A nation-wide analysis of Wikipedia and Google Searches in Italy reveals a growing interest towards biological invasions

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Abstract

Biological invasions are a major driver of global change and the target of many public policies. However, we still do not know whether they attract the interest of laypeople and motivate them to know more about this topic. We modeled the temporal evolution of on-line searches about general terms regarding invasive alien species in Italy, on Wikipedia and Google.

Wikipedia pages about biological invasions steadily increase their number of views and the GoogleTrends index for queries about invasive species also increased or remained stable, albeit a growing number of searches, between 2010 and 2019. The number of months without searches decreased through time, for both Google and Wikipedia searches. Also, the number of Google searches increased after the first EU regulation 1143/2014 invasive alien species entered in force. All the Wikipedia pages increased their number of views, by a magnitude suggesting that also laypeople contributed to this dynamic.

A portion of the Italian society seems to have become interested about biological invasions, at least since 2010, regularly documenting about them on the Internet. This paves the way for increasing public awareness about this phenomenon, as well as citizen engagement in monitoring and management initiatives. The increase in Google searches after the EU Regulation on invasive alien species could indicate that general interest towards biological invasions is influenced also by large-scale public policies.

Introduction

Biological invasions can rapidly reshape ecosystems, often with negative consequences for biodiversity and human well-being [1], and over the last few decades they became the target of many public policies [2] [3], which advanced our capacity to counteract them [4].

However, a very important question concerning biological invasions remains largely unaddressed: we are still uncertain whether society is becoming interested towards them. This information would be extremely precious, because making people aware of a certain problem is fundamental to change their beliefs and attitudes, and to foster long-term behavioral change [5], and because biological invasions, like other environmental issues, do not last in the political agenda if they are unappealing to citizens [6]. To the best of our knowledge, no longitudinal survey has ever been designed to measure temporal changes in public interest towards biological invasions and only two studies were carried out, based on a repeated cross-sectional design [7][8].

Over the last few years, various studies suggested that analyzing Internet search volumes might be effective for monitoring public attention [9]. Nowadays people actively search for information on Google or Wikipedia, and the analysis of on-line search volumes was adopted to monitor temporal changes in the salience of conservation-related topics [10]. In this study, by combining time-series analysis of searches on Wikipedia and Google, we aim to show that it is possible to draw meaningful conclusions about changes in public interest towards Invasive Alien Species (hereinafter IAS). Notably, we will show that GoogleTrends, when combined with transparent information from Wikipedia can shed some light on how society has changed its interest towards biological invasions. Considered the progressive implementation of policies and communication campaigns about IAS in Italy, altogether with the growing number of biological invasions [11], we argue that a portion of the Italian society had become interested towards IAS, searching for terms related to IAS on Google and Wikipedia. We therefore formulated our hypotheses: H_1: a growing portion of Internet users searched for IAS-related terms on Google, between 2010 and 2019; H_2: a growing number of Internet users visited IAS-related pages on Wikipedia, between 2010 and 2019.

Methods

In this study, we restricted the analysis of on-line searches on Google and Wikipedia to Italy. With more than 3000 IAS that established populations on its territory, Italy hosts more than 20% of European IAS (https://easin.jrc.ec.europa.eu/easin) and at least 30 different projects were implemented over the last two decades to counteract biological invasions, including the LIFE project "ASAP" (https://www.lifeasap.eu/index.php/it/), which aimed to increase the awareness and the active participation of citizens. In 2014 the European Union produced its first Regulation about biological invasions (EU Regulation n. 1143/2014) on the prevention and management of IAS, which entered into force in January 2015 [12], followed by a list of IAS of European concern [13]. Transposing the EU Regulation, Italy adopted a national legislative decree (Dlgs n. 230/2017), which identifies management actors, with various competences in terms of biosecurity, management of IAS and the estimation of their impacts.

We analyzed online searches about invasive species in Italy, between January 2010 and September 2019, comparing monthly values of the GoogleTrends index and monthly visits to Wikipedia pages. The Italian language is not spoken outside of Italy and therefore almost all the searches on the Italian version of Google and Wikipedia came from Italian citizens, reflecting changes at the national level. The GoogleTrends index is obtained by: (*i*) dividing the monthly number of searches for a certain keyword for the total volume of Google searches in the same

timespan, then by (*ii*) dividing again this value for the maximum value of the time series and (*iii*) multiplying by 100. Considered that access to the Internet steadily increased over the last 10 years in Italy [14], so did the overall volume of Google searches, the denominator of the index. A stable or increasing GoogleTrends index, between 2019 and 2020, therefore indicates that a certain keyword was searched by an increasing number of people.

In this study we queried terms about IAS, deeming them to be a more accessible and tangible concept for the general public than biological invasions [15]. We queried for 10 common terms describing IAS or biological invasions: "specie aliena", "specie aliene" (literally, "alien species", singular and plural), "specie invasiva", "specie invasive" ("invasive species", singular and plural), "specie alloctona", "specie alloctone" ("allochthonous species", singular and plural), "specie esotica", "specie esotiche" ("exotic species", singular and plural) and "invasioni biologiche" ("biological invasions", singular and plural). Among these terms, we were able to extract the Google trends index for four of them: "Alien species" (singular), "Alien species" (plural), "Invasive species" (singular), "Allochthonous species" (singular). We also extracted the monthly number of visits to the three Wikipedia pages about IAS: "specie aliena" or "specie alloctona" ("alien" and "allochthonous species", same page, created in December 2005), "specie invasive in Italia" (invasive species in Italy, created in May 2013), "specie invasive in Europa" (invasive species in Europe, created in March 2013).

Then we: (*i*) modeled the long-term trend of the GoogleTrends index, and of the monthly number of visits to Wikipedia, through a multiplicative moving average, (*ii*) modeled how the probability of having months without searches on Google changed through time, through a logistic regression

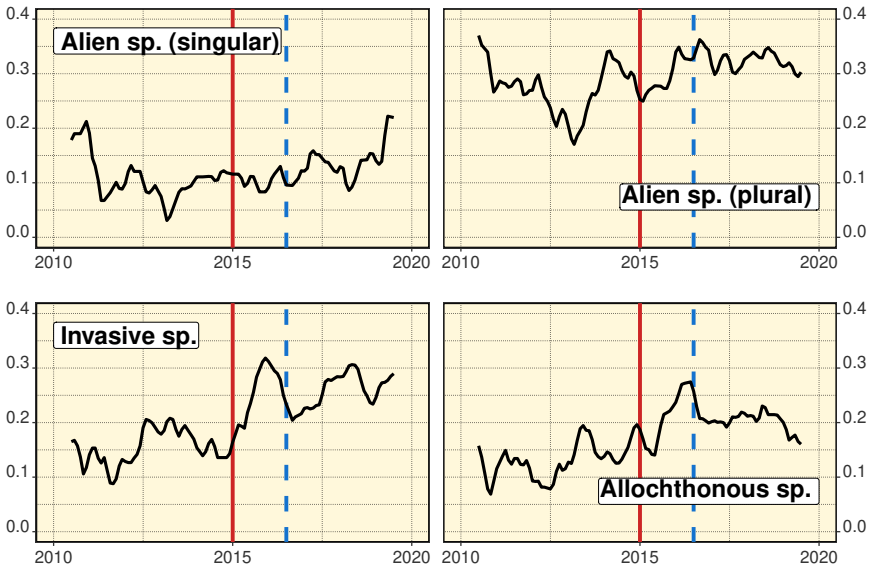

Figure 1 | Long-term trend of the GoogleTrends index: solid vertical lines refer to January 2015, when the EU regulation (n.1143/2014) entered into force, while dashed lines represent the publication of the first list of IAS of EU concern, in August 2016. GoogleTrends values were rescaled between 0 and 1.

Results

Our decomposition based on a multiplicative moving average, showed that the GoogleTrends index for "Invasive species" has clearly increased through time, and that the metric for "Allochthonous species" has slightly increased as well (Figure 1). Furthermore, while the probability

of having months without searches declined through time for all the four searches about IAS, the temporal decline was stronger and clearer for "Invasive species", which basically had no months without searches after 2017 (Figure 2).

Our data about visits to Wikipedia pages about IAS steadily increased through time (Fig. 3). Indeed, we found that daily counts of visits had a substantial increase between December 2015 and January 2016 ("Allochthonous species" = + 441%, "Invasive species in Europe" = + 231% and "Invasive species in Italy" = + 346%), as Wikipedia started counting data from mobile devices in 2016 (https://dumps.wikimedia.org/other/pagecounts-raw/). However, our moving average decomposition, which was based on local trends, showed that Wikipedia visits also kept increasing even after a few months from January 2016 and that increase was a long-term process.

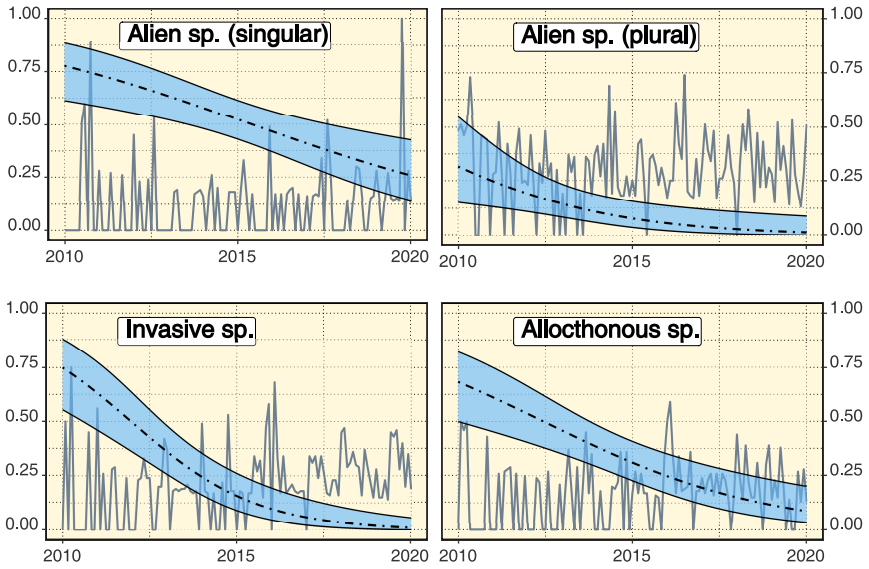

Figure 2 | Monthly GoogleTrends index for the various keywords (gray line) and predicted probabilities indicating the temporal evolution of months without searches on Google (dashed line with 95% confidence intervals, in blue).GoogleTrends values were rescaled between 0 and 1, and they match predicted probabilities for the logistic regression of months without zero searches on Google.

Discussion and conclusion

Our analyses of on-line searches on Google and Wikipedia indicates that, over the last ten years, a growing portion of the Italian society became interested in biological invasions and IAS, searching for them on the Internet after having heard about them. We believe this conclusion to be supported by three different points, which would confirm both H_1 and H_2. First, the GoogleTrends metric for our four queries increased or remained stable through time. The only way for this to happen is to have an increase in the number of searches greater than the increase in the volume of Internet users, and their searches, who almost doubled between 2010 and 2019. This indicates that a growing number of people in Italy, between 2010 and 2019, searched for these terms on Google, counteracting the deflation that the GoogleTrends index would have naturally experimented. Second, months without searches about IAS on Google decreased through time and almost disappeared after 2017. Finally, in late 2019, overall visits to the three Wikipedia pages were above 2500 per month: this number seems to be too high, for having been generated by experts alone, indicating that on-line searches probably involved laypeople as well.

Considered also that an independent survey in Italy, found that 67% of respondents correctly identified the definition of IAS, over a set of different definitions [16], our findings might indicate that biological invasions are becoming more familiar to Italian society, at least to a minimum extent: this can be an important precondition for the creation of stable attitudes towards them, and eventually their management. Of course, this does not imply that management will become easier: people will probably still conflict because of their value orientations or their identity [17], and having more stable attitudes might actually exacerbate conflicts [18]. However, a greater interest towards IAS paves the way for citizen engagement [19][20]. Given the importance of these changes for the long-term management of biological invasions, we absolutely encourage the replication of our approach to larger geographical scales and different countries, to see if similar patterns in online searches emerge at the global level.

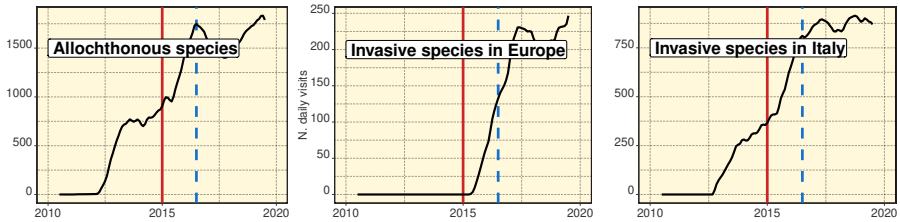

Figure 3 | Long-term trend of monthly visits to the Wikipedia pages. Solid vertical lines refer to January 2015, when the EU regulation (n.1143/2014) entered into force, while dashed lines represent the publication of the first list of IAS of EU concern, in August 2016.

Our findings also highlight that major policy initiatives can affect public interest towards biological invasions, as shown by the effect of the entry into force of the first EU Regulation on IAS over the GoogleTrends index for three of our four queries. However, it was also interesting that there was no clear increase associated with the publication of the first Union list. This was partially surprising, because lists of IAS can be perceived as a user-friendly tool to promote the concept of biological invasions through accessible examples, and because the Union list received media resonance. Differences in media coverage, and in the timing of the two initiatives, could probably explain these differences and we encourage future studies exploring the importance of media coverage and exposure over on-line information search about IAS, as media were already found to trigger on-line information search for other topics [21].

Acknowledgements

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