zealand: our results indicate that this does not seem to be the case. The various items of the PMA scale were well-associated to overall attitude scores, a finding that was somehow surprising, considering that experts worked on very different groups of IAS, each one characterized its own impacts, invasion history and control methods.
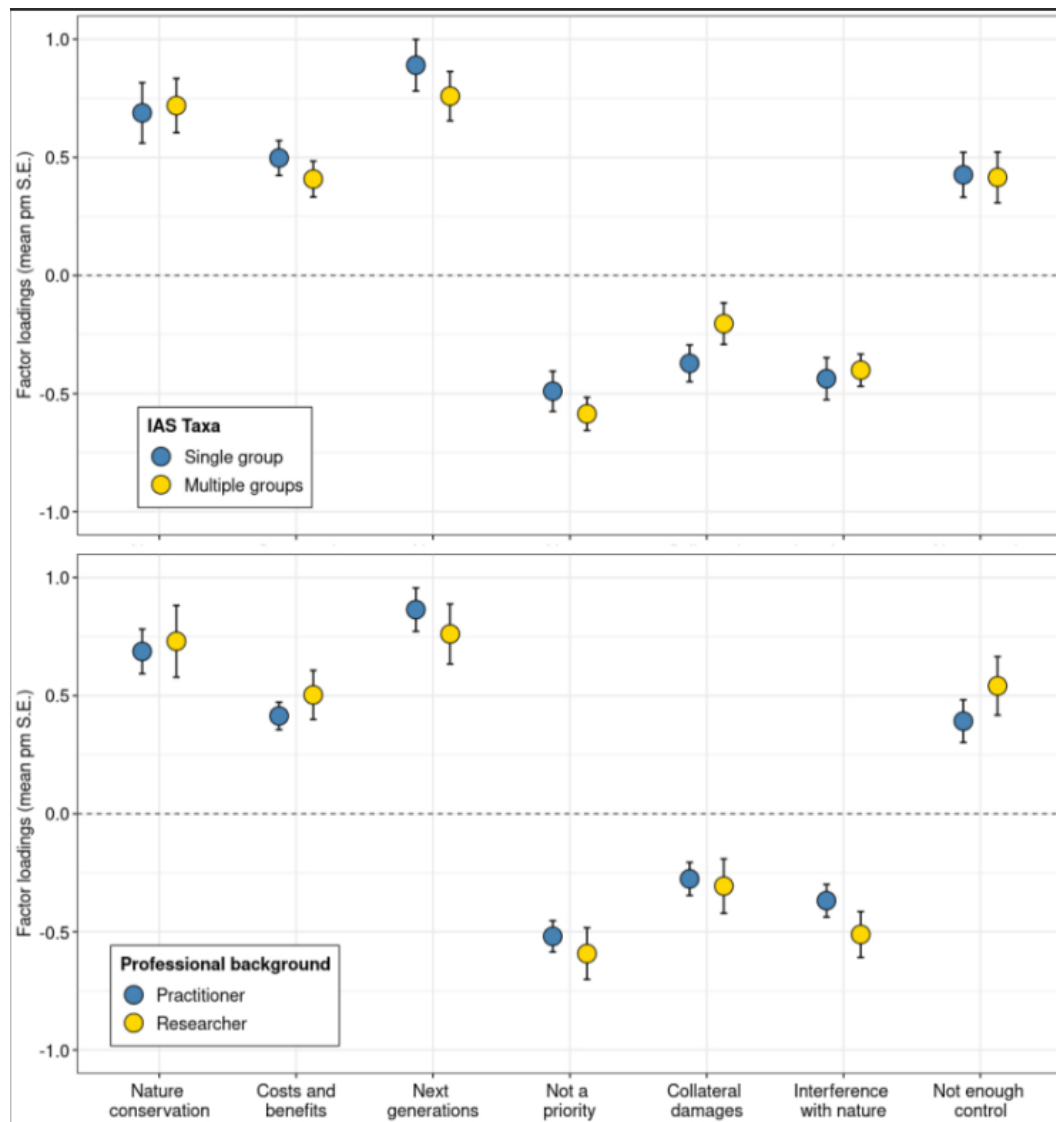
Figure 3: Comparison of factor loadings. Upper panel: between respondents working on a single taxonomic group of IAS ("Single group") or on multiple taxonomic groups ("Multiple groups"). Lower panel: between respondents with a different background, namely conservation practitioners ("Practitioner") and researchers ("Researcher").

Table1. Overview of the main item of the PMA scale. Original items are from Aley *et al.* (2020), but the term "invasive alien species" is used instead of "pest". Translations in Italian language are in square brackets. The code of each item is used in Fig. 1 and Fig. 3.

Code	Item
Nature conservation (NC)	Invasive alien species are a significant conservation problem. ("*Le specie aliene invasive sono una minaccia rilevante per la conservazione della natura*")
Costs and benefits (CB)	The benefit of invasive alien species control outweigh the risks to native species ("*I benefici derivanti dal controllo delle specie aliene invasive superano i danni che questo può comportare per le specie autoctone*")
Next generations (NG)	Investment in invasive alien species control is beneficial for future generations ("*Un investimento serio nel controllo delle specie aliene invasive andrebbe a vantaggio delle prossime generazioni*")
Not a priority (NP))	Invasive alien species control is less important than other conservation issues ("*Il controllo delle specie aliene invasive è meno urgente di altri problemi legati alla conservazione della natura*")
Collateral damages (CD)	Invasive alien species control has unknown side effects ("*Il controllo delle specie aliene invasive può avere effetti collaterali imprevedibili*"))
Interference with nature (IN)	Invasive alien species control interferes with nature ("*Il controllo delle specie aliene invasive interferisce con la natura*")
Enough control (EC)	Not enough invasive alien species control is being done already ("*Fino ad oggi, non è stato fatto abbastanza per controllare le specie aliene invasive*")

There were also no strong differences between respondents with different professional backgrounds, or different experience in biological invasion research: the scale worked equally well for conservation professionals and researchers, as well as for experts that had worked on one or more IAS. This second point was even more non-trivial, because attitudes are partially embedded into personal experience, and differences in wildlife-related attitudes are a well-known cause of attrition between policymakers, professionals and researchers, in areas such as wildlife management [11].

The use of a broadly applicable attitudinal scale, to measure beliefs about IAS and their control, paves the way for large-scale, and long-term, research about conservation experts working on biological invasions. For example, the PMA scale could detect differences between conservationists working in different countries, or being characterized by different cultural backgrounds, similarly to other well-known scales (e.g., the wildlife value orientation scale)[15]. Studies of this kind can be extremely important to facilitate transboundary collaborations in IAS management, often a challenging issue [26]. At the same time, it would be possible to test if constructs, such as social norms [27] or value orientations, affect attitudes towards IAS differently across cultures and countries, or to detect country-specific differences between stakeholders. Large-scale maps of attitudes towards IAS and their control can also be produced, similar to what has been done in North America for wildlife value orientations [7], with the goal of identifying areas where attitudes and awareness of conservation stakeholders can be improved through tailored communication campaigns.

Moreover, a widely applicable attitudinal scale could also be used to measure how the perceived importance that conservation scientists attach to biological invasions can change through time. Topics in conservation biology are not static in time, but they also change with existing beliefs and paradigms [28]. Although over the last few decades researchers became increasingly aware of IAS and their impacts [21], as biotic communities become more homogenized it might happen that they would perceive IAS as part of invaded ecosystems (the "shifting baseline syndrome")[29], with potentially important repercussions on their management.

Of course, our study was limited to experts working on bioinvasion research. Future studies could either administer the PMA scale to other relevant conservation stakeholders (e.g., environmental agencies staff, policymakers) or to the resident population of Europe. Probably, at least in some European countries, public awareness of biological invasions might be significantly lower than in New Zealand, where public policies for bioinvasions date back to various decades ago. Nevertheless, comparing different European countries could be useful to design strategies for the large -scale outreach of biological invasions.

Conclusions

We found that the PMA scale, originally proposed to measure attitudes towards invasive pests in New Zealand, could also be used to measure attitudes towards IAS in a European country, at least among experts and practitioners working on biological invasions. This finding paves the way for large-scale, or long-term, quantification of attitudes towards invasive alien species and their management in Europe. Moreover, this study further encourages the application of the PMA scale in other countries, in an attempt to understand if it could be a broadly applicable tool for cross-cultural studies in the conservation social sciences.

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Conflict of Interest

The authors declared no conflict of interest.

Authors' contribution

JC, AS and EM conceived the ideas and designed methodology; AS, EM and JC collected the data; JC and ES analysed the data; JC and ES led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

Data availability statement

Supplementary information, including Appendix1, Appendix2 and reproducible data and software code is available at: https://osf.io/yj8tp/.

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