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First record of the Asian Yellow-Legged Hornet (*Vespa velutina* Lepeletier, 1836) in Austria

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Abstract: First record of the Asian Yellow-Legged Hornet (*Vespa velutina* Lepeletier, 1836) in Austria. Here, we report the first observed occurrence of the invasive Asian Yellow-Legged Hornet *Vespa velutina* Lepeletier, 1836 for Austria and provide information about the specimen and its discovery. The discovery occurred on the 9th of April 2024 in the city of Salzburg. The Austrian Agency for Health and Food Safety (AGES) verified this finding. As *V. velutina* is an invasive alien species of economic and ecological importance for the European Union, its occurrence needs to be reported by any of the member states. Hence, the Austrian authorities were immediately notified of this finding. Because the female specimen was found in early spring, and since dissections showed clear evidence for the presence of oocyte formation, we concluded the individual to be a founder queen. We briefly discuss the increasing risk of the invasion success by *V. velutina* for Austria. We also refer to the experience and scientific literature from already invaded countries regarding the current best practice for pest management, containment, and eradication. Among the key factors for successful management of *V. velutina* are (i) a well-informed public, (ii) an efficient and fast cross-country communication as well as coordination, and (iii) pre-budgeting of necessary tasks, infrastructure, and services. Recommendations for a well-informed public and target-specific measures are also needed in terms of conservation efforts, to avoid collateral damage in non-target organisms such as in the similar looking but native European Hornet (*Vespa crabro* Linnaeus, 1758).

Keywords: invasive alien species, pest, beekeeping, agriculture

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Introduction

Since its first occurrence in Europe in 2004 (Haxaire 2006, Villemant et al. 2011a, b), the hornet *Vespa velutina* Lepeletier, 1836 (commonly known as "Asian Hornet", "Asian Black Hornet", "Yellow Legged Hornet" or "Asian Yellow-Legged Hornet") has been unambiguously identified as invasive species with characteristics typical for pest species for apiaries in all environments where it could establish stable populations (Monceau et al. 2014, Arca et al. 2015). Hence, it has been declared an invasive alien species by the European Union authorities with the obligation of member states, like Austria, to report its presence and to apply countermeasures such as eradication where possible

or deemed necessary (European Comission 2014, 2016; legislation text and reasons explained in more detail in Carboneras et al. 2018). Information on the Southeast-Asian biogeographical origins, biology and pest management can be found extensively elsewhere (Villemant 2011b, Monceau et al. 2014, Arca et al. 2015, Laurino et al. 2020 and the references therein). Here, we only provide some basic information on the life cycle and reproduction of *V. velutina*. Like most other members within the Vespinae (Jeanne 1980), *V. velutina* monogynously produces annual colonies initiated by a founder queen. After the end of the winter season, the hitherto hibernating queens start producing so-called primary nests (in literature older than 2010 usually referred to as "embryo nests" in Vespinae, see e.g. Yamane & Makino 1977, Archer 2008, Rome et al. 2015) in spring, which are small in size and usually built in shrubs or cavities to protect them against wind and rain. After nursing the first emerging larvae herself, the queen of each nest increasingly focuses on egg-laying tasks as soon as the first adults (in spring only workers) are capable of foraging themselves. Workers mainly feed on carbohydrates (e.g. nectar, sap, fruit juices) but catch flying insects, among them bees (predominantly honey bees, *Apis mellifera* Linnaeus, 1758, whenever available, which in Europe make up about 40% of the reported prey, Rome et al. 2021), for feeding the larvae (Villemant et al. 2011b, Monceau et al. 2014, Arca et al. 2015, Rome et al. 2015, Laurino et al. 2020). In queenright colonies, workers remain sterile like in other *Vespa* species (Jeanne 1980). Their numbers increase as summer approaches, which usually triggers the workers to gradually start building a so-called secondary nest (usually in trees, frequently above 10 m) while abandoning the primary nest as soon as the last remaining larvae of the primary nest turn into adults (Archer 2010, Rome et al. 2015). Soon the number of workers increases dramatically, reaching up to mean numbers between three to six thousand individuals produced by mature nests each month in invaded habitats, such as in France (estimated mean numbers for France from September to November; Rome et al. 2015). Hence, *V. velutina* belongs to those hornet species with the largest reported nests, estimated to consume on average about 11 kg of insect biomass each season (Rome et al. 2021). In autumn, the reproductive period starts with the production of males (on average about 900 individuals; Monceau et al. 2014) and gynes (potential future queens; on average about 350 gynes), which is characterized by polyandry (multiple mating of queens). It might be noteworthy that *V. velutina* workers at this time usually are indistinguishable from gynes in size, though gynes of same nests are heavier than workers (Rome et al. 2015). Only the mated gynes survive winter (Archer 2010, Rome 2015), by hibernating under stones or tree bark (Chauzat & Martin 2009). Among the 22 known hornet species worldwide (Perrard et al. 2013), most occur in Asia, where *V. velutina* occurs over a vast area with more than ten subspecies and colour varieties, among them *Vespa velutina nigrithorax* (van der Vecht 1957, Perrard et al 2014).

The only hornet species reported for Austria so far is the naturally occurring *Vespa crabro* Linnaeus, 1758 (Gusenleitner 2008) which is slightly larger than *V. velutina* and also well known to occasionally attack honey bees (Baracchi et al. 2010), although causing by far less harm to apiaries as compared to *V. velutina* (Monceau et al. 2014).

After being unintendedly introduced to France in 2004, *V. velutina* began to spread over Western Europe, with a mean speed between 18 and 68 km per year (Bertolino et al.

2016, Robinet et al. 2017, Verdasca et al. 2021). These notable differences are assumed to be correlated with habitat suitability for *V. velutina*, but also with different intensities of control efforts (Bertolino et al. 2016, Verdasca et al. 2021). Up to now, *V. velutina* is established in substantial parts of the Iberian Peninsula, France, the Benelux-region, Southern England (re-invasions after successful eradications; Kennedy & Osborne 2023, Rome 2024), some parts of Germany, Switzerland, and Italy (Lioy et al. 2022; for a continuously updated map on nest reports see Rome 2024). The most recent invasion events with established nests were reported for Northern Germany (Husemann et al. 2020), Great Britain (Jones et al. 2020), Hungary (August 2023, Márta & Vas 2023), and Czechia (October 2023, Walter et al. 2024).

Potential arrival of *V. velutina* in Austria

Among the possibilities for *V. velutina* reaching Austria are (i) natural migration of founder queens from neighbouring countries (self-mediated dispersal; Robinet et al. 2017), (ii) "hitchhiking" of nests or founder queens (vehicles or transport of materials containing *V. velutina*, jump dispersal; Robinet et al. 2019), or (iii) intentional import of *V. velutina* nests or founder queens. However, no case has yet been reported for (iii). Whereas in temperate zones (ii) and (iii) can occur throughout the year, (i) usually takes place under favourable weather conditions in spring and autumn.

The risk of *V. velutina* nest establishment in Austria

For the establishment of stable populations, founder queens need to build-up nests each year that are large enough to produce sufficiently large numbers of reproducing offspring that will be able to sustain a functional reproduction cycle. Regions capable of sustaining this reproduction cycle are suitable for long-term colonisation by *V. velutina*. Climatic models using areas in Europe describe the Atlantic coast and parts of the Mediterranean coast as most suitable for this species, while the continental climate has been predicted to be suboptimal based on models and likelihood calculations that consider reported climate and other environmental data from regions with differing *V. velutina* nest densities (Villemant et al. 2011, Fournier et al. 2017, Robinet et al. 2019). However, the precise optimal ranges of the hypothesised limiting factors (such as in context of temperature, humidity, precipitation, occurrence of honey bee nests), to the best of our knowledge, remain unclear or lack direct causal evidence so far. Additionally, a high level of urbanisation and agriculture (especially wine- and fruit crop areas) was also reported to increase the probability of high nest densities (Fournier et al. 2017) and therefore also an increased risk for apiculture (Requier et al. 2024). For Austria, the North-Eastern regions are suggested to be among the most suitable areas for establishment (Robinet et al. 2019). However, a fine-scale modelling for Austria including habitat suitability, such as available for Czechia (Biemann 2023) or some Mediterranean islands (Herrera et al. 2023) is currently lacking. Among the factors that should be considered in such models for Austria are climate change as well as the species' reported environmental adaptation and tolerance abilities which allow the species to survive and reproduce even in regions previously thought suboptimal (Barbet-Massin et al. 2013).

Aims

The aims of this study are (i) to describe the discovery of the first observed *V. velutina* present in Austria, (ii) to provide evidence for species identification, and (iii) to provide a general description of the found specimen.

Material and methods

Keys and identification

For identification at the species level, we used the keys by Archer (1989a, b). For subspecies level we consulted van der Vecht (1957). Photos were taken by GP prior and by GP and DLPS after capture for documentation and for potential later analysis.

Documentation of body size, weight and ovarian status

Since body weight can provide some indication to e.g. the health and reproductive status of the individual, weighing (Mettler Toledo AT21, Switzerland) was conducted right after transport and prior to species identification. A scale paper (cm, mm) was used to record the general dimensions of the body. Dissection of the abdomen was done to check for the ovary status (Poidatz et al. 2018) and the status of the spermatheca. A large part of dissected tissues and the removed abdominal segments (including the sting apparatus) were transferred to ethanol (96%, Brenntag, Austria) for conservation. Weather information for the day of discovery was retrieved from https://meteostat.net/de/station/11150?t=2024-04-05/2024-04-12.

Results

Discovery

The specimen was discovered at a window within the building of the University Hospital Salzburg (47.813 N, 13.018 E) at around 9 a.m. (Fig. 1) after it had been heard moving around in the same room for half an hour. At this moment the specimen was capable of flight and tried to escape. However, it is likely that the individual already had been in the room at least over night as the windows were closed prior to the discovery. In case the

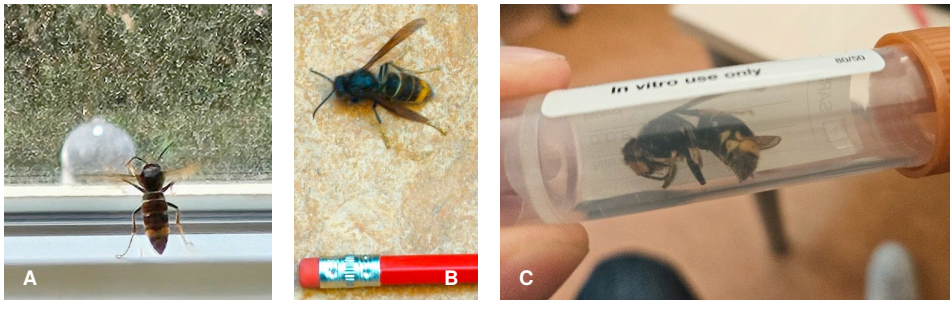

Fig. 1: Photos inside the hospital building, during discovery of the specimen (city of Salzburg, 09.04.2024), which flew against the window (A) and later crawled on the floor (B) (metal ring length of pencil = 1.4 cm), prior being captured in a vial (C) and transported for further identification and analysis. © G. Pisecker.

specimen was looking for a nesting site it might be noteworthy that the windows were approximately 2 m above ground and that several taller trees were in close proximity (5–10 m). On both days the weather conditions were favourable for hornet flight (warm and sunny, daily minima/maxima in the city of Salzburg were 3.7/28.8 °C on 08.04.2024 and 3.4/24.7 °C on 09.04.2024). Prior to transport, the specimen was killed and stored at –79 °C. The specimen was kept in a clean vial (Fig. 1C) for transport and was transferred to AGES in Vienna during the night of the same day.

Fig. 2: *Vespa velutina* specimen after species identification and prior to dissection (1 Euro coin as reference; diameter = 23.25 mm). © AGES/D. L. P. Schorkopf.

Body dimensions and general appearance

Although the body was at some points covered with dust-like dirt, no damages were seen on any cuticular structures. The wings had no signs of wearing as found for older queens or workers. No parasites or other organisms were observed on the specimen or in the transport vial. The 2.4 cm long specimen weighed 384.8 mg right after taking it out of the vial (hence, the fresh weight at time of capture was likely slightly higher).

Identification

Following the identification key of Archer (1989a) for the genus *Vespa*, the specimen was identified as *V. velutina* due to the following characteristics: (1) posterior ocelli closer to each other than to the eyes, (2) clypeus without a median tooth between the laterally produced margins, (3) head not strongly produced behind the eyes, (4) distances between lateral punctures on the second gastral tergum larger than puncture diameters, (5) pretegula carina incomplete, (6) inter-puncture distance more than puncture diameter at the centre of the clypeus, (7) clypeus without [distinct] black markings, (8) mesoscutal punctures separated by one puncture diameter, (9) gastral terga not entirely black beyond terga II, (10) no orange-yellow spot on either mesepisternum or mesoscutellum, (11) area around the ocelli black, (12) second gastral tergum with only a narrow yellow or orange band, (13) lower pronotum rugose, and (14) coloured areas of the head are yellow. Following the identification key of van der Vecht (1957), the specimen was further identified to subspecies level as *V. velutina nigrithorax* de Buysson, 1905 due to the following characteristics: (a) second abdominal tergite black with yellow or orange band at apical margin, (b) upper half of head mainly black, (c) femora I as a rule dark brown, (d) apical band of third tergite at least in the middle narrow, not distinctly wider than the band of the first tergite, (e) tergite 3 brownish in front of the apical narrow band, (f) visible part of tergite 4 entirely orange-yellow, and (g) thorax entirely black [= nigrithorax].

Dissection

After removal of a large portion of tracheal tissue, we were able to clearly see the gut containing dark/blackish material. First signs of decay were clearly visible during dissection, as expected from the conditions and duration of transport, though all organs of interest were distinctly visible. Ovarian tissues were present with oocytes in formation as well as a spermatheca. However, we were unable to conclude whether the spermatheca showed evidence for fertilization due to the signs of tissue decay. No obvious signs of parasitism could be observed on any tissues visible.

Discussion

The results clearly show that the insect caught in Salzburg on the 9th of April 2024 belongs to the species *V. velutina* (subspecies *nigrithorax*) which had not yet been reported for Austria. This triggered an alert of the Austrian authorities regarding the presence of this invasive alien species of environmental and economic importance (see also the paragraph below). The individual was a founder queen, most likely originating from established European nests. The precise origin of the queen remains for now unknown, though it seems likely that the sunny and warm weather contributed to the early Austrian discovery in spring 2024.

This first report of *V. velutina* in Austria, follows a quite long list of first sightings for Europe, beginning with France (2004, Haxaire et al. 2006), followed by Spain (2010, Castro et al. 2010), Belgium (2011, Moncousin 2011, Renneson et al. 2020), Portugal (2011, Grosso-Silva & Maia 2012), Italy (2012, Demichelis et al. 2014), Germany (2015, Witt 2015), Britain (2016, Budge et al. 2017), The Netherlands (2017, Smit et al. 2018), Switzerland (2017, SCNAT 2017, Amacher et al. 2021), Luxembourg (2020, Ries et al. 2020), Ireland (2021, Dillane et al. 2022), Hungary (2023, Márta & Vas 2023), and Czechia (2023, Walter et al. 2024).

Putative future invasion events in Austria

As *V. velutina* shows a fast invasion history in Europe (see Introduction), we expect that the invasion pressure will increase substantially for Austria in the next months and years, especially if nest densities in neighbouring countries continue to increase in border regions (2023: nest findings within 30 km of the Western Austrian and 20 km of the Eastern Austrian border). Due to the difficulties of finding nests and to destroy them efficiently prior to the dispersal of individuals capable of reproduction, particularly when all nests of a certain region are considered, data about the actual presence of *V. velutina* nests are imprecise. The previously mentioned "hitchhiking" of founder queens or nests represents another risk factor (Robinet et al. 2019). This is because hitchhiking events are unpredictable in time and space, which further impedes the precision of predictions regarding *V. velutina* invasions. However, it seems feasible that those Austrian border regions may be challenged more frequently which are closest to countries already invaded by *V. velutina*. This might seem particularly feasible for border regions, where areas of increased *V. velutina* suitability occur on both sides of the border. Particularly suitable areas are often urbanized and/or provide diverse-structured agricultural landscapes (see Introduction and

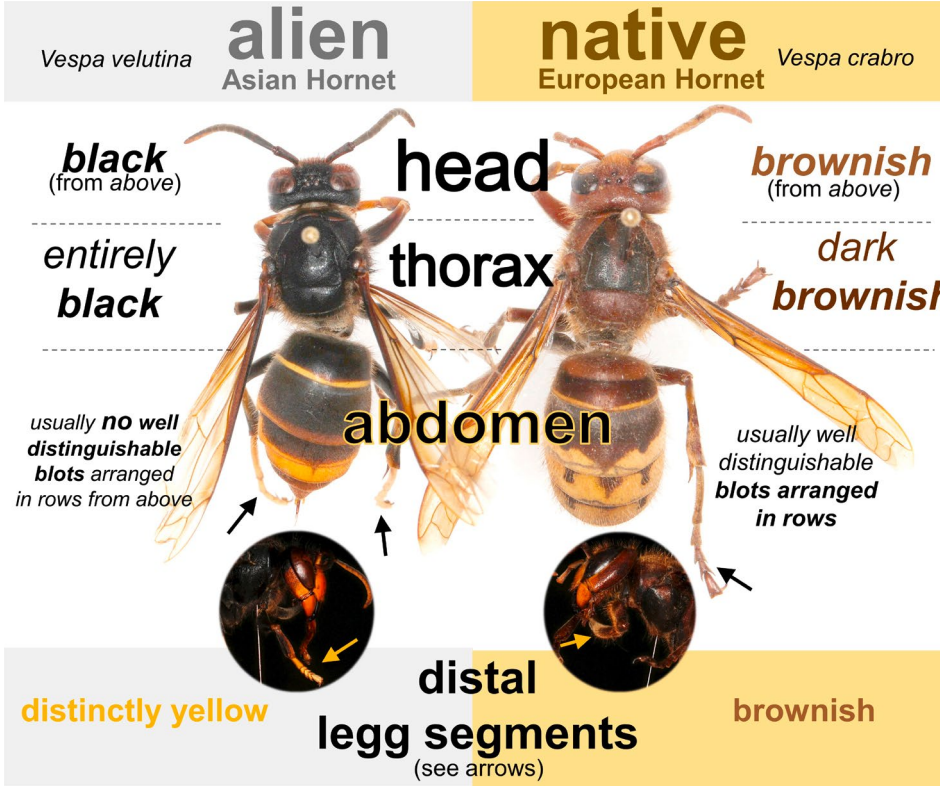

Fig. 3: Characteristics which enable discriminating the slightly smaller alien hornet (*Vespa velutina*) from the native hornet (*Vespa crabro*) at close range even without specific taxonomic or entomological knowledge. Note that some features can only be seen clearly under good light conditions and from the right viewing angle (e.g. from above). © D. L. P. Schorkopf (non-commercial use explicitly permitted for information purposes).

Fournier et al. 2017). Hot-spot areas of transport, such as motorways are also known to bear an increased risk for invasion by *V. velutina* (Bertolino et al. 2016, Verdasca et al. 2021). Hence, it seems to be less surprising if invasions occur under above described circumstances, such as happened with the herein reported case in the city of Salzburg.

Potential environmental and economic consequences

Precise long-term predictions for Austrian biodiversity, apiculture and agriculture would be speculative, already because much depends on which measures will be taken or neglected by the society and the authorities in case of continuous invasion pressure by *V. velutina*. However, we want to stress the fact that a significant amount of evidence is available for the consequences of a successful invasion by *V. velutina* which amounts to the advice not to ignore the risks for apiculture (Requier et al. 2024), fruit production and fruit processing agriculture and to some degree human health (see Fedele et al. 2019, Laurino et al. 2020, Lioy et al. 2022, and the references therein). It also seems noteworthy that fast, precise and efficient information on how to best detect, identify, report and combat *V. velutina* would profit society (Kennedy & Osborne 2023).

Additionally, this would protect native species that could find themselves in the crossfire of misunderstandings and imprecise combat measures, most evidently in the similar looking but regionally protected hornet species *V. crabro*. Information on how to distinguish *V. velutina* from *V. crabro* without a microscope is given in Fig. 3.

Conclusions

The first reported specimen of the Asian Yellow-Legged Hornet (*V. velutina*) in Austria was observed on the 9th of April 2024 in the city of Salzburg, the location being about 3 km away from the German border. All available evidence strongly indicates the singly found female individual being a founder queen. Since *V. velutina* nests commonly produce a great number of founder queens in autumn, it is likely that other founder queens have also reached Austria within the same period. Together with the fact that *V. velutina* nests were already reported in natural migration-relevant distance to other parts of the Austrian border (e.g. Hungary, Germany, Switzerland) in 2023, it seems therefore very likely that first reports of established nests from *V. velutina* in Austria will follow this report, as well as first active Austrian countermeasures against this serious invasive pest.

Zusammenfassung

In der vorliegenden Beschreibung des Erstfunds von *Vespa velutina* Lepeletier, 1836 (Subspezies *nigrithorax* du Buyson, 1905; der „Asiatischen Hornisse“) in Österreich werden die Umstände des Auffindens kurz beschrieben, gefolgt von der Beschreibung und Identifizierung der Spezies und Subspezies (bzw. Varietät). Der am 9. April 2024 in der Stadt Salzburg als *V. velutina* vermutete Fund wurde durch die Agentur für Gesundheit und Ernährungssicherheit (AGES) verifiziert, und der Fund sodann an das Bundesland Salzburg gemeldet. Bei *V. velutina nigrithorax* handelt es sich um eine invasive gebietsfremde Art von besonderer wirtschaftlicher und ökologischer Bedeutung (Laurino et al. 2020) und ihr Auftreten muss an die Europäische Union gemeldet werden (European Comission 2014, 2016). Eine Sektion des Hinterleibs zeigte im Ovar die beginnende Eientwicklung. Zusammen mit der Tatsache, dass das Tier im Frühling aufgefunden wurde, lässt auf eine nestgründende Königin schließen. Die Erfahrung aus den bereits betroffenen Ländern (Lioy et al. 2022) zeigt folgende Schlüsselfaktoren für eine erfolgreiche Eindämmung des Schadens durch *V. velutina* auf: eine ausreichend gut informierte Bevölkerung und eine rasche, koordinierte bundesländerübergreifende Meldungsstruktur sowie eine ausreichende Vorbudgetierung der notwendigen Bekämpfungsmaßnahmen. Der hier vorgelegte Bericht soll hierzu einen Beitrag leisten, auch weil andere heimische Insekten durch nachlässige oder nicht zielgerechte Bekämpfung beeinträchtigt werden könnten (Kennedy & Osborne 2023). So ist beispielsweise eine irrtümliche Bekämpfung der heimischen Hornisse *Vespa crabro* zu befürchten.

Author contributions

DLPS wrote the first manuscript draft, identified, dissected and described the reported specimen. GP discovered and secured the specimen and provided all information on the discovery. DLPS, CS, GP, and LM contributed to manuscript writing and interpretation of the findings. CS was responsible for efficient communication with the Salzburg

authorities to secure approval for transport to Vienna and thorough specimen analysis by AGES, coordinated by LM.

Acknowledgements

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