Combining surveys and on-line searching volumes to analyze public awareness about invasive alien species: a case study with the invasive Asian yellow-legged hornet (*Vespa velutina*) in Italy

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Abstract

The Asian yellow-legged hornet (*Vespa velutina*) has been invading Italy since 2013, and it was subjected to management projects aimed at counteracting its spread and raising awareness about its impacts.

In autumn 2019, we administered an on-line questionnaire to a convenience sample of 358 beekeepers in Italy. The questionnaire asked them about their sources of information about *V. velutina*, their perception of its potential impacts, and its severity compared to that of other threats to beekeeping. We also explored Internet searching volumes on Google and Wikipedia about *V. velutina*, to identify seasonal and long-term trends in public awareness.

Workshops, journals or bulletins, the Internet and word-of-mouth with colleagues were the main sources of information about *V. velutina*. Beekeepers believed *V. velutina* to affect beekeeping by predating upon honey bees (*Apis mellifera*), paralyzing foraging, reducing honey availability and depleting the winter cluster. Moreover, *V. velutina* was ranked, especially among beekeepers from the invaded range of the species, as one of the most serious threats to honey bees conservation, similarly to other threats like pesticides and the varroa mite (*Varroa destructor*). Internet searches peaked during the activity period of the species and increased over time, with thousands of visits to Wikipedia each month.

This study constitutes a first quantification of the perceived awareness of beekeepers and the general public, about the problem represented by *V. velutina* in Italy, and it also indicates which

media should be targeted by information campaigns. Our findings indicate that beekeepers seem to be aware about the potential impacts of *V. velutina* in Italy, both within and outside of its invaded area, considering it a major threat to beekeeping. Moreover, information campaigns on the Internet and specialized magazines might be useful to communicate about the impacts of the species, and the need to develop diffused surveillance networks.

1 Introduction

Biological invasions are a major driver of change at the global scale, determining environmental and socio-economic impacts, whose frequency and magnitude are increasing in synergy with global trade and climate change [1][2]. Therefore, many countries developed public policies aimed at preventing, counteracting, or mitigating biological invasions [3], including both dedicated legal frameworks, and also the financial support for specific conservation projects targeting invasive alien species (e.g. the LIFE programme in the European Union [4]).

Most conservation projects include specific outreach activities to raise the awareness of specific stakeholders, or the general public, about biological invasions and invasive alien species [5]. Awareness raising is a prerequisite for attitudinal and behavioral change, which could in turn foster compliance with regulations about biological invasions or the long-term endorsement of dedicated policies [6]. Surveys based on questionnaires are a common approach to measure awareness about biological invasions, and before-and-after designs [7] as well as repeated cross-sectional designs [8] are commonly adopted to test for temporal changes in public awareness. However, while these studies might be effective for specific stakeholders, or over small spatial scales, they might fail to consider broader changes in public awareness that occurred at larger spatial and temporal levels of detail. For example, while a before-and-after survey could measure changes in public awareness following a project about a certain invasive alien species, the same species might be targeted by multiple projects over a timespan of several years. Designing a specific survey for this scope might be unfeasible and expensive.

On the other hand, at a time where Internet is becoming a main source of information in developed and developing countries, many studies showed that a growing number of people search on the Internet for those topics they are curious about. Therefore, the analysis of on-line searching volumes, on search engines and Wikipedia, could become a valuable tool to measure public interest towards political [9][10] as well as environmental issues [11][12], including biological invasions [13]. In this study we aim to show that it is possible to combine questionnaire-based surveys with the analysis of Internet searching volumes, to draw conclusions about the awareness of stakeholders and the general public about invasive alien species, by considering the case of the invasive Asian yellow-legged hornet (*Vespa velutina*) in Italy.

V. velutina has become invasive in Europe, where it was introduced for the first time in 2004, in France, and where it is increasing its distribution across Central and Mediterranean countries, as well as in the UK [13][14]. From 2013 onwards, several nests of the species have been reported in Italy, where it colonized the Westernmost portion of the Liguria region, close to the French border, from which it then expanded to some areas of the Piedmont and Tuscany regions [15][16].

Apart from its impact on native insects and wild pollinators, because of its intensive predation upon the western honey bee (*Apis mellifera*), its reproductive potential and the lack of specialized predators, *V. velutina* can have serious impacts over beekeeping in Europe [17]. The predation of honey bees could undermine honey production, as well as reducing the availability of individuals for the winter cluster, with consequences for the overwinter survival of the colonies [18]. The predator activity of *V. velutina* also limits the foraging activity of honey bees by promoting homing failure and determining a “foraging paralysis”, where honey bees do not leave the colony fearing its predation [19], which could further reduce honey production. *V. velutina* could

also damage fruit production, as adult individuals need sweet carbohydrates to sustain their metabolism. Finally, *V. velutina*, by building nests mainly on man-made structures or on trees in or near urban area, can also be problematic due to the risk of stings to people [20] that in some cases could lead to fatal events [21]. The management of invasive *V. velutina* is becoming a relevant issue for some European countries, with France documenting an expenditure of about 23 million € for nest removal in the 2006-2015 period [22], and Spanish beekeepers from la Coruña province reported an expenditure of about 67,000.00 € in 2016 only [23]. The hypothetical cost for managing the species, in case it will colonize all the climatic suitable area in France, Italy and the UK, is estimated to reach about 29.5 million € per year [22].

Due to its potential impacts over beekeeping, and their associated costs, the invasion of *V. velutina* was targeted by various conservation projects in Italy. These included the LIFE STOPVESPA (**https://www.vespavelutina.eu**) and the LIFE ASAP (**https://www.lifeasap.eu**) projects, the Aliem Interreg Med project (**http://interreg-maritime.eu**), all of three co-founded by the European Union, and the projects VELUTINA and STOPVELUTINA (**https://www.stopvelutina.it/il-progetto/**). While, all these initiatives differed in their spatial scale, as well as in their specific goals, all of them included many outreaching initiatives about the species, such as press campaigns, meetings with stakeholders and workshops at beekeeping events. The main scope of these activities was to raise the awareness of both beekeepers and laypeople about the invasive alien *V. velutina* in Italy, but to date no scientific studies were published for quantifying whether this was achieved apart a specific report from only one of these projects [24].

This research aims to fill this gap, by implementing two different approaches. First, we administered a questionnaire to a sample of beekeepers in Italy, to ask them about their perception of *V. velutina* and its impacts, as well as about their main sources of information about the species. Then, we conducted a time-series analysis to identify long-term trends in on-line searches on Google and Wikipedia about the species in Italy, to capture temporal trends in public awareness about the species.

2 Methods

2.1 Questionnaire design and administration

In August 2019, we designed a questionnaire on GoogleForms, to measure beekeepers' perception of *V. velutina* as a threat to beekeeping and the conservation of honey bees. The questionnaire was divided into 4 different sections for measuring: (*i*) the main sources of information about *V. velutina*, adopted by the beekeepers, (*ii*) the perceptions about the most significant impacts of *V. velutina* on beekeeping and human activities, (*iii*) the severity of *V. velutina* as a threat to beekeeping, compared to other major threats, and (*iv*) the characteristics of respondents and their beekeeping activity.

Information sources were measured by asking respondents to complete a check-box with some of the main types of traditional and digital media: the Internet, newspapers, television or radio, specialized magazines, beekeeping bulletins, social networks, mailing lists, word-of-mouth with other beekeepers, communication with agronomists or entomologists, beekeeping workshops and large beekeeping events (e.g. showrooms, conventions).

The main impacts of *V. velutina* included reduction in honey production caused by predation on honey bees and the inhibition of foraging, decrease in honey bees for the winter cluster, disease transmission to honey bees by foraging upon multiple colonies, damages to fruit orchards, increased risk of stings for the beekeepers. Moreover, we asked whether the impact of *V. velutina* was greater than that of the native European hornet (*Vespa crabro*). We asked for respondent's agreement with a series of statements about these impacts on a 5-points bipolar scale, ranging

from "*Totally disagree*" to "*Totally agree*". As respondents could not have been familiar with some of the impacts, questions also had an "*I have no idea / I do not know*" option.

Then we asked respondents about which were the main threats to beekeeping, in their opinion. These included honey bee predation by *V. velutina*, predation by native Hymenoptera, predation by birds, pesticide poisoning, infestation from the small hive beetle (*Aethina tumida*), infestation from the varroa mite (*Varroa destructor*), nosemosis or fungal, bacterial and viral diseases.

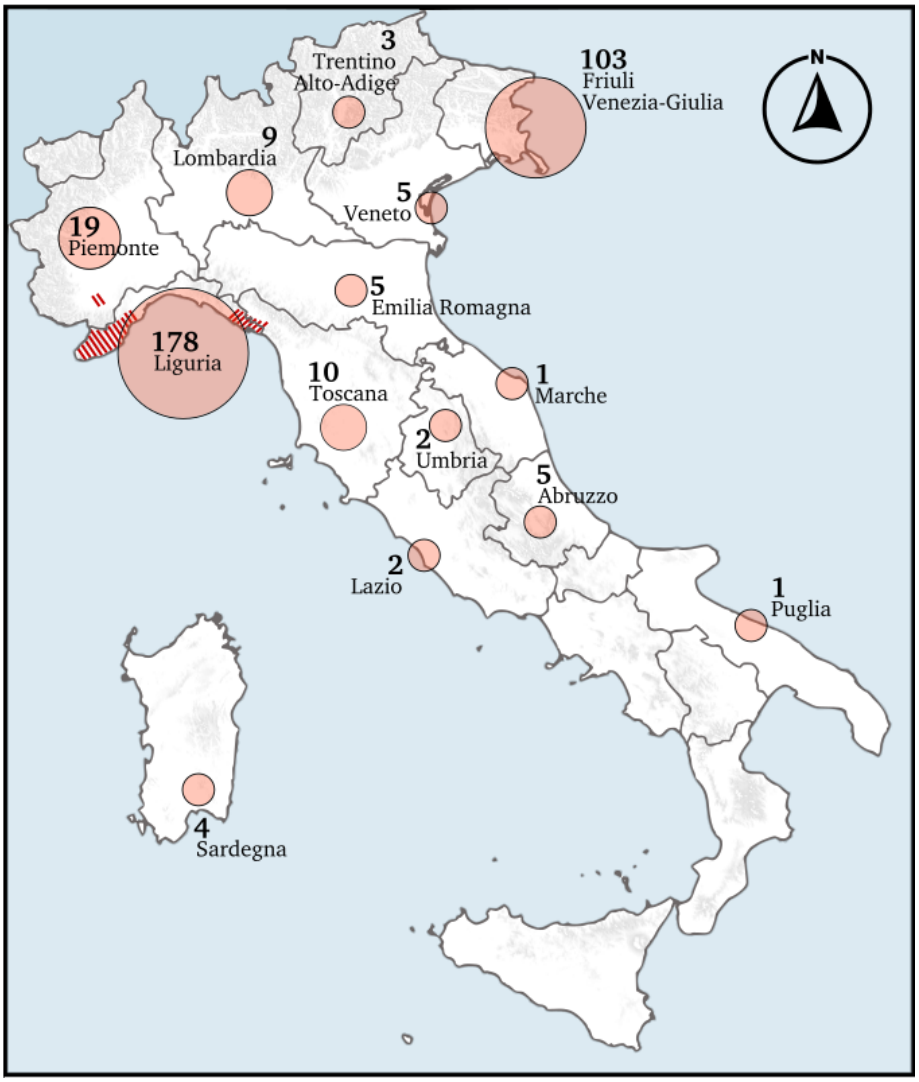

Figure 1 | Geographical distribution of respondents, between the various Italian regions. Dashed areas correspond to the invaded range of *V. velutina* in Italy, in the Piemonte, Liguria and Toscana regions. 11 respondents did not indicate their region.

Each of these threats was evaluated on a 5-points unipolar scale, ranging from "*Not serious*" to "*Extremely serious*". In the final section, we asked respondents whether they came from an area which had already been invaded by *V. velutina*, the decade when they started beekeeping, the size of their apiary, their sex, age and level of education, as well as the location (at the district level) where they practice beekeeping. Questionnaires were forwarded to a sample of beekeepers in Italy, both from invaded and non-invaded areas, through a snowballing approach.

Researchers who already operated in the management of *V. velutina* contacted referents from beekeeping organizations, asking them to forward the questionnaire to their contacts. This approach was chose since a representative sample was not achievable with other techniques, due to the absence of complete data about single beekeepers and the impossibility of designing a sampling strategy to recruit them on the field, because of their different habits and the spatial scale of the study. A complete copy of the questionnaire, in English and Italian language is available in the Supplementary Information (S2).

2.2 Analysis of GoogleTrends and Wikipedia data

To measure whether there was an increase in public awareness about *V. velutina* through time, in Italy, we explored the temporal evolution of the volume of searches on Google about the Italian name for the species: "*Calabrone asiatico*" (literally, Asian hornet, in Italian) and also the scientific name "*Vespa velutina*", which has become widely adopted. Moreover, we also explored the temporal evolution in the monthly number of visits to the Wikipedia page "*Vespa velutina*", since 2015. GoogleTrends is a relative index, obtained by dividing the total number of searches related to a certain query, for the total volume of searches on Google. The index is then rescaled between 0 and 100, by assigning the maximum value (100) to the point of the time series with the highest value of the index. Therefore, GoogleTrends is a relative metric, which is strongly discounted for the increasing number of searches on Google through time. On the other hand, the WikiMedia foundation allows users to access the number of visits, expressed as a raw count, to the various pages of Wikipedia, at least since July 2015. The combined use of GoogleTrends and Wikipedia visits therefore enabled us to both identify whether searches for the species had become more common through time, as well as to appreciate their order of magnitude.

2.3 Data analysis

To highlight differences in beliefs about the impacts of *V. velutina*, as well as in its perception as a threat to beekeeping, between respondents from the invaded and the non-invaded range of the species, we compared the distribution of answers by means of the Potential for Conflict Index (PCI) [25]. The PCI is a common measure of respondents' polarization in human dimensions studies adopted in surveys with bipolar or unipolar scales, ranging between 0 and 1. The minimum value of the PCI indicates the maximum agreement between respondents, when their answers lie entirely on the same point of the scale, while the PCI peaks when respondents are equally divided between the two opposite points of the scale. Moreover, we tried to segment respondents according to their sources of information about *V. velutina*, through a hierarchical cluster analysis. On-line searches on Google, based on the GoogleTrends index were converted on a logarithmic scale, then decomposed in their long-term trend and in their seasonal component, based on Bayesian structural time series with a Gaussian distribution of the error, a state-space model for time-series data [26]. Statistical analyses were carried out with the statistical software R [27].

3 Results

3.1 Structured questionnaire

Overall, we collected 358 surveys from our sample of beekeepers. Most respondents (59.7%) came from Liguria, Piedmont and Tuscany, regions that had already been invaded by *V. velutina*, while the remaining ones by uninvaded regions, almost entirely in Central and Northern Italy (Fig. 1). Most respondents were men (82.3%), with a higher education (86.0%) and an age between 36 and 65 years (18-25 years = 2.8%, 26-35 years = 13.4%, 36-45 years = 28.2%, 46-55 years = 27.4%, 56-65 years = 17.0%, over 65 years = 11.2%). The majority of respondents

started beekeeping after 2010 (62.0%) or in early 2000s (16.5%) and had a small apiary (5 colonies or less = 26.8%, 6-10 colonies = 27.7%, 11-25 colonies = 25.1%, 26-50 colonies = 8.9%, 51-100 colonies = 5.6%, more than 100 colonies = 5.9%).

Beekeepers documented about *V. velutina* with multiple sources of information, in particular beekeeping workshops (53.4%), specialized journals (51.4%), the Internet (49.2%), beekeeping bulletins (42.5%), word-of-mouth with other beekeepers (37.7%) and agronomists/entomologists (36.3%), beekeeping events (20.9%), social networks (19.3%), generalist newspapers (17.6%), television or radio shows (14.0%) and mailing lists (6.1%). Hierarchical cluster analysis did not identify any major cluster of respondents, but rather 10-11 small clusters whose differences were unclear. Most respondents believed *V. velutina* to have major impacts over honey bee colonies, mostly by reducing honey production through bee predation and foraging paralysis, as well as by decreasing the size of winter clusters. On the other hand, respondents were less certain about a potential role of *V. velutina* in disease transmission to honey bees, by foraging over multiple colonies. Moreover, respondents believed that *V. velutina* could increase the risk of stings to beekeepers and that its impacts were more severe than those of the native European hornet (*V. crabro*). Respondents from invaded areas (PCI = 0.09) were more certain than those from uninvaded areas (PCI = 0.20) about this point (Fig. 2).

V. velutina was considered an extremely serious threat to honey bees and beekeeping, and respondents from invaded areas assigned it a severity score comparable to that of pesticides or the varroa mite (*V. destructor*) (Fig. 3).

3.2 Anaysis of Internet search volumes

The GoogleTrends index for the queries "*Calabrone asiatico*" and "*Vespa velutina*" showed clear seasonal fluctuations, with a high number of searches between April and October, corresponding to the activity period of the species. Searches usually had two peaks per activity period. Moreover, the two queries had an increasing long-term trend in their number of searches on Google. Notably, while "*Vespa velutina*" increased its volume of searches mostly until summer 2015, and then stabilized, the query "*Calabrone asiatico*" increased steadily through time (Fig. 4).

The monthly number of visits to the Italian Wikipedia page for *V. velutina* was quite high and variable (median ± sd = 2,503 ± 3,042), but it showed a similar seasonal pattern, with visits increasing between April and October and being characterized by a double peak in this timespan (Fig. 5).

4 Discussion

To the best of our knowledge this study constitutes a first attempt to draw conclusions about the awareness of beekeepers and citizens towards *V. velutina* in its invaded range in Europe. While another study [28] explored the behavior of beekeepers in response to *V. velutina*, no study formally asked beekeepers about their beliefs over the potential impacts of *V. velutina*, nor about its potential magnitude, with respect to other threats that could affect honey bees and the beekeeping activity. Taken together, findings from the questionnaire for the beekeepers and the analysis of Internet searching volumes, seem to confirm that outreach actions from different conservation projects in Italy, were effective at raising the awareness of stakeholders and the general public about the invasion of *V. velutina* and its social and ecological impacts.

Beekeepers in Central and Northern Italy seem to have received considerable exposure about news concerning *V. velutina* and its potential environmental and socio-economic impacts, and

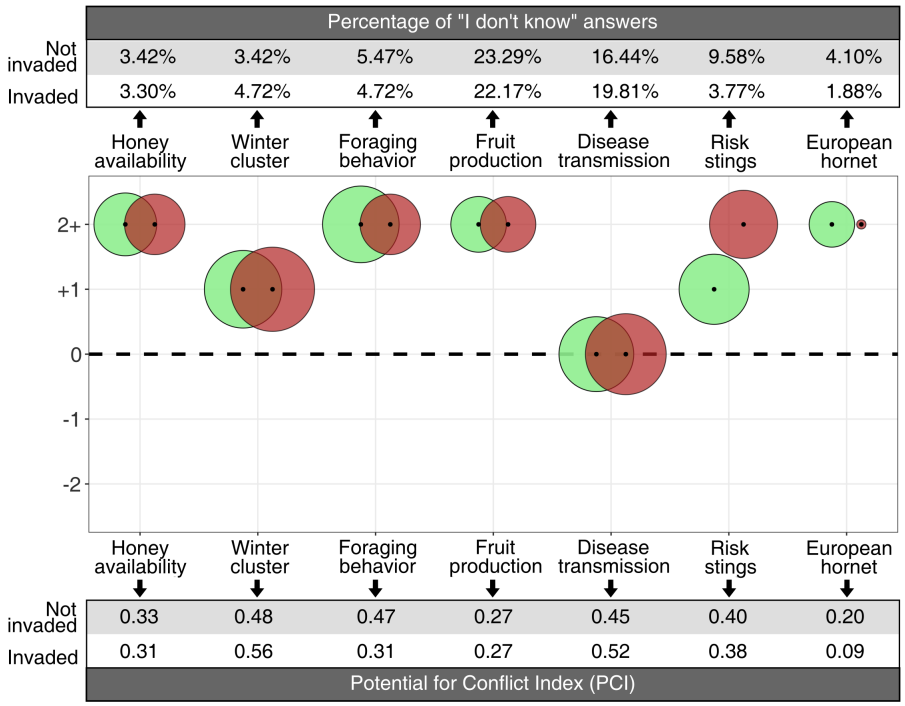

Figure 2 | Comparisons between perceived impacts of V. velutina between respondents from the invaded and the non-invaded range of the species. Answers were measured on 5-points of a bipolar scale (y-axis), ranging from "Strongly disagree" (-2) to "Strongly agree" (+2). Bubbles were centered on the median score of invaded and non-invaded areas, and their size was proportional to the Potential for Conflict Index, which ranged between 0 (no disagreement, all answers on the same point of the scale) and 1 (respondents were equally divided between the two opposite points of the scale). Bubbles on the left (in green) represented answers from respondents living in non-invaded areas, while bubbles on the right (in red) answers from respondents living in invaded areas. Bipolar scales also had an "I don't know option", for respondents who did not feel sure about their answer. The distribution of scores for each answer is available in the Supplementary Information (S1).

that such of an exposure in turn affected their concerns about the species. The vast majority of our sample believed that *V. velutina* could have detrimental impacts for the conservation of honey bees and beekeeping, in line with the available scientific evidence [17][19]. Respondents from invaded areas seemed to be even more concerned about this, and they believed *V. velutina* to have greater impacts than the native *V. crabro*, another species that could prey on honey bees. Moreover, these impacts were also considered to be relevant for beekeeping and the conservation of honey bees, as their severity was comparable to that of other major causes of honey bee decline, such as pesticides [29][30] or *Varroa destructor* [31], and even more severe than other stressors, like the predation from other native Hymenoptera, or viral, fungal and bacterial diseases. While our findings came from a convenience sample of beekeepers, which could be more in contact with beekeeping organizations and more aware than the "average" beekeeper, we believe our findings to be so strong that it is unlikely that the scenario from the overall beekeeping community is radically different. *V. velutina* seems to be considered a species with systematic, and not-negligible impacts, over honey bees and beekeeping.

Moreover, we found that beekeepers documented about *V. velutina* from a wide range of different channels, which encompassed both the Internet but also specialized magazines and activities with other members of their community, like other beekeepers and professionals holding workshops. On the other hand, conventional media and mailing list seems to be a minor source

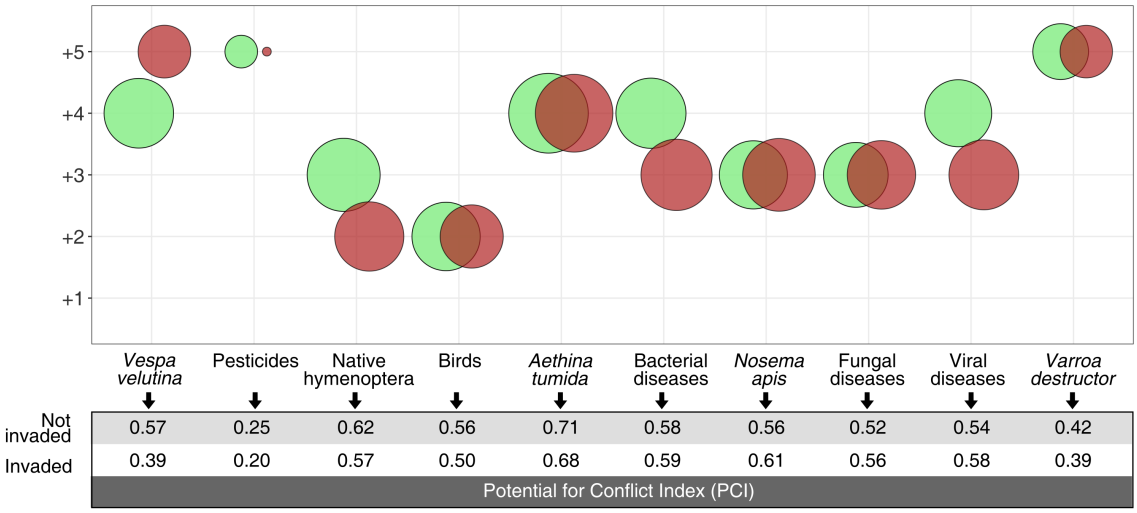

Figure 3 | Comparisons between the perceived severity of various threats for beekeeping. Answers were on a unipolar scale ranging from "Not at all serious" (+1) to "Extremely serious" (+5) (y-axis). Bubbles were centered on the median score of each answer, and their size was proportional to the Potential for Conflict Index, which ranged between 0 (no disagreement, all answers on the same point of the scale) and 1 (respondents were equally divided between the two opposite points of the scale). Bubbles on the left (in green) represented answers from respondents living in non-invaded areas, while bubbles on the right (in red) answers from respondents living in invaded areas. The distribution of scores for each answer is available in the Supplementary Information (S1).

of information about *V. velutina*. These findings might be useful for designing communication campaigns about *V. velutina* among beekeepers. The fact that beekeepers seem to be at least familiar with the species and its impacts indicate that they might have stable attitudes about this topic [6]. This is confirmed by their participation to ongoing management initiatives. Both LIFE STOPVESPA and STOPVELUTINA projects have seen the participation of many beekeepers in the monitoring of *V. velutina* distribution (see projects website). The awareness of the impact caused by *V. velutina* and the willingness to collaborate to its management is fundamental for the extension at the national scale of an Early Warning and Rapid Response system already developed in the invaded area by the University of Turin thanks to the collaboration of the beekeepers and their associations [32]. Considering the sources of information that are adopted the most by beekeepers, conservationists should further promote participation in management activities through peer-to-peer communication within the beekeeping community, as well as by papers on specialized magazines and advertising on Internet sites about beekeeping, decreasing their expenditures for communication campaigns on traditional media. The fact that Italy hosts approximately 40,000 amateur and 18,000 professional beekeepers, their engagement in rapid detection and early warning activities could be fundamental to monitor the species at the national scale.

The seasonality of Internet searches about *V. velutina* seems to indicate that on-line searching volumes reflect when common people observe the species in Italy [33]. Searches on Google increased during the activity season of the species, between April and October, with two peaks in May-June and August-September, corresponding to the first phase of nest construction and to the time of the year when colonies reach a considerable size, becoming a concern for people.

Moreover, the overall volume of Internet searches about *V. velutina*, and their long-term trend indicated a progressive awareness about its presence and consequences, as well as its progressive establishment into new areas. The number of visits to the Wikipedia page about the species was in the order of thousands of visits per month, with peaks of more than 10,000

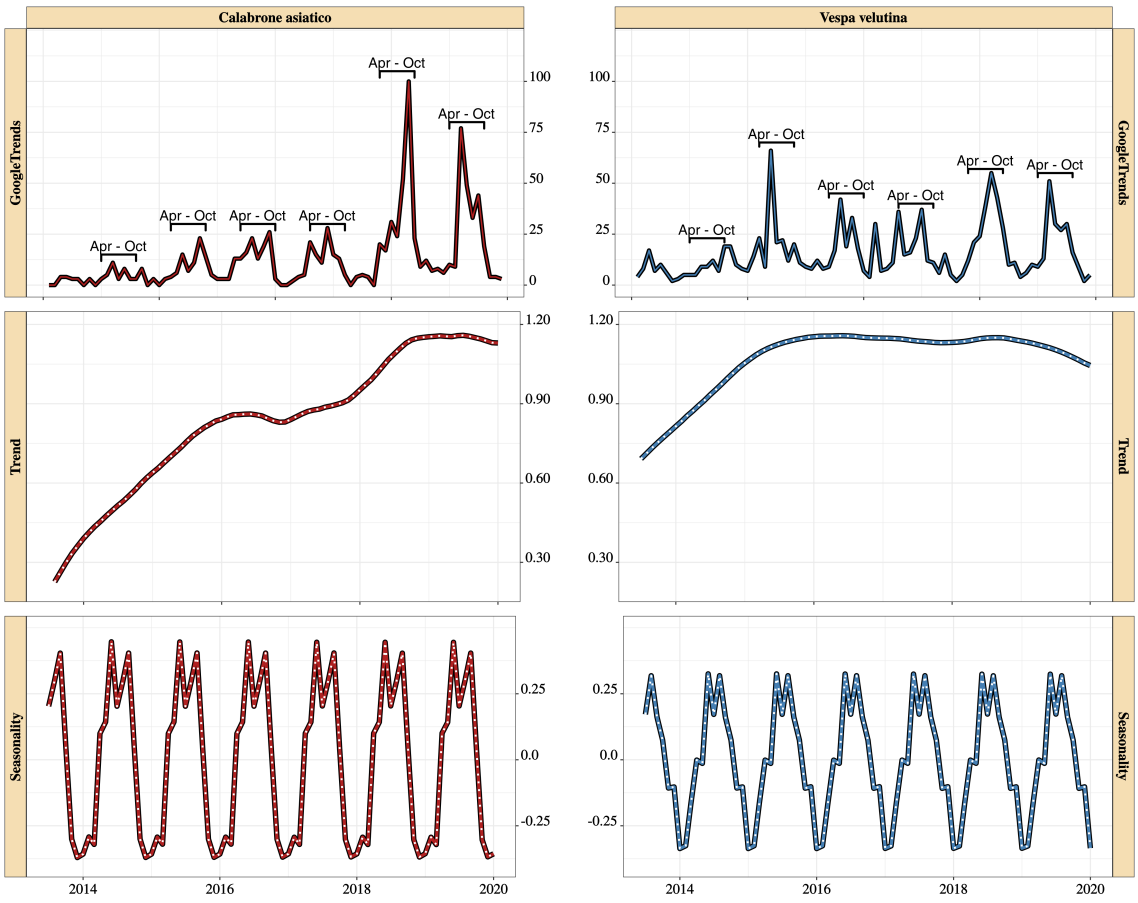

Figure 4 | Volume of searches on Google for the queries "Calabrone asiatico" and "Vespa velutina", the two Italian words mostly used for naming the species: GoogleTrends index (top), long-term trend (center) and seasonal component (low) of the log-converted GoogleTrends index.

visits. We believe that such of a high number of visits is unlikely to have been generated by stakeholders or researchers alone, and that it probably involved laypeople as well. This aspect was confirmed by the long term-trends of the GoogleTrends index for the two Italian words for the species, which increased between 2013 and 2020, reflecting the progressive spread of the species in Italy and the emergence of relevant impacts on beekeeping [15][24]. The GoogleTrends index is discounted for the overall number of searches on Google, which strongly increased between 2013 and 2020 [34]: the fact that such of an index grew steadily during this period indicates that a growing proportion of Internet users, therefore a growing number of people, were interested about *V. velutina* and searched for it on the Internet.

The analysis of Internet searching volumes might be a promising complementary tool for monitoring the presence of *V. velutina* in Italy and Europe. As GoogleTrends can be downloaded at the regional level, peaks in searches about *V. velutina* could signal the colonization of a certain area by the species. This approach is already adopted in epidemiology, to trace the circulation of viral disease [35], and other studies considered it for the monitoring of common invasive alien species, such as the tiger mosquito (*Aedes albopictus*)[36]. As *V. velutina* actively exploits human buildings for constructing its nests, becoming visible and concerning to residents, this approach should work well in its invaded range, due to the high proportion of urban and rural landscapes. Nevertheless, due to the high misidentification rate of the species with native insects, peaks

in searches should be followed by insights or by a direct monitoring with traps [37][38], for assessing with certainty the presence of *V. velutina*. Moreover, the analysis of seasonal patterns in relation to searches on Google and Wikipedia might also highlight spatial patterns in the phenology of the species in its invaded range, contributing to improve our understanding of how the phenological plasticity of invasive alien species affects their invasion success at a time of climate change [39].

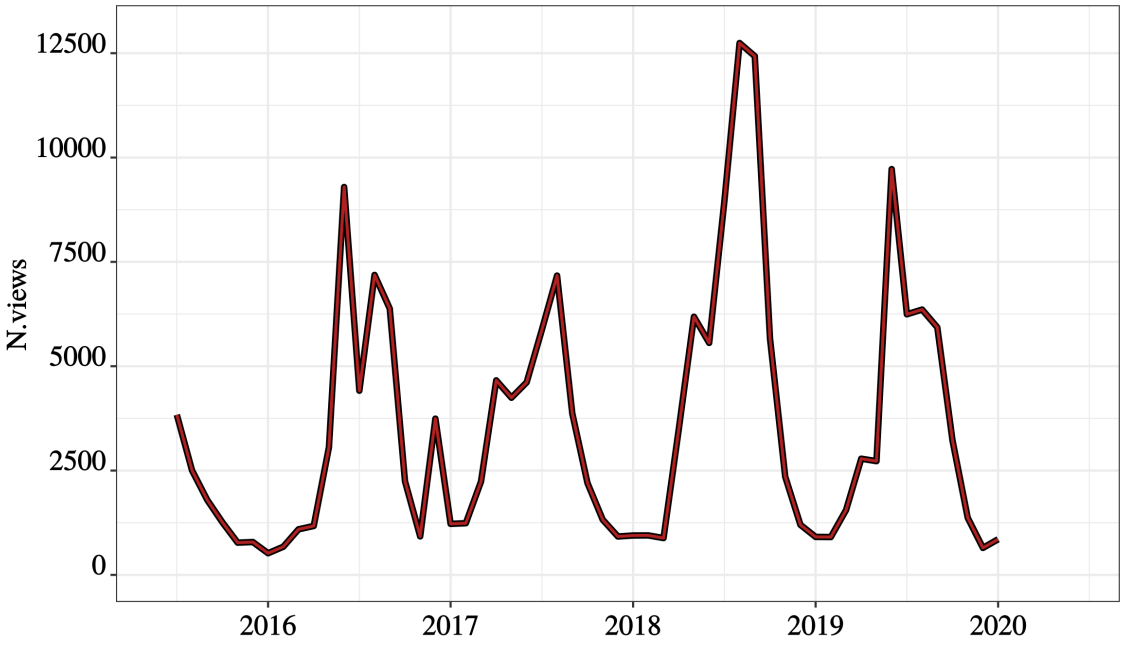

Figure 5 | Temporal evolution of the monthly number of visits to the Wikipedia page "Vespa velutina", in Italy, over the last few years. The time series starts in July 2015.

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Supplementary Information (S1)
Distribution of scores for each question about the impacts of *V. velutina* and its perceived severity as a threat to beekeeping

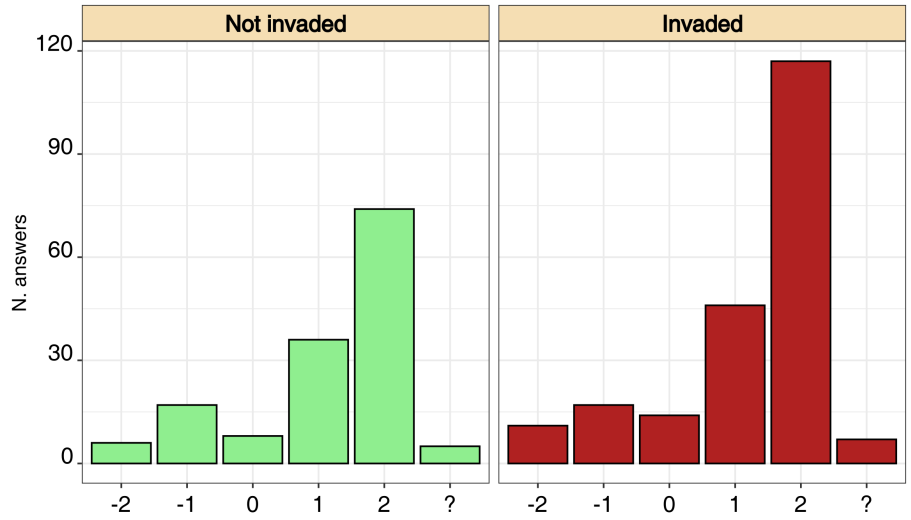

Figure 6 | Distribution of individual answers to the question "*By preying upon worker bees, the Asian yellow-legged hornet can weaken bee colonies by decreasing the production of honey that will be available for the wintertime*". Scores range from "*Strongly disagree*"(-2) to "*Strongly agree*"(+2), with a neutral point "*Neither agree nor disagree*" (0). Answers included an option for avoid answering, in case they never really considered this aspect before "*I have no idea /I do not know*" (? on the scale of the plot).

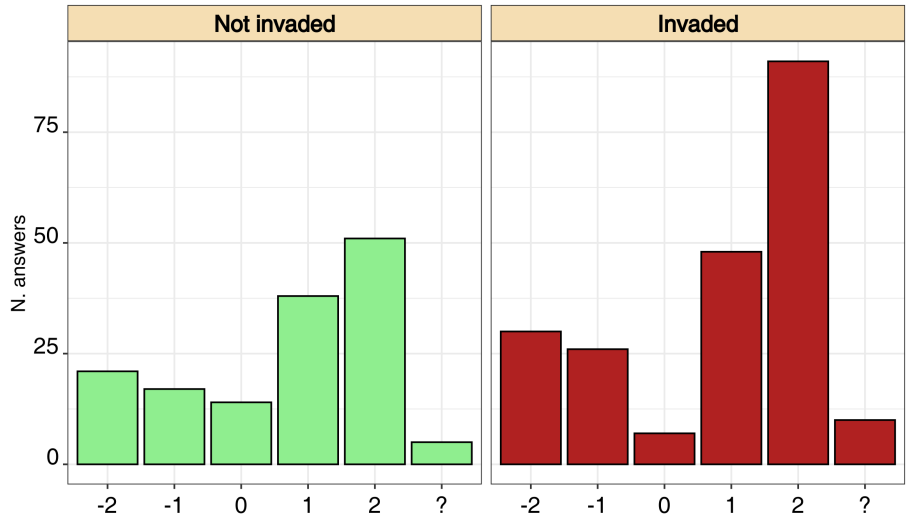

Figure 7 | Distribution of individual answers to the question "*The predatory activity of the Asian yellow-legged hornet decreases the number of bees that will contribute to the winter cluster*". Scores range from "*Strongly disagree*"(-2) to "*Strongly agree*"(+2), with a neutral point "*Neither agree nor disagree*" (0). Answers included an option for avoid answering, in case they never really considered this aspect before "*I have no idea /I do not know*" (? on the scale of the plot).

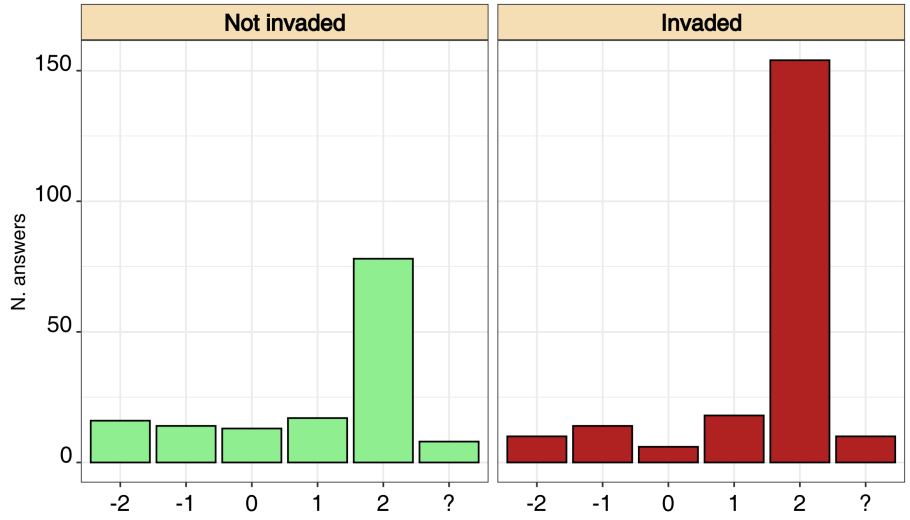

Figure 8 | Distribution of individual answers to the question "*Whenever the Asian yellow-legged hornet arrives in a certain area, worker bees there try to avoid being predated by decreasing the number of times they exit their beehive*". Scores range from "*Strongly disagree*"(-2) to "*Strongly agree*"(+2), with a neutral point "*Neither agree nor disagree*" (0). Answers included an option for avoid answering, in case they never really considered this aspect before "*I have no idea /I do not know*" (? on the scale of the plot).

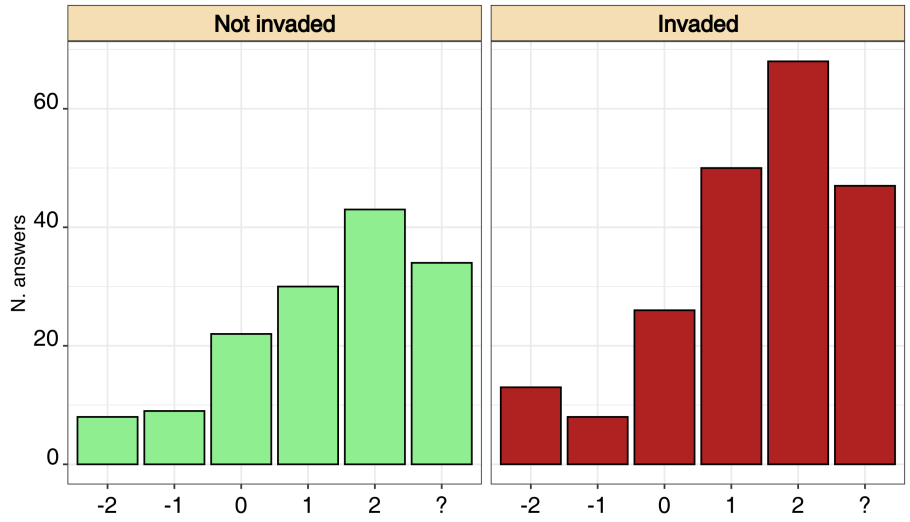

Figure 9 | Distribution of individual answers to the question "*The Asian yellow-legged hornet could damage fruit orchards*". Scores range from "*Strongly disagree*"(-2) to "*Strongly agree*"(+2), with a neutral point "*Neither agree nor disagree*" (0). Answers included an option for avoid answering, in case they never really considered this aspect before "*I have no idea /I do not know*" (? on the scale of the plot).

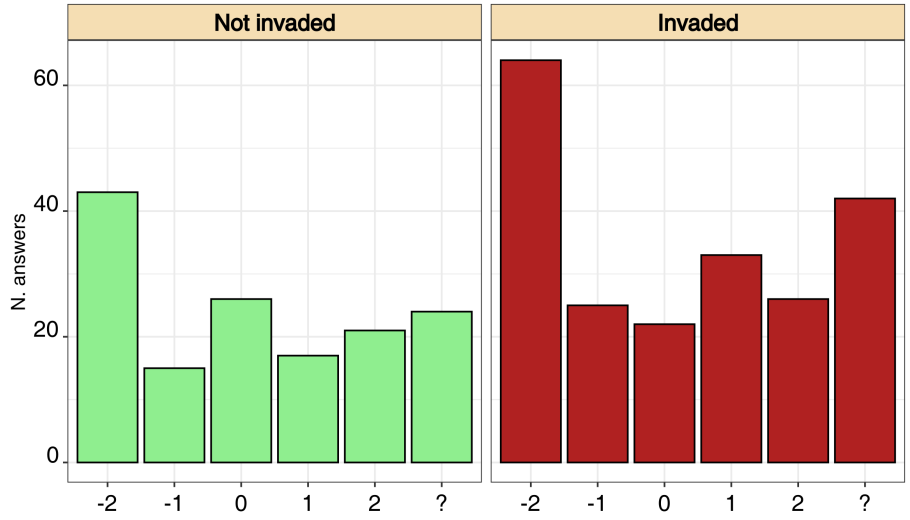

Figure 10 | Distribution of individual answers to the question "*By preying honeybees from multiple beehives, the Asian yellow-legged hornet could contribute to disease transmission among honeybees*". Scores range from "*Strongly disagree*"(-2) to "*Strongly agree*"(+2), with a neutral point "*Neither agree nor disagree*" (0). Answers included an option for avoid answering, in case they never really considered this aspect before "*I have no idea /I do not know*" (? on the scale of the plot).

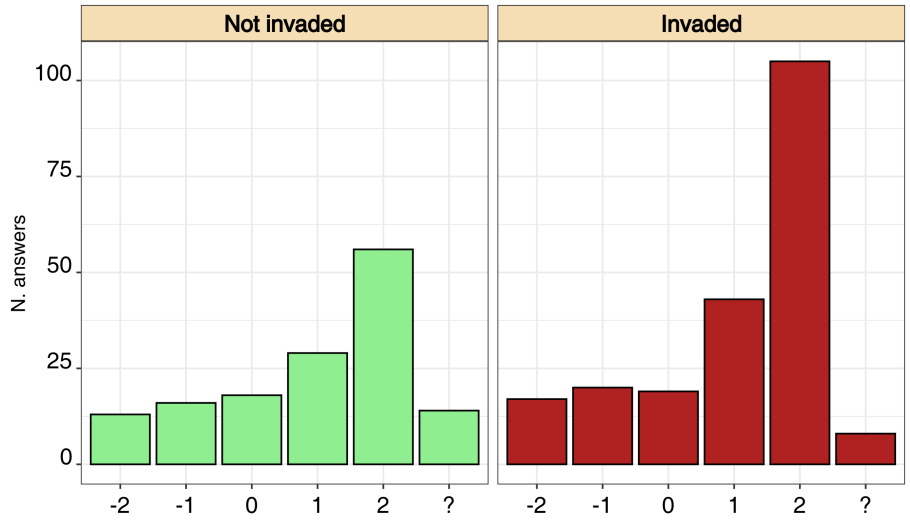

Figure 11 | Distribution of individual answers to the question "*The presence of Asian yellow-legged hornets around a beehive could be dangerous for beekeepers, by increasing the risk of being stung*". Scores range from "*Strongly disagree*"(-2) to "*Strongly agree*"(+2), with a neutral point "*Neither agree nor disagree*" (0). Answers included an option for avoid answering, in case they never really considered this aspect before "*I have no idea /I do not know*" (? on the scale of the plot).

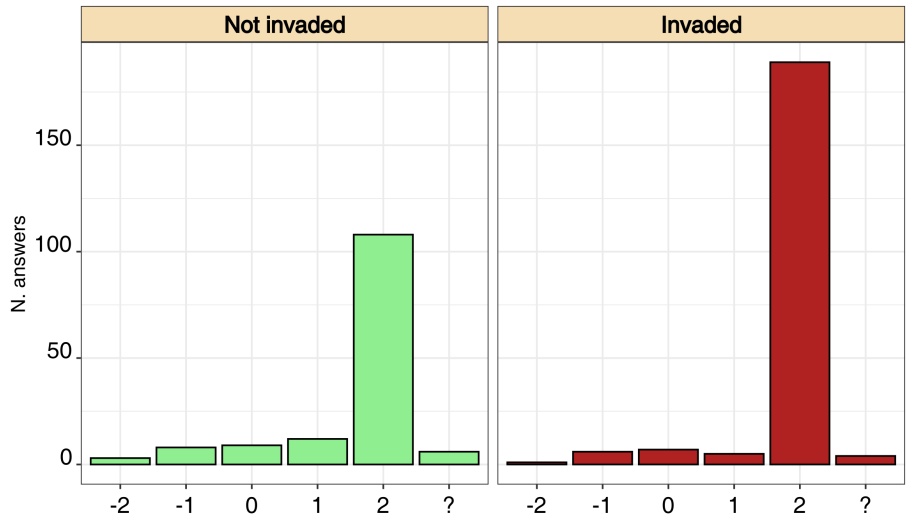

Figure 12 | Distribution of individual answers to the question "*The Asian yellow-legged hornet is more harmful to beehives, than the European hornet (Vespa crabro)*". Scores range from "*Strongly disagree*"(-2) to "*Strongly agree*"(+2), with a neutral point "*Neither agree nor disagree*" (0). Answers included an option for avoid answering, in case they never really considered this aspect before "*I have no idea /I do not know*" (? on the scale of the plot).

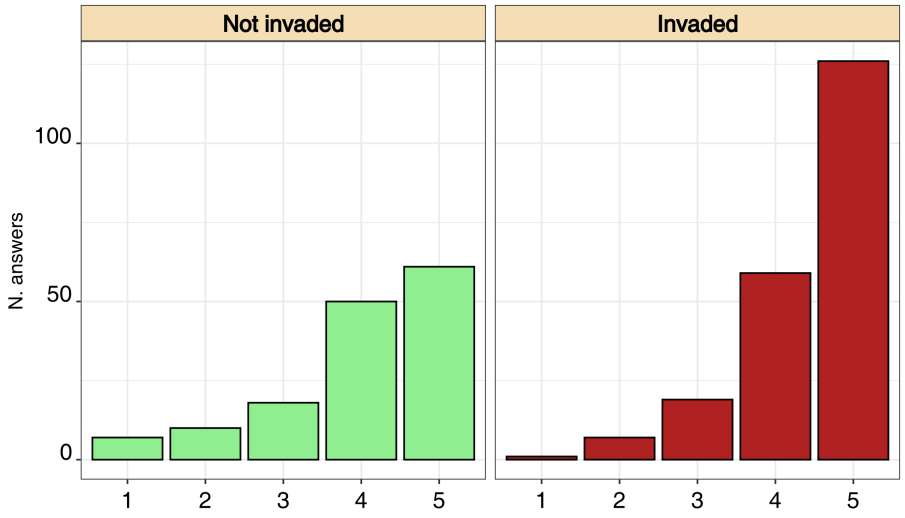

Figure 13 | Distribution of individual answers to the question "*In your opinion, which are the main threats to honey bees and beekeeping?*" Option: "*Predation by the Asian yellow-legged hornet*". Scores range from "*Not serious*" (1) to "*Extremely serious*" (5).

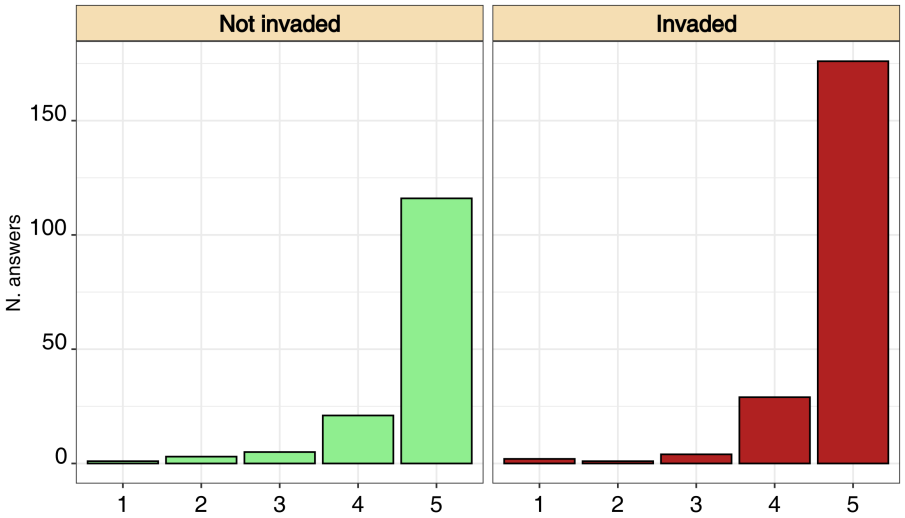

Figure 14 | Distribution of individual answers to the question "*In your opinion, which are the main threats to honey bees and beekeeping?*" Option: "*Poisoning from pesticides*". Scores range from "*Not serious*" (1) to "*Extremely serious*" (5).

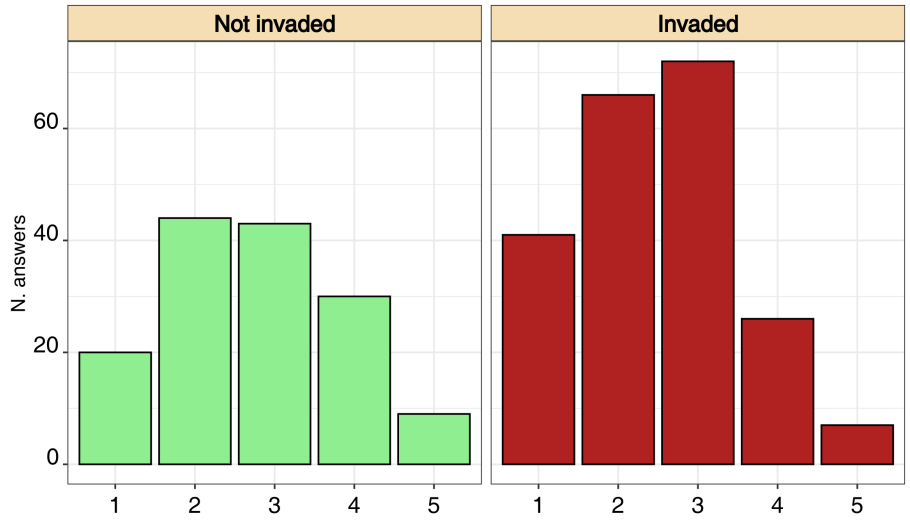

Figure 15 | Distribution of individual answers to the question "*In your opinion, which are the main threats to honey bees and beekeeping?*" Option: "*Predation by other species of hymenoptera (Vespa crabro, Vespa orientalis, Vespula spp., Dolichovespula spp., Philanthus triangulorum)*". Scores range from "*Not serious*" (1) to "*Extremely serious*" (5).

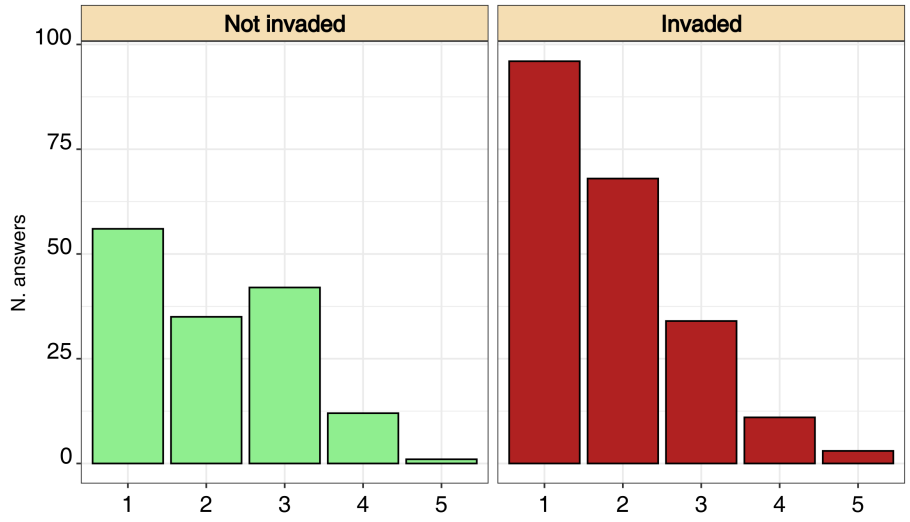

Figure 16 | Distribution of individual answers to the question "*In your opinion, which are the main threats to honey bees and beekeeping?*" Option: "*Predation by birds (woodpeckers, raptors and other birds)*". Scores range from "*Not serious*" (1) to "*Extremely serious*" (5).

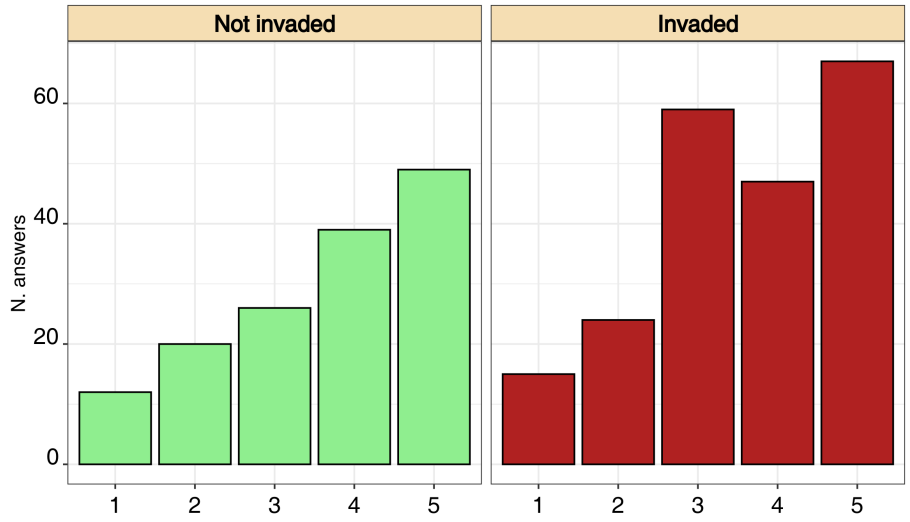

Figure 17 | Distribution of individual answers to the question "*In your opinion, which are the main threats to honey bees and beekeeping?*" Option: "*Infestation by Aethina tumida*". Scores range from "*Not serious*" (1) to "*Extremely serious*" (5).

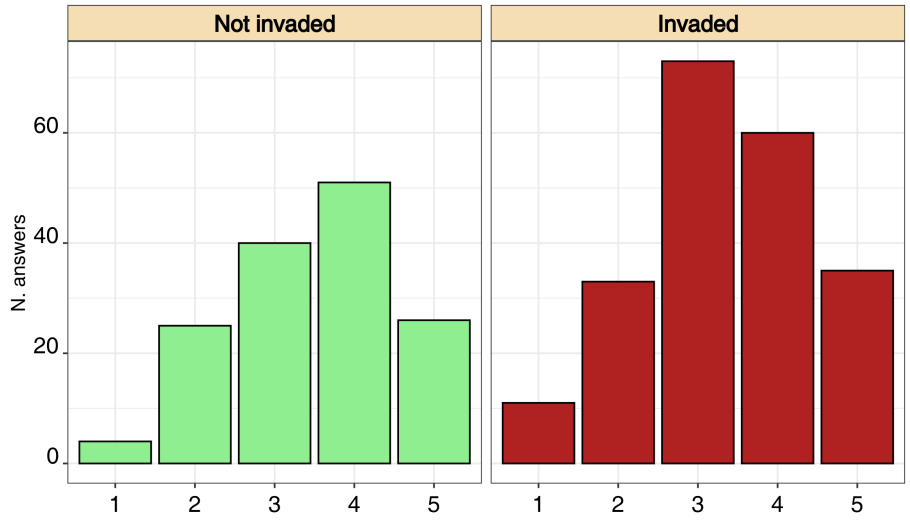

Figure 18 | Distribution of individual answers to the question "*In your opinion, which are the main threats to honey bees and beekeeping?*" Option: "*Bacterial diseases (Penibacillus larvae, Melissococcus plutonius, Bacterium eurydice, Enterococcus faecalis etc..)*". Scores range from "*Not serious*"(1) to "*Extremely serious*" (5).

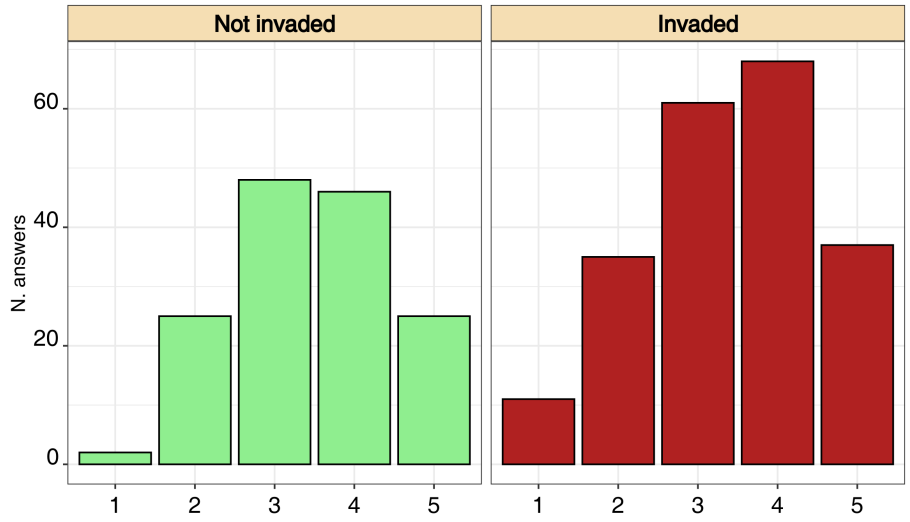

Figure 19 | Distribution of individual answers to the question "*In your opinion, which are the main threats to honey bees and beekeeping?*" Option: *"Nosemosis (Nosema apis and Nosema ceranae)*". Scores range from "*Not serious*" (1) to "*Extremely serious*" (5).

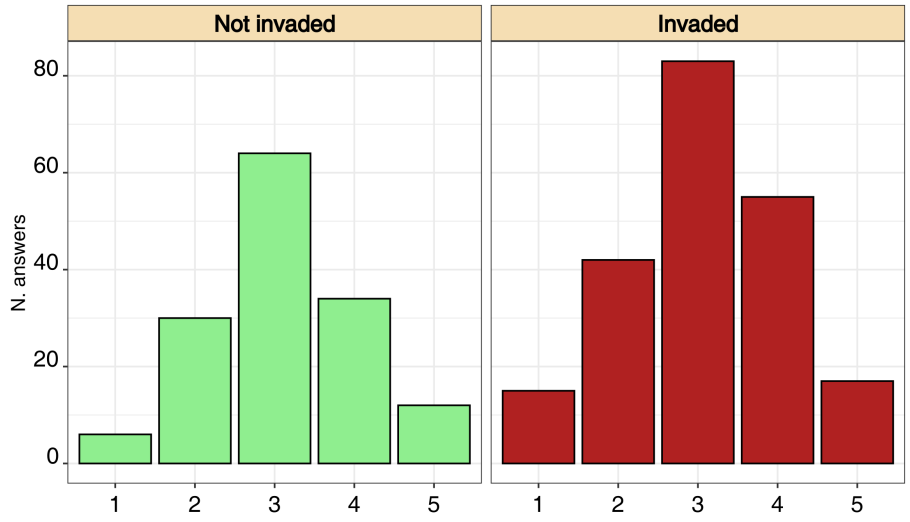

Figure 20 | Distribution of individual answers to the question "*In your opinion, which are the main threats to honey bees and beekeeping?*" Option: *"Mycoses (Ascosphaera apis, Bettsia alvei, Aspergillus flavus, Aspergillus fumigatus etc...)*". Scores range from "*Not serious*" (1) to "*Extremely serious*" (5).

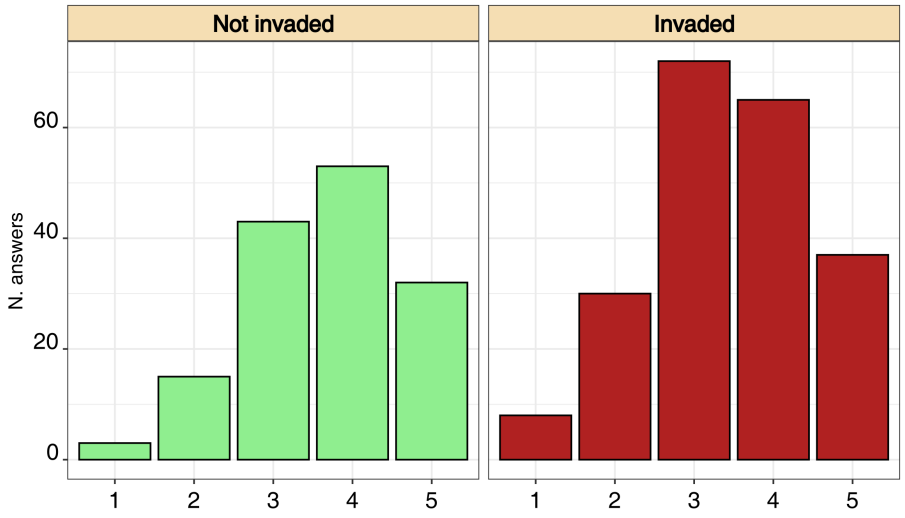

Figure 21 | Distribution of individual answers to the question "*In your opinion, which are the main threats to honey bees and beekeeping?*" Option:"*Viral diseases (ABPV, IAPV, CBPV, DWVV, BQCV, SBV etc...)*". Scores range from "*Not serious*" (1) to "*Extremely serious*" (5).

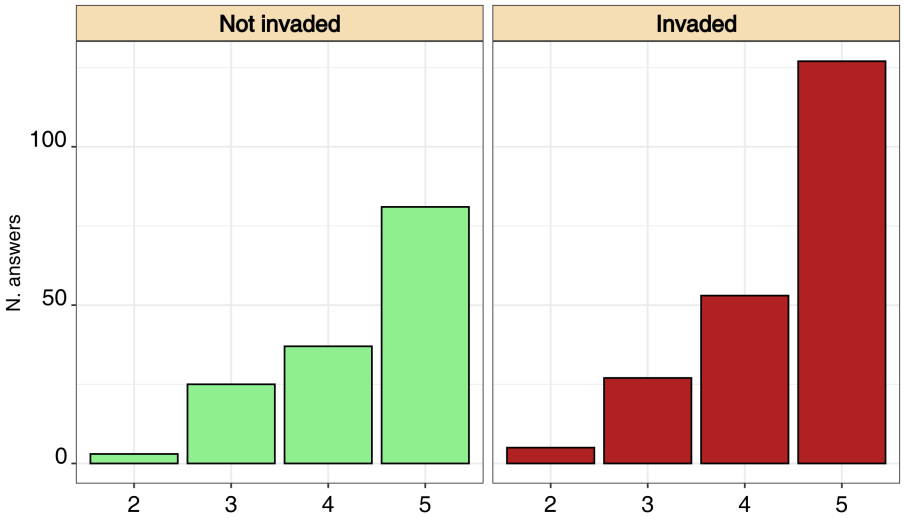

Figure 22 | Distribution of individual answers to the question "*In your opinion, which are the main threats to honey bees and beekeeping?*" Option: "*Varroa mite (Varroa destructor)*". Scores range from "*Not serious*" (1) to "*Extremely serious*"(5).