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# CONTROLLING *VESPA VELUTINA NIGRITHORAX* (HYMENOPTERA: VESPIDAE) IN MAJORCA

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**Abstract** The yellow-legged hornet, *Vespa velutina nigrithorax*, is an Invasive Alien Species (IAS) accidentally introduced in Europe from South East Asia. It was reported for the first time in south-west France in 2004 and rapidly spread to nearby European countries: Spain, Portugal, Italy, Belgium, Germany, Great Britain, Switzerland and the Netherlands. This social insect preys primarily upon honeybees (*Apis mellifera*), but also upon other pollinators and insects. Consequently, the introduction of this IAS raises two important concerns: economic impact because the invasion will likely cause high losses due to death of honeybee colonies (which provokes the reduction of honey production and the pollination services provided by honeybees), and impact on the natural ecosystem and local biodiversity by causing declines in insect populations. Here we provide information about the surveillance strategies that have been established in this area to stop its colonization: spring queen trapping, adult detection, nest detection and techniques of nest removal. Moreover, we provide information about the evolution of this hornet in the Mallorca, since its introduction in 2015: a total of 30 secondary nests were detected and removed during the three fists years of invasion and none of them during the last year 2018 and 2019. Considering the presumably early stage of the invasion, the size of the island and the promising results obtained, we consider that this species could be eradicated if resources and a specific program for eradication in Mallorca are implemented in coordination with all involved partners.

**Key Words** Yellow-legged hornet, invasive alien species, eradication, island.

## INTRODUCTION

The yellow-legged hornet, *Vespa velutina nigrithorax* Lepeletier 1836, is an Invasive Alien Species (IAS) which was accidentally introduced in Europe from Asia. It is native to tropical and subtropical areas of Southeast Asia. It is being reported for the first time in south-west France in 2004 (Haxaire et al., 2006) and rapidly spread to nearby European countries: Spain, Portugal, Italy, Belgium and Germany, Great Britain, Switzerland and the Netherlands. In the case of Spain, the yellow-legged hornet is established in the northern regions (Navarra, Basque Country, Galicia and Cantabria) (López et al., 2011), and in Catalonia. Biological invasions around the world have experienced an unprecedented increase during recent decades as a result of global change, worldwide trade, and human mobility. These biological invasions cause severe impacts on agriculture and natural resources.

In the case of *V. velutina*, this social insect preys primarily upon honeybees (*Apis mellifera*), but also upon other pollinators and insects (Monceau et al., 2013). Consequently, the establishment of this IAS is a major concern because of its potential negative impact on pollinators and biodiversity. Major impacts will likely cause high economic losses due to the death of honeybee colonies and therefore the reduction in honey production (Monceau et al., 2013; Monceau et al., 2014). Further, *V. velutina* may have negative impacts on the natural ecosystem and local biodiversity by causing declines in insect populations (Beggs et al., 2011). In addition, attacks to humans are possible (de Haro et al., 2010) when colonial nests are established in urban areas. In the particular case of Mallorca, this invasion could be devastating, considering the situation of the populations of honeybees, the fragility of the ecosystem (typical of the island ecosystems) and the impact on endemic insects.

Here we report the current situation of *V. velutina* in the Balearic Islands and provide information on the surveillance strategies that have been established in this area to stop its colonization, which could be an example of the first steps of an eradication plan. More specifically, we investigated the combination of the following methods: (1)

spring trapping of queens; (2) detection of the presence of adults using traps; (3) use the citizen science data for detection of presence; (4) detection of nests using triangulation method following adults; and (5) destruction of nests using mechanical method.

## MATERIALS AND METHODS

In October 2015 the Laboratory of Zoology of the University of the Balearic Islands received a sample from an apiary of a beekeeper located in Sóller (39º47'45.3''N; 2º42'53.9''E) suspected to be *V. velutina*, according to the morphology of the insect. From October 2015 to November of 2018, an intensive survey was implemented which followed strategies: (1) Spring trapping of queens. (2) Detection of the presence of adults using traps, during summer and autumn. Traps baited with a sucrose or protein attractant (raw fish) were located in the areas/nearby areas where previously the hornet has found, in order to detect the presence of adults. (3) Use the citizen science data for detection of presence. An important community information task was carried out with leaflets, informational brochures and local media. Moreover, the general public had access to an emergency 24-hour phone number they could call or send a message (also Whatsapp) for notifications. Since 2016, a year after the first detection, a software called Vespapp was developed in order to public could send photos to detect individuals or nest of V. velutina. Vespapp aims to send a picture of suspicious observation (hornest) to a database, then the experts confirm or discard it. Vespapp involves a website:

**(http://vespapp.uib.es/) and a free android app:**
**(https://play.google.com/store/apps/details?id=com.habitissimo.vespapp&hl=es).**

(4) In order to detect the nest, feeding points with protein attractant (raw fish) were set in the area in order to locate and follow adults approaching the traps. Flight routes of observed adult hornets from two or three feeding points were followed by drawing a triangulation on the map that allowed location of the nest by visual inspection. (5) Destruction of nests using mechanical method.

## RESULTS AND DISCUSSION

The specimen sent in 2015 by a beekeeper was identified as *Vespa velutina nigrithorax* according to an identification key (Archer, 2012). After this first identification, more yellow-legged hornets were observed preying upon honeybees in the apiary of the detection, located in Sóller (39º47'45.3''N; 2º42'53.9''E). At the same time, one hornet was found in the zone of Deià (39º 45' 1.9''N, 2º 38' 47.8''E), at 8 km distance from the apiary of Sóller. Following the triangulation method, one secondary nest was detected on the 30th of October 2015 in the zone of Sóller at 14 m high in a pine tree (Table I). This nest was entirely removed and frozen for future studies. After that date, no further adult flying hornets were observed either in Sóller or in Deià, possibly due the onset of the hibernation period. In July 2016 the first yellow-legged hornet of the season was detected by a collaborative effort with local citizens. Nine secondary nests were located from August to November 2016 (Table I), due to an intensive, active search for nests using the triangulation method. All nests were entirely removed and were frozen. The third year, in 2017, twenty nests were located and removed (Table I). During 2018 no secondary nest was found. Only one primary nest was found by a citizen in Sóller, which was entirely removed. Moreover, during 2018, ten queens were trapped during spring trapping. Finally, during 2019 no queen or adult was captured and no nest was detected.

All nests located during 2015 and 2016 were located in the "Serra de Tramuntana". This area is characterized by specific climatic and geomorphological conditions compared to the rest of the regions in Mallorca or the neighboring islands. In fact, the climatic conditions in that area of Mallorca are the most similar to those encountered in the areas of distribution of *V. velutina* in mainland Spain, that is, the northern regions. However, some nests found in 2017 were located out of the "Serra de Tramuntana", showing the high adaptability features of this IAS.

Some nests were located really close to urban areas. For example, nest 2 (the first one of 2016) that was located in a private garden at the entrance of Sóller. This is a clear indicator that *V. velutina* has reached some urban areas on the island, which is important because its stings are potentially deadly for allergic people. However, to date no cases have been reported on the island.

**Table I**. Main characteristics of the secondary nest's location: locality, date of location of the nests, altitude, type of tree or rock where nests were found, and height of nest

| ID Nest | Locality | Date of location | Altitude (m) | Host tree or rock | Height of nest (m) |
|---|---|---|---|---|---|
| 1/15 | Sóller | 30th October 2015 | 303 | *Pinus halepensis* | 14 |
| 1/16 | Fornalutx | 19th August 2016 | 100 | *Pinus halepensis* | 12 |
| 2/16 | Sóller | 26th August 2016 | 525 | *Pinus halepensis* | 25-30 |
| 3/16 | Deià | 6th September 2016 | 412 | *Pinus halepensis* | 10 |
| 4/16 | Sóller | 9th September 2016 | 155 | *Pinus halepensis* | 15-20 |
| 5/16 | Deià | 13th September 2016 | 464 | *Quercus ilex* | 8 |
| 6/16 | Deià | 19th September 2016 | 216 | *Pinus halepensis* | 10-15 |
| 7/16 | Fornalutx | 14th October 2016 | 642 | *Cupressus sempervirens* | 15 |
| 8/16 | Fornalutx | 31st October 2016 | 464 | *Pinus halepensis* | 12.5 |
| 9/16 | Sóller | 22nd November 2016 | 375 | *Quercus ilex* | 20-25 |
| 1/17 | Deià | 22nd June 2017 | 320 | *Pinus halepensis* | 12 - 15 |
| 2/17 | Deià | 28th June 2017 | 110 | *Pinus halepensis* | 15 - 18 |
| 3/17 | Deià | 4th July 2017 | 336 | Rock | 25 |
| 4/17 | Bunyola | 6th July 2017 | 687 | *Quercus ilex* | 6 |
| 5/17 | Bunyola | 8th July 2017 | 509 | *Pinus halepensis* | 10 |
| 6/17 | Sóller | 18th July 2017 | 492 | *Quercus ilex* | 5 |
| 7/17 | Sóller | 10th August 2017 | 560 | *Quercus ilex* | 6 |
| 8/17 | Valldemossa | 11th August 2017 | 40 | Rock | 8 |
| 9/17 | Orient | 14th August 2017 | 621 | *Pinus halepensis* | 12 - 15 |
| 10/17 | Orient | 22nd August 2017 | 426 | *Pinus halepensis* | 12 - 15 |
| 11/17 | Valldemossa | 28th August 2017 | 89 | *Pinus halepensis* | 15 - 18 |
| 12/17 | Selva | 5th September 2017 | 175 | *Ceratonia siliqua* | 4 - 5 |
| 13/17 | Sóller | 8th September 2017 | 689 | *Quercus ilex* | 10 |
| 14/17 | Lloseta | 11st September 2017 | 220 | *Pinus halepensis* | 10 - 12 |
| 15/17 | Esporles | 11st September 2017 | 318 | *Quercus ilex* | 10 - 12 |
| 16/17 | Santa Maria | 13rd September 2017 | 114 | *Pinus halepensis* | 15 - 18 |
| 17/17 | Lluc | 15th September 2017 | 490 | *Prunus spinosa* | 0 |
| 18/17 | Bunyola | 11st October 2017 | 750 | *Pinus halepensis* | 10 - 12 |
| 19/17 | Bunyola | 19th October 2017 | 716 | *Pinus halepensis* | 10 - 12 |
| 20/17 | Bunyola | 23rd October 2017 | 587 | Rock | 5 |

It is important to note that in Mallorca is the first report of the yellow-legged hornet nesting in these three tree species: *Pinus halepensis* Miller, *Quercus ilex* L., and *Cupressus sempervirens* L. In contrast, in Northern Spain, nests were found primarily in black locust trees (*Robinia pseudoacacia* L.), plane-trees (*Platanus hispanica* Miller ex Münchh), and other species of oak trees: *Quercus robur* L. (Goldarazena et al, 2015). This fact demonstrates the high plasticity of this insect for nesting in a wide variety of plant species and locations, as described by Monceau and Thiery (2016). The three tree species where nests were detected are evergreen species (pines, holm oaks, and common cypress), which represents an important disadvantage for visual detection of nests by direct observation. This is an important difference compared to other European countries, even in the case of other Mediterranean areas, such as Italy or mainland Spain, where nests are found mainly in deciduous forests where visual detection can be easier. This distinction should be taken into account in the eradication plans on this island as well as in other areas sharing similar vegetation.

Regarding the citizen science data to detect the presence, the total number of reports from Vespapp, COFIB and the species protection service (SPS) was 995 (422 in 2016, 227 in 2017 and 346 in 2018). The proportion of positive reports was less than 13% (2016: 6.4%; 2017: 12.8%; 2018: 0.9%), although in 2017 the number of positive reports were double than in 2016. On the other hand, spring and summer were the seasons with higher number of reports, and the lowest reports were detected in winter. Referent to Vespapp, a total of 2,634 downloads were recorded. Specially, 1,439 downloads in 2016, 615 in 2017 and 580 in 2018. All peaks of both reports and downloads have been related with social media events which have been divided in three categories: awareness sessions, news in communication media and scientist talks.

Here, we present the situation of the yellow-legged hornet on a small island of the Western Mediterranean Sea, the encouraging results obtained during 2019, and the challenge of eradication. All indicators suggest an early stage of invasion of *V. velutina* in Mallorca. According to International Union for Conservation of Nature (IUCN), the early detection of IAS and the confinement of its population in limited territories, may lead to the eradication of the invasive species if effective measures are taken in time (Veitch et al., 2011). However, insects with dormant life stages and high reproductive rates present a greater challenge for eradication, even in isolated populations.

The path of introduction of *V. velutina* in the Balearic is unknown, since there are few biosecurity or quarantine measures in place for commodities arriving from overseas. One hypothesis could be the introduction via maritime transportation in the port of Sóller (located 176 km from mainland). Ports should be taken into consideration for a eradication policy in the Balearic Islands, since a priori seems to be the main path of introduction of *V. velutina*. Future work may include the testing of microsatellite markers as a useful tool for investigating the relatedness of the hornets and their dispersion during an outbreak.

The presumably early stage of the invasion of the Asian hornet in Mallorca in 2015, its confinement to an island, the proper planning and activities conducted (i.e., total removal of detected nest), the support from local people (i.e., active detection), and the results obtained during 2019, indicate that the eradication of this species is possible in Mallorca. In fact, to date it is possible to remove the nests faster than they reproduce (due to the low density of the population) and decrease the population year by year, by implementing active surveillance and total removal of detected nests. However, it is essential that financial resources for implementing these measures are made available for emergency responses to invasions and establish stringent biosecurity policies.

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