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COLOSS Task Force to Investigate and Reduce *Vespa velutina* Impacts and Spread

Daniela Laurino, Ivana Tlak Gajger, Simone Lioy and Marco Porporato

Introduction

The Asian yellow-legged hornet (*Vespa velutina* Lepeletier, 1836) is an invasive alien species introduced in Europe, South Korea and Japan, where it generates negative impacts on apiculture, native biodiversity (e.g. wild insects) and ecosystem pollination services. Due to its multiple impacts, the spread and impacts of this species should be mitigated.

V. velutina is a social wasp native to South-East Asia, naturally distributed in the subtropical and temperate areas between Southern China, India, Indochina and Indonesia. Among the 13 subspecies occurring in Asia, only the northernmost subspecies, *Vespa velutina nigrithorax* (du Buysson, 1905), was accidentally introduced from China to other parts of the world: South Korea in 2003, Europe in 2004 and Japan in 2012 (Laurino et al., 2019). The first sighting of the presence of *V. velutina* in Europe occurred in France, near the city of Bordeaux. Probably the introduction was caused by a single queen transported by a cargo ship from China (Monceau et al., 2014). From France, the species reached Spain (Navarra province and Basque country in 2010, Galicia and Catalonia in 2012, Majorca Island in 2015), Portugal (Minho province in 2011), Belgium (Flobecq in the Hainaut province in 2011), Italy (Liguria region in 2012), and Germany (Rhineland-Palatinate in 2014). More recently, the species was observed in the United Kingdom and Channel Islands (2016), Netherlands (2017), Switzerland (2017) and Luxembourg (2020) (Laurino et al., 2019). The rapid spread of *V. velutina* in Europe is associated with a dispersal pattern that encompasses natural diffusion and human-mediated transportation (Robinet et al., 2017).

Characteristics of the Species

V. velutina is characterised by a dark brown, almost black thorax. The first three abdominal segments are dark brown with a yellow or yellow-brown backside margin; the fourth segment is almost entirely yellow-brown, with a reddish-brown end of the abdomen. The size of the workers ranges between 19 and 30 mm, with a wingspan of 37-50 mm. The front part of the head is yellow-orange, and the antennae are black at the ends and brown on the bottom. The legs are dark, except for the ends (tarsi) that are yellow, hence the common name Asian yellow-legged hornet (Figure 1a). The males of *V. velutina* can be recognised from workers or queens by the absence of the sting and bigger antennas (males have one more antennomere than females). Workers and queens are very similar, although the queens are generally heavier; the section analysis of the reproductive organs allows best to distinguish between castes (Monceau et al., 2014).

Very often, *V. velutina* could be misidentified by the public with other insect species that have similar colours, mostly with the native European hornet *Vespa crabro*. The two species could be recognised by the following characteristics: different abdominal patterns, colours of the legs and of the head, different body sizes (the native species is greater than the invasive species) and different predatory activity in front of honey bee colonies (generally, *V. velutina* is preying the forager bees by hovering in front of the colonies, while *V. crabro* is preying bees on the landing board).

Impacts

In Europe, *V. velutina* is considered an invasive species because of its multiple impacts, also in relation to the predation on honey bees, solitary bees, bumblebees and other flying insects. Impacts in invaded areas can be divided into economic, ecological and social issues (Laurino et al., 2019). Economic impacts caused by *V. velutina* invasion can be grouped in: i) losses of honey bee colonies (weakening and deaths of managed honey bee colonies, Leza et al., 2019; Requier et al., 2019) and consequently decreased production of hive products, as well as ii) costs for the removal of hornet nests, iii) costs associated with public information campaigns and iv) for the implementation of monitoring and control measures (Laurino et al., 2019). Negative impacts on losses in biodiversity of different bee species and beneficial insect pollinators may have huge effects on their pollination activity, efficiency and consequently on plant biodiversity (Rojas-Nossa & Calviño-Cancela, 2020). Generally, the decrease in the number of bees and other flying insects in the environment generates alteration in the ecosystem pollination services. Moreover, invasive hornets may represent a competitor of native insect species, such as other wasps with a similar ecological niche. Finally, *V. velutina* may represent a potential source of fear and other kinds of social risks for citizens, thus involving possible public health threats (Laurino et al., 2019).

Because *V. velutina* invasion causes considerable environmental and socio-economic impacts, this hornet has been included in the so-called blacklist of invasive alien species of Union concern (Commission Implementing Regulation (EU) 2016/1141) by the EU. Consequently, it is required to develop surveillance plans and actions, including control measures and eradication strategies, to limit its spread and impacts.

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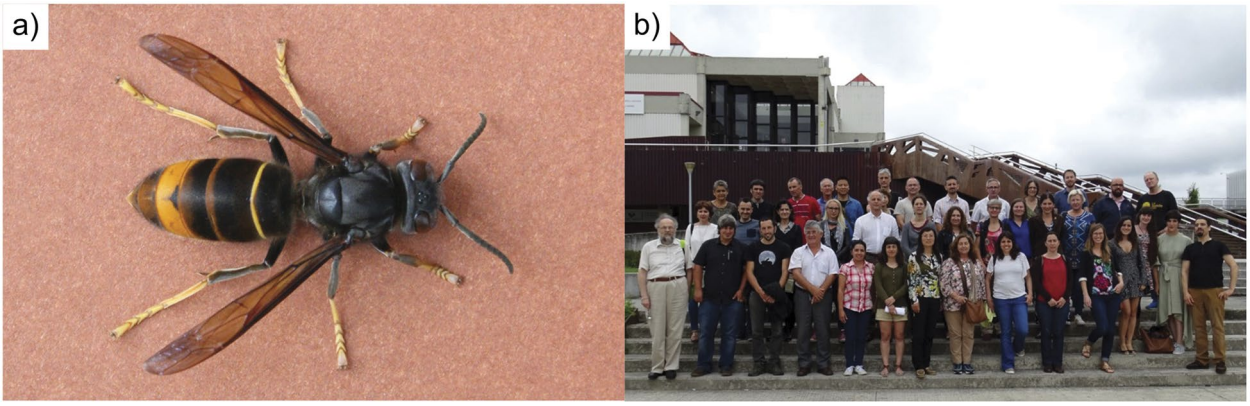

Figure 1. (a) worker of *V. velutina;* (b) some of the members of the Velutina Task Force of COLOSS during the annual international workshop in Bilbao (Spain, 28–29 June 2018).

Velutina Task Force

The Velutina Task Force (VTF) of the COLOSS association has thus been established in 2015 in Lukovica (Slovenia) for fulfilling the following objectives:

- promote the establishment of monitoring networks throughout the area of probable *V. velutina* invasion;
- gather information on *V. velutina*-induced colony losses and lost honey production from beekeepers in areas where *V. velutina* is established and areas where it is now expanding;
- gather information on control methods adopted in the areas where *V. velutina* is present and test the most promising of such methods in different environments;
- develop and adopt uniform methods to assess colony development, kind and abundance of insects *V. velutina* preys upon, *V. velutina* impact on honey bees and the beekeeping industry;
- apply for joint research projects on *V. velutina* in the endemic and the invaded ranges.

Structure and Organization

The VTF group consists of 83 members from 22 countries on four continents (Figures S1 and S2), and it is coordinated by two co-chairs, Dr Daniela Laurino, Dr Mar Leza (until October 2019) and afterwards Dr Ivana Tlak Gajger.

The Velutina Task Force brings together more than half of the researchers that are working on *V. velutina* worldwide. Indeed, by analysing the scientific manuscripts published on this species ($n = 190$; see Table S1), it can be noted that 52% of the published manuscripts were authored by one or more researchers that are part of the VTF, particularly from 2011 onwards (Figure S3), highlighting the skills and multidisciplinarity that characterises this group.

Activities of the Velutina Task Force

The VTF meets twice a year, once by organising an international workshop specifically on *V. velutina*, and once during the annual COLOSS Conference, for discussing and updating participants and COLOSS members on the activities performed by the Velutina Task Force (Figure 1b). Annual international workshops last generally for two days: the first day, VTF members have the opportunity to describe new insights concerning their own research or management activities on *V. velutina*; the second in-field day has the scope to illustrate to the participants the strategies and procedures that are adopted for monitoring the species or tackling its spread and impacts (e.g., procedures for removing *V. velutina* colonies).

Meetings of the VTF allowed to share knowledge and experiences on a wide range of topics connected to *V. velutina*, thanks to 87 contributions of which 62 were oral presentations and 25 posters (Table S2). The main topics reported by participants are those connected with the strategies that should be developed for affording the species (monitoring, eradication, control and management), followed by research aspects on the biology and impacts associated with *V. velutina* presence and by research on innovative techniques for locating *V. velutina* nests (e.g., harmonic radar tracking, radio-tracking). No less important although less frequent are the topics connected with: viruses and parasites associated with *V. velutina*, ecology and genetics of the species, modelling approaches for predicting its spread and impacts or comparison with other invasive species (Figure S4). Authors that mostly contributed to sharing knowledge are those connected to research groups of Italy (50%), Spain (17%) and France (9%), although many important contributions were also provided by researchers of eleven other countries (Figure S5). Among these, contributions were also provided by researchers from China and South Korea, for sharing research knowledge from the native range of the species and from other areas of introduction, respectively.

As previously stated, the VTF is contributing to share experiences on the techniques that can be applied for i) monitoring *V. velutina* presence, ii) eradicating the species and iii) controlling established populations, with the general aim of sharing good practices for reducing the spread and impacts of this species.

Monitoring techniques for assessing *V. velutina* presence may rely on i) citizen science schemes, which could be developed by implementing websites or specific smartphone applications for gathering sightings from the public, and on ii) the engagement of beekeepers for the establishment of monitoring networks, thanks to the use of monitoring traps and observation of hornets in apiaries when preying on honey bees (Laurino et al., 2019). Examples of citizen science schemes can be found in many European countries such as Austria, Belgium, France, Italy, Luxembourg, Portugal, Spain, and the UK (Table S3). Beekeepers are also organised in local monitoring networks, either in countries already colonised by *V. velutina* and in countries where the species is not yet present such as Croatia and Slovenia, for an early detection of the species (Table S2).

Eradication strategies are attempted by delimiting the area colonised by the species (traps, sentinel apiaries or attractive baits are used for this purpose) and by applying techniques for locating nests, possibly before the emergence of gynes

during the autumn (Lioy et al., 2021). Effective techniques that may be used for nest detection are: visual tracking and triangulation of flying directions (applied in Majorca, Spain), harmonic radar tracking (Italy), radio-tracking (UK, France and Switzerland) or the use of thermal imaging cameras (Italy) (Table S2). Good examples of eradication programmes are those adopted in Majorca (Leza et al., 2021) and the UK (Jones et al., 2020).

Established *V. velutina* populations that cannot be eradicated should be controlled, for limiting environmental and socio-economic impacts. Control strategies are mainly based on the establishment of procedures for gathering reports (position of the colonies) from citizens, followed by the removal of the nests by trained teams, firefighters or civil defence teams (Laurino et al., 2019).

Future Plans of the Group

In the last decade, the state of the art on *V. velutina* knowledge has been considerably extended, however several knowledge gaps are still present. Examples of such gaps are: a good quantification of the impacts that this species could generate on the status of wild insect populations and on pollination ecosystem services; an advancement in the methods for trapping *V. velutina*, particularly by developing more selective trapping techniques (e.g., pheromone traps); an advancement in the methods for eradicating and controlling the species. The VTF will thus promote research activities for filling the current gaps of knowledge.

At the same time, the VTF will continue to share knowledge and experiences through the annual conferences organised by the group, by the publication of scientific manuscripts, and by contributing to the COLOSS BEEBOOK with a chapter (standard methods to be used in research on *V. velutina*). Regular updates on the VTF activities (e.g., conference proceedings) will also remain available for the public.

Financial resources for implementing shared international research activities mainly depend on common research projects that are developed between VTF members. Also, combinations with fundings from agencies at national and local levels are welcome, as well as those with the aim of supporting and strengthening international researchers' networks in their scientific, educational and professional work.

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Disclosure Statement

No potential conflict of interest was reported by the authors.

Supplementary Material

Supplementary Figures and Tables are available via the 'Supplementary' tab on the article's online page (http://dx.doi.org/10.1080/0005772X.2021.2006504).

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