

Perspective: A review of the success of the UK strategy to tackle the invasive insect *Vespa velutina nigrithorax*, the “Asian hornet”.

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Interreg Atlantic Area project: Atlantic Positive – Conservation of Atlantic Pollination services and control of the invasive species *Vespa velutina*

Work-package 8; Action No. 1: Strategy to prevent the spread of *V. velutina* to the UK

To prevent *Vespa velutina* from spreading across the British mainland, avoiding economic loss and harm to biodiversity, this report describes action plans and specific measures for the British mainland and the maritime space between UK and mainland Europe.

The UK’s strategy to prevent the establishment of the Asian hornet, *Vespa velutina nigrithorax*, and/or manage its presence and impacts is embedded within the UK’s generic strategy for invasive non-native species, but specifically informed by the non-native species risk assessment for *Vespa velutina* and the pest-specific contingency plan for the Asian hornet. This report introduces relevant UK policies and legislation for invasive non-native species, before summarising the UK’s assessment of risk of entry, establishment and impact, and its rapid response plans addressing the Asian hornet’s periodic incursions in the UK. The report describes the effectiveness of those plans to manage and control the spread of the Asian hornet on the British mainland over the last seven years; and provides a reflection on the next steps required to ensure establishment is delayed as long as possible, while preparing for a time when the species may become established in the UK. The details may provide useful pointers for other European countries in which the Asian hornet is not yet established, but also incorporates suggestions for the UK based on actions from regions where the hornet has already become established.

Introduction

UK biosecurity policies addressing animal health, plant health, aquatic animal health (fish health) and bee health have been around for decades, but UK policies addressing invasive non-native species (INNS) are relatively more recent¹. There is some ambiguity on how authorities decide whether a species constitutes an animal/plant health issue or is an invasive non-native species (INNS): for example the Small hive beetle (*Aethina tumida*) – a coleopteran free-living predator/scavenger of *Apis mellifera*, *Bombus* spp. and *Melliponini* spp. brood - is defined as causing an animal/plant health issue; but the Asian hornet (*Vespa velutina nigrithorax*) – a hymenopteran free-living predator/scavenger with broad diet but known impact on *Apis mellifera* – is defined as an INNS. This can have significant

consequences in regard to the resources and agencies available to deal with these threats. Overall, expenditure on biosecurity in GB (England, Scotland and Wales) is estimated at £ 220 million per year, with the bulk of this expenditure on animal health (£ 200 million) followed by plant health (£ 13 million) and only small fraction (0.4%; £ 0.9 million) spent on INNS¹.

Invasive non-native species (INNS), equivalent to the term Invasive Alien Species (IAS) used by the United Nation's Convention on Biological Diversity or the European Commission, are defined as "any non-native animal or plant* that has the ability to spread causing damage to the environment, the economy, our health or the way we live", but the term is further limited to species "intentionally or unintentionally introduced outside their native range by human actions"². Consequently, the definition excludes species that naturally expand their range into a neighbouring country (even if as a consequence of climate change), but includes species that were introduced into a non-native country and subsequently spread naturally into neighbouring non-native countries³. Increasing globalization of trade and travel has greatly facilitated and escalated the spread of non-native species, with a proportion of these becoming established outside their native range, and a further subset able to spread and exert negative impacts in their new environment, and thereby become regarded invasive⁴. INNS are recognised as one of the top five threats to biodiversity, impacting and leading to the decline of native species through resource use, competition, predation, and transmission of disease, as well as disrupting ecosystems and ecosystem function. Economic costs alone are estimated to be at least € 12.5 billion per year (probably over € 20 billion per year) in Europe⁴ and £ 1.84 billion per year in Great Britain².

A number of recent studies have reported a dramatic global rise in INNS, with no evidence that INNS are reaching levels of saturation and many such taxa even showing increases in establishment in recent years^{4,5,6}. Alarming, Seebens *et al.* (2020) predict that emerging alien species will rise globally by about 35% between 2005 and 2050, with Europe expected to top continental rankings with an estimated 2,500 additional alien species by 2050. Not all alien species are likely to become invasive, with Williamson's⁷ "ten rule" providing a rough rule of thumb: 10% of introduced species will become established, and approximately 10% of those species will become invasive. In Great Britain, there were 3,248 non-native species listed in 2021, of which 2,016 were classified as established (self-sustaining in the wild), of which 187 are considered to be invasive, i.e. exert a negative impact on biodiversity³. It is estimated that currently ten new species become established in the UK each year, with 10-20% becoming invasive; approx. 40 INNS are expected to become established in Great Britain in the next 20 years¹. Reviewing changes in INNS in Great Britain since 1960, the UK Biodiversity Indicators 2022 summary report describes the long-term trend as "deteriorating", and a recent House of Commons Environmental Audit Committee report¹ is critical of the UK Government for missing its legal targets on invasive species and not allocating the subject the priority and funding needed to address the threat of INNS.

* Other definitions often include fungi, micro-organisms, and pathogens, but the UK has to date dealt with these under its other biosecurity policies. However, there are calls for such policies to be joined-up more in the future.

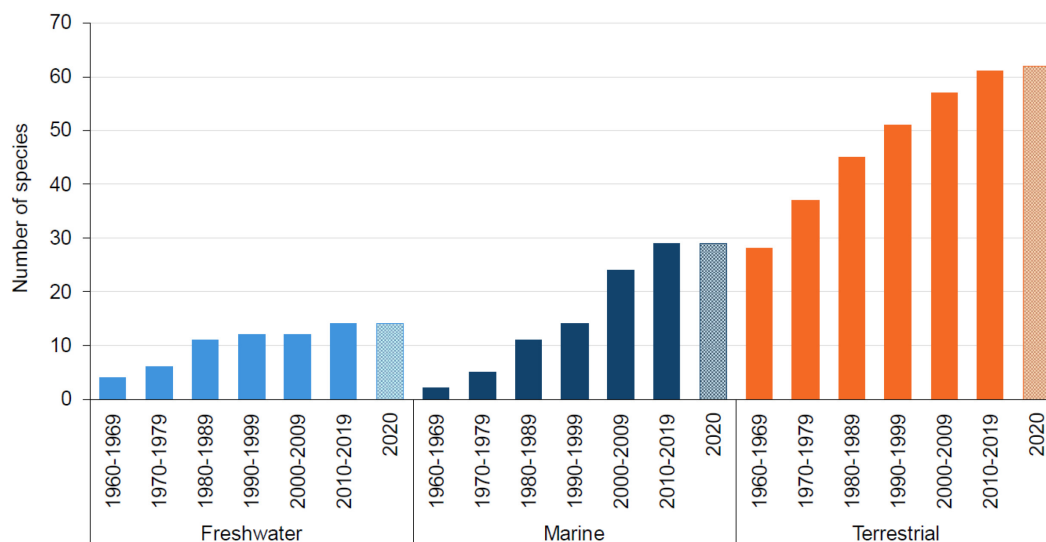


Figure 1. Number of INNS established in different environments in Great Britain.
Source: ref 2.

GB Invasive Non-Native Species strategies

In Great Britain, strategies addressing Asian hornets (*Vespa velutina nigrithorax*) are covered by the generic strategies addressing all INNS. These were derived following a fundamental review of the UK's Department for Environment, Food & Rural Affairs' (Defra) non-native species policy, the report of which was published in 2003; soon after the United Nation's Convention on Biological Diversity implemented article 8(h) "recognizing that invasive species represent one of the primary threats to biodiversity" and "that risks may be increasing due to increased global trade, transport, tourism and climate change"⁸. Based on the recommendations of the 2003 report, the GB Non-Native Species Secretariat (NNSS) was formed as the designated lead organisation to coordinate Great Britain's approach to invasive non-native species, reporting to relevant governments and agencies in England, Scotland and Wales via the Non-Native Species Programme Board (NNSPB). Key actions assigned to GB NNSS included development of risk assessment procedures to assess the risks posed by non-native species and prioritise actions, of codes of conduct to prevent introductions, of targeted education and awareness strategies, and to establish adequate monitoring and surveillance mechanisms. It also led to the publication in 2008 of the 'Invasive Non-Native Framework Strategy for Great Britain'⁹, in recognition that more co-ordinated and structured approaches were required to reduce introductions, enable more rapid detection of potentially invasive non-native species and make better use of existing resources.

To assist an objective, evidence-based approach to determine the likelihood of entry, establishment and spread, and associated potential biological and economic consequences, of a non-native species in Great Britain and thereby prioritise use of finite resources, the GB NNSS initiated a risk assessment process for existing and potential INNS in 2007² (see 'GB Risk Assessment for *Vespa velutina*' below). In recognition of the Great Britain risk assessment for INNS being substantially compliant (alongside EPPO Decision-Support Scheme for Pest Risk Analysis, Hamonia+, and ENSARS) with minimum standards set by the EU¹⁰, many aspects of the GB risk assessment were also included in the EU IAS risk assessment scheme.

The 2008 and subsequent revised and relaunched 2015 'Great Britain Invasive Non-native Species Strategy'¹¹ have more recently been updated by the 2023 published 'Great Britain Invasive Non-Native Species Strategy 2023 to 2030'². The period since 2008 has enabled significant improvements, especially via the development of strong partnerships across government, industry, non-government organisations and other stakeholders. Other improvements are the establishment of the Non-Native Species Information Portal (NNSIP) as a central repository for GB NNS information and distribution data, the publication of 120 risk assessments on non-native species, the successful eradication of four INNS[†], the ongoing eradication of four other species, expansion of INNS awareness campaigns amongst the general public and relevant stakeholder groups, and assessing the economic damage caused by INNS - now recognised as an annual cost to the British economy of £1.84 billion. The new 2023 strategy sees greater emphasis placed on analysing and prioritising pathways of introduction, developing generic contingency plans to address INNS incursions (five generic contingency plans are already in place for England, although the terrestrial invertebrate generic contingency plan is still in development¹²), and evolving risk analysis mechanisms to prioritise species for eradication based on cost, risk and feasibility.

The UK Government also significantly contributed to arguments in favour of collective action across Europe to address INNS, leading to the European Union's Invasive Alien Species Regulation (EU) No 1143/2014¹³ coming into force in 2015. The principal legislation in Great Britain dealing with NNS is the Wildlife & Countryside Act (WCA) 1981¹⁴, which has for some time already made it illegal to release into the environment any animal or plant which is not ordinarily resident in Great Britain. Despite the withdrawal of the UK from the European Union in 2020, under the concept of 'retained EU law' many EU regulations remain in place for now[‡], including Regulation (EU) No 1143/2014.

GB Risk Assessment for the Asian hornet, *Vespa velutina*



Figure 2. The Asian hornet, *Vespa velutina nigrithorax*, foraging on ivy.

Great Britain published its NNS risk assessment on *Vespa velutina nigrithorax* (the Asian hornet)¹⁵ in 2011, well before this non-native species reached Great Britain. This risk assessment also served as the foundation for the EU risk assessment on Asian hornets and the subsequent decision to include Asian hornets within the first adopted list of invasive alien species of Union concern (the first insect to do so)¹⁶. The GB risk assessment explores the pathways and probability of entry, probability of establishment, spread, and an assessment of the economic, environmental and social harm caused by the species. It concluded, with low levels of uncertainty, that the Asian hornet was very likely to enter Great Britain with multiple pathways of entry being plausible, was very likely to establish, and would spread rapidly if allowed to establish. Specifically on pathways of entry, review of the known literature and experiences from the invaded range prior to 2011, placed the likelihood of entry as 'high/very-likely' for natural spread by flight

[†] African clawed toad (*Xenopus laevis*), Fathead minnow (*Pimephales promelas*), Black bullhead (*Ameiurus melas*), and American bullfrog (*Lithobates catesbeianus*).

[‡] Until the Retained EU Law (Revocation and Reform) Bill comes into force.

(especially as the Asian hornet was already present in at least one northern coastal area of France) and for entry of overwintering queens via importation of wood and wood products^{15,17}. Entry of overwintering queens via importation of man-made goods and entry of adults via importation of fruit/plant products were considered of intermediate (likely) risk; entry of overwintering queens via importation of soil and entry of queens or adults via movement of freight containers/transport vehicles were considered as low (moderately likely) risk. Movement of honey bees into Great Britain was considered to pose very low risk of Asian hornet's entry as rarely associated with the insides of hives and likely to be spotted during inspections. Based on this risk assessment and a review of management options, the NNSPB concluded that it was unlikely that methods could be deployed to prevent Asian hornets entering the UK, and instead recommended measures were put in place to detect early, rapidly intercept and prevent establishment via effective nest and colony destruction of the hornet. Although much has been learned since on pathways of entry and spread of Asian hornets, the NNSPB's conclusion still holds. If efforts to detect, intercept and prevent establishment fail, the plan would then move to containment and, if number and extent of outbreaks indicated, longer term management and guidance on control methods at apiaries. These recommendations were encapsulated in an initial response plan (for England and Wales) published in 2012¹⁸, that have since been reviewed and updated in 2017¹⁹ and, recently, in 2023²⁰.

Asian hornet Response / Pest-Specific Contingency Plans in the UK

Soon after the publication of its risk assessment for Asian hornets, the UK was unique in Europe by drawing up a response plan (initially for England and Wales)¹⁸, to describe the UK government's response to the potential arrival and spread of Asian hornets before this INNS had arrived in the country. Largely due to the rapid spread of Asian hornets across France, their imminent arrival in the UK was anticipated approx. 5 years before it actually happened. For the initial response plan, the main impacts were perceived to be honey bees and beekeeping, due to Asian hornet predation, and to people, should these inadvertently disturb an Asian hornet's nest. The former has been modified in the most recent contingency plan, with its aim broadened "to protect insects and particularly pollinators"²⁰, as evidence has emerged of the breath and disruption to other pollinators caused by Asian hornets. Much of the response plan was devoted to defining roles and responsibilities, and clear lines of communication, between government, agencies, non-government organisation, and stakeholders – areas that have been frequently overlooked elsewhere and resulted in costly delays in decision making and freeing necessary resources. As prior to the establishment of the EU Regulation on IAS (No 1143/2016), the initial response plan relied on voluntary action (e.g. voluntary cooperation of landowners to permit nests destruction) as neither domestic or European legislation required control of Asian hornets (as it was not a designated statutory pest of honey bees), but this has since been rectified by the Infrastructure Act 2015 enabling emergency provisions for species control agreements and orders under the Wildlife and Countryside Act 1981. Further, Asian hornets are now considered "species of special concern" in the UK and are subject to retained EU legislation and the UK's Invasive Alien Species (Enforcement and Permitting) Order 2019.

The first UK nest of Asian hornets (Tetbury, Gloucestershire; September 2016) and following annual incursions have given opportunity to learn from direct experiences and knowledge acquired to update the initial response plan with revised pest-specific contingency plans (published 2017 & 2023). The Asian hornet response/contingency plans are designed to meet the principles of government response to emergency situations, and specifically aim to protect insects and particularly pollinators from the Asian hornet. They encompass the following sequential objectives:

1. Early detection; detection of Asian hornet presence as soon as possible;
2. Interception and preventing establishment;
3. Eradication of any outbreak, if considered practicable;
4. Containment and controlling an outbreak within a limited geographical area;
5. Establishing long-term management of Asian hornets where eradication and control is no longer possible due to the number and extent of outbreaks.
6. Aiding the beekeeping industry, pest controllers and local authorities in the form of training on pest and disease control

As Bee Health policy is a devolved topic, an Asian hornet outbreak in a GB country is the responsibility of either Defra, Welsh Government, Scottish Government or Department of Agriculture, Environment & Rural Affairs, Northern Ireland, respectively, depending in which country the outbreak occurs. Similar contingency plans exist across all GB countries. The Lead Government Department (LGD) is responsible for the overall strategy, but decisions such as moving from eradication to containment or to long-term management would be made by a Government minister, with advice from senior relevant civil servants. Both Scotland and Northern Ireland, now have similar contingency plans^{21,§,22} to those of England and Wales.

To address early detection, the Non-Native Species Secretariat (NNSS) and the Animal & Plant Health Agency's National Bee Unit (APHA-NBU) provide information on Asian hornets, including identification factsheets and downloadable alert posters, on their websites and hold periodic public and stakeholder events to raise awareness amongst various sectors. Beekeepers and bee farmers have and continue to receive training and advice from the NBU on how to recognise and best monitor for Asian hornets, but since 2017 British beekeepers have also coordinated their own groups of volunteers within their various associations into Asian Hornet Teams (AHTs) to augment the public engagement efforts of the NBU and to assist in monitoring for the presence of Asian hornets²³. There are currently 966 volunteers spread across 148 distinct Asian Hornet Teams, coordinated by the British Beekeepers' Association, in England alone. Both NNSS and beekeeping associations issue press releases aimed at raising awareness amongst the general public of the Asian hornet, the threat it poses and how the public may assist by reporting any suspected presence, often timed to coincide with spring emergence of overwintered queens and past sightings of mature nests. The British Beekeepers' Association also hold an annual Asian hornet conference aimed at beekeepers and AHT members, as well as an annual Asian hornet awareness week aimed more at the general public. In addition, there are 120 "sentinel apiaries" in England & Wales (typically placed near risk areas e.g. marine ports, airports, & major distribution centres) in which beekeepers have agreed to voluntarily screen colonies for statutory exotic pests for the NBU according to standard protocols. Exotic pests monitored include Asian hornets, using traps modified to maximise Asian hornet capture while minimising impact on other insects – an important factor in countries where the Asian hornet is not established yet and other insects would make the bulk of insects caught in such traps. Various non-government organisations, especially those involving members surveying nature e.g. Bees, Wasps & Ants Recording Scheme (BWARS), Hymettus Ltd, Bumblebee Conservation Trust (BBCT), the Royal Horticultural Society, the Royal Society for the Protection of Birds (RSPB), and the British Association for Shooting and Conservation (BASC), are aware of Asian hornets and encourage their members to report sightings.

The preferred method for reporting sightings is via a specific mobile reporting app developed for the UK: the [Asian Hornet Watch](#) app²⁴. This app provides identification details & images of the Asian hornet and of native species often confused with Asian hornets. It also enables a sighting to be

[§] The Scottish Government's Asian hornet contingency plan is currently being reviewed.

submitted (ideally with a photograph) alongside date, location (using GPS location features on smart phones), indication of number seen and additional comments. For those unable to access the app, there is also an online reporting form or an email address to which details with a photograph can be submitted. Suspected sightings are triaged by expert volunteers and the UK Centre for Ecology and Hydrology (CEH) within one working day and credible sightings passed on to the NNSS and NBU. Sightings are considered credible if they include a photograph recognisable as an Asian hornet, or otherwise include strong supporting evidence.

Based on past successes in locating nests when present, the follow-up to a credible sighting is initiated by the local team (closest to the sighting) of NBU bee inspectors. The bee inspectors will gather background information from the person who submitted the sighting and search the site and surrounding area up to a 500m radius for signs of adult hornets or nests. A surveillance area covering a min. 20 km radius is established, but apiary inspections prioritised within a radius of 2 km. If foraging Asian hornets are seen in the surveyed area, NBU's bee inspectors deploy bait stations, visit nearby apiaries, and use an ArcGIS-based app ("Track & Trace") to log locations of sightings, and flight directions and flight return times of marked hornets in efforts to triangulate and close in on a nest location. The Head of Bee Health Policy and Head of NBU are kept informed on progress on a daily basis. All known beekeepers within 20 km of a sighting are informed via an alert, and beekeepers within 5 km are actively encouraged to monitor for the presence of hornets. Local beekeeping associations and AHTs work collaboratively with the NBU bee inspectors, by monitoring in their own apiaries, observing insect visitation of local forage for signs of Asian hornet activity, and providing local knowledge to the NBU. Additional national NBU & APHA team members can be brought in, especially if the search takes longer than a week or submitted credible sightings indicate the outbreak is no longer considered isolated. Decisions to escalate the response are made by the national control centre in consultation with the relevant LGD.



Figure 3. Marked Asian hornets at a bait station (wick pot) on Jersey.

Once a nest is located, the local team inform the national control centre and the LGD, and arrange for the nest's destruction by trained professionals from National Wildlife Management Centre (NWMC; part of the UK's Animal & Plant Health Agency). Nest destruction via chemical treatment (e.g. 0.5% permethrin; Vulcan P5 DP) is typically completed in the evening of the day the nest is located, with the nest removed and sent for diagnostic analysis to FERA Science Ltd the following morning. Nest dissection and microsatellite analysis enables confirmation of the growth/reproductive stage of the colony at the point of destruction, its genetic diversity, its likely source of origin and its genetic relatedness to previous UK nests²⁵. All UK colonies to the end of 2022²⁶ had stemmed from the invaded European zone (rather than the Asian hornet's native range), had low genetic diversity with the majority of queens mated with one or two males, and were not directly related to any previous UK nests^{25,27}. On two instances (Fowey 2018 & Christchurch 2019), when two nests were found in relative proximity to one another, these were confirmed as primary and secondary nests of the same colony. Consequently, the evidence to date suggests that the UK colonies originated from separate

incursions from the European continental population and lends support to the current view that a population has not yet established in the UK.

Surveillance at a sighting location and surrounding areas remains in place until a successful eradication, and continues until the end of the season (if the nest is located relatively early in the season; or continues until the next season if reported late). Such surveillance includes the use of monitoring traps, where these and guidance on their correct use are provided to beekeepers within 5 km of a sighting and are encouraged to be used by beekeepers within 20 km of a sighting. Risk analyses and modelling are updated after confirmed incursions to predict the potential spread from points of entry and to assist in targeting future inspections.

There is currently no clear guidance on how criteria will be used to decide a change in policy from eradication to containment or long-term management of the Asian hornet as this is considered an evolving area. Nevertheless, it is likely to be based on the number of nests detected, their geographical distribution, the time taken to detect the nests, and an assessment of the viability of eradication provided by the national control centre to senior officials and the LGD²⁰. It is expected that operational agencies will re-focus their activities on providing technical advice and training for beekeepers, pest controllers and local authorities for these to take on aspects of Asian hornet confirmation and control²². It is possible that the treatment of nests will be passed to professional pest controllers, with the costs of such treatments carried by the land/property owner^{18,27}. As things stand at present, UK authorities believe they can continue to manage the levels of incursions seen to date but, as the Asian hornet spreads in Europe, an increase in incursions to the UK is anticipated.

Effectiveness of the UK's plan

Although Defra and NNS acknowledge that the UK's long-term record concerning pressure from invasive species overall (UK Biodiversity indicator B6) is deteriorating and urgently needs improving, they do consider the UK's response to Asian hornets, to date, as a success².

This section reviews the success of UK's action in regard to the Asian hornet against each of the objectives of the pest-specific contingency plan, establishing where the UK is on the expected invasion curve (especially England and Wales). To date (May 2023) there is evidence of success in achieving Objectives 1-3 (any known outbreaks have been eradicated) and no evidence that the hornet has established in any defined geographic area of the UK, so Objectives 4 -6 have not been initiated.

1. Detecting its presence as soon as possible

- **Reporting of visual sightings:** The UK contingency plan is reliant on the public and stakeholders noticing, recognising and reporting sightings of Asian hornets as soon as they are observed. The reporting process has been greatly improved by the release of the reporting Asian Hornet Watch app in 2017²⁴, prior to which sightings were reported largely by email to a central non-native species alert address, with emails rarely including all required details. On average, there are about 6000 alerts of Asian hornets reported annually, of which an average of four (0.06%) are subsequently confirmed to be Asian hornets. There was a particular spike in alerts submitted in 2020, but many of these can be explained by the New York Times' article on "murder hornets" (*Vespa mandarinia* in north-western America) on 2 May 2020 and the subsequent follow-up articles in the UK press which confused accounts and pictures of *V. mandarinia* (not found in the UK) with *V. velutina*.

Table 1: Number of sighting alerts received and of subsequently confirmed sightings of Asian hornets in the UK.

Year	Alerts received	% via app or online form	Confirmed sightings	% confirmed AH of alerts received
2016	n.d.	-	4	-
2017	3585	33%	2	0.06%
2018	8011	33%	10	0.12%
2019	6702	55%	5	0.07%
2020	9592	73%	1	0.01%
2021	5502	73%	2	0.04%
2022	4918	77%	4	0.08%
Average =	6385	57%	4	0.06%

Source: Semmence (2023) (ref. 27), augmented with information from Appendix 1.

Nevertheless, a lot of native insects are confused by both the public and beekeepers, despite publicity campaigns, outreach activities and providing visual guides to common look-a-likes on the Asian Hornet Watch app. The most common native insect confused with the Asian hornet is the European hornet *Vespa crabro*, but the Hornet mimic hoverfly *Voluzella zonaria* and Giant woodwasp *Urocerus gigas* are also commonly confused with the Asian hornet²⁸. The stated preference for people to include photographs with their sighting reports (approximately 60% have²⁷) has been invaluable in enabling received alerts to be triaged and thereby managing the resource required to follow-up such sightings. In a typical year, approximately 100 credible sightings (~17%) are passed on to the NBU and local AHTs to investigate and confirm²⁷. The fact that < 0.1% of reported sightings by the public (including beekeepers) are Asian hornets does, on one hand, demonstrate the public engage with the issue but, on the other hand, indicate there is much scope for improvement and further need for public education. A recent Environment Audit Committee report¹ recommended that the UK government “should significantly expand its approach to public engagement” and utilise the “biosecurity citizens’ army” to boost the fight against priority species. This especially in regard to the identification and reporting of invasive species.

- **Automated detection:** There is also potential for technology to assist with the detection and identification of Asian hornets with the development of automated sensory devices linked with artificial intelligence to detect and identify the presence of an Asian hornet at a location without trapping native insect by-catch^{29,30}. The University of Exeter has recently received UKRI (UK Research and Innovation) funding in support of development of such a device.

2. Intercepting and preventing establishment

- **Interception of confirmed sightings:** Between 2016 to 2022, there were 28 confirmed/credible sightings of Asian hornets in the UK (see Appendix 1). Not all sightings are related to the presence of a nest: Thirteen sightings led to the subsequent confirmation of further hornets present and on to the discovery of their nest, but the remaining 15 sightings related to single individuals (except one recorded sighting of two males reported separately but closely within the same Dungeness area) where no further hornets were located despite close extended surveillance in the areas. Of the 15 single-hornet sightings, six were early-season and suspected or confirmed to have been queens, and three were of males (August – October).

Given that genetic analysis of UK Asian hornet nests finds no evidence of nests from different locations being related to one another and that continuing close surveillance in areas where

sightings, including nests, had been located largely** found no further signs of hornet activity, it is reasonable to conclude that the UK has been successful in detecting the presence of Asian hornets in the UK to date. The absence of Asian hornet sightings via other national surveys, such as the citizen science Big Wasp Survey (www.bigwaspsurvey.org), the BBCT's BeeWalk (www.bumblebeeconservation.org/beewalk) and the records submitted to the volunteer Hymenoptera recording scheme of BWARS (www.bwars.com) also provides no indication of an established population of Asian hornets in the UK. There is an underlying nervousness, especially amongst beekeepers, that not all hornets that have entered the UK may have been detected (a known unknown) but there certainly is no current evidence to support this.

- **Geographic spread:** Confirmed Asian hornet sightings in the UK have been reported over a wide geographic area with adult Asian hornets reported from the Central Belt of Scotland to mid-Channel between England and France, and from Felixstowe, Essex to Fowey, Cornwall. All nests to date have been located in southern England (below latitude 52.6 north, approximately equivalent to Amsterdam and Berlin on the European mainland), but previous reports of Asian hornet nests in Hamburg demonstrate that this species can survive and reproduce at a latitude of 53.5 north (equivalent to Sheffield and Manchester). Villemant *et al.* (2014)³¹ summarised that many countries of Western Europe were predicted, based on climate suitability models, to be at risk from an expanding French population of Asian hornets, especially along Atlantic and Mediterranean coasts, with reduced risk only for dryer southern countries. Such modelling certainly indicates that much of England and Wales would provide suitable climate for range expansion into the UK.
- **Pathways of entry:** In some instances, background information from those making reports and/or information on the proximity of sightings to risk areas has provided some insight (although rarely direct evidence) to pathways of entry into the UK (see Appendix 1). In line with the UK risk assessment placing timber imports as a very likely pathway of entry, the first nest in the UK (Tetbury 2016) can be speculatively linked with a timber merchant who regularly received shipments of green oak from the Loire valley and other parts of France. On the other hand, evidence for entry by natural flight – another pathway of entry deemed as very likely – is understandably sparse. To date there was only one event (Dungeness 2018, following a storm from a SSE direction) when two male Asian hornets are thought to have been blown across the English Channel. There are number of sightings near shipping ports that give credibility to shipping traffic and imported goods being important as routes of entry, but two sightings of Asian hornets observed on ferry mid-channel do open consideration of Asian hornets flying away from the European coastline hitching a ride on shipping traffic in the English Channel and potentially continuing their journey as they approach another coastline. Off the Channel Island of Jersey, there was at least one report of a recreational sailing vessel noting the arrival and subsequent departure of a hornet on the boat while travelling in waters between France and Jersey³². Hornets that are not enclosed inside imported goods, freight or tourist vehicles could therefore easily bypass any border control points. In practice, only a sample of imported goods, freight and tourist traffic are likely to be checked at border control points and these not necessarily for Asian hornets given the diversity of INNS and illegal contraband that border officials needs to be alert for (in the European Union, with free movement of goods a keystone to its internal market, goods are only likely to be inspected where there is a clear association of such imports with the movement of INNS; none such exists for Asian hornets). A new UK NNS

** Other than on two occasions when continuing surveillance revealed either the primary or secondary nest to the previous nest of the same colony at a location (Fowey 2018 and Christchurch 2019).

Inspectorate, setup in 2023, has recognised the need for increased inspections at the UK border and post-border², but it is still unclear what this would like as any significant delay in goods passing through borders would impact trade. It is clear that there are multiple pathways of entry available to Asian hornets (e.g. imported goods including within winter-grown vegetables, on or in freight vehicles, goods or packaging, in tourist equipment & vehicles) with the final destination potentially anywhere (e.g. supermarket goods imported by lorry to a distribution centre in Scotland), confirming the conclusion by the NNSPB that preventing entry was unlikely and the contingency plan should focus on a rapid response to reported sightings.

3. Eradicating any outbreak if considered practicable

- **Eradication of nests:** When Asian hornet activity (involving more than an individual hornet) in an area has been confirmed, NBU bee inspectors have typically been able to locate the associated nest within three good-weather (permitting regular hornet activity) days from initiating their track & trace efforts at a location. An exception to this was the first nest in 2016, which took approximately 1 week to locate, partly due to search methods not having been refined. The track & trace method relies on visually observing and triangulating hornet departing flight directions from various foraging and bait-station locations until the likely location of the nest has been sufficiently reduced to enable it to be found. In more complex environments e.g. woodland, the NBU have other techniques e.g. radio-telemetry³³ available to assist them with locating a nest, but to date have only called upon this on one occasion (Brockenhurst 2018)³⁴. All thirteen nests found to date in the UK were found via rapid response activities and no further nests have been revealed, e.g. following leaf fall in winter.



Figure 4. A radio-tagged Asian hornet returning to its nest (Brockenhurst, 2018); the lower part of the nest was damaged in a recent storm. Insert: close-up of the tagged hornet.

What happens next?

No clear trend in the number of confirmed sightings or Asian hornet nests in the UK is apparent across successive years to date (Table 2). It thus appears that England and Wales have not yet reached the point at which outbreaks need to be contained in large geographic areas thanks to the level of surveillance and the rapid response to hornet sightings and eradication of nests. However, it is pertinent to consider the level of pressure that may transpire when the hornet does establish in a

geographic region. Table 2 shows the low and relatively stable number of UK nests compared to the increasing trend in nest numbers in neighbouring regions, e.g. the Channel Island of Jersey, the French (Normandie) Department of La Manche and Flanders in Belgium.

Table 2: Reported Asian hornet nests in 4 regions of Europe

Year	S. England	Jersey	La Manche	Flanders
2016	1	0	869	0
2017	1	15	1,447	2
2018	4	53	5,897	42
2019	2 ⁺	83	2,503	34
2020	1	28	4,034	135
2021	2	63	4,139	264
2022	1	174	9,924	1,150 [*]
Area (km ²)	64,042	120	5,951	13,625
2022 nests/km ²	< 0.01	1.45	1.67	0.08

⁺ Three nests were found in the UK in 2019, but only 2 in southern England (Drayton Bassett being in the Midlands).

^{*} Official nest records end October 2022, as government support stopped, but it is estimated that another 300-600 nests were located subsequently, i.e. a total of ~1500 nests or 0.11 nests/km² (Dominique Soete, pers. comm.)

We can therefore look to Jersey and to the North of France, and Belgium to consider how quickly populations grow when the hornet becomes established in an area.

- **Jersey:** Asian hornets were first sighted in Jersey in late 2016 but a nest could not be located. Consequently, their efforts to systematically locate nests started in 2017, from when they adopted a similar rapid response to the Asian hornet as the UK. Jersey has since become a pioneering ‘test-bed’ for developing techniques to locate nests and a location often utilised by the devolved agencies of the UK to train their field staff. A small but dedicated group of volunteers (the Jersey Asian Hornet Group) have worked closely with, and under the authority of, the States of Jersey and through active engagement with the public to search out nests via a track & trace approach. Although their efforts have been regarded as successfully up to 2021, the proximity and close connections of Jersey to Normandy and Brittany likely favour an annual reinvasion from France such that numbers are gradually rising (in 2023, up to end of May, 250 queens have already been caught indicating a significant rise likely this year; Alastair Christie, pers. comm.).
- **La Manche, France:** Asian hornets initially arrived in the Normandy department of La Manche in or before 2011 but collective efforts, coordinated by FDGDON La Manche, to destroy nests were not begun until 2016³⁵. Since then many municipalities and communes in La Manche subscribe to collective action by which FDGDON collates reports of observed nests and organises for trained and collectively subsidised pest controllers to destroy the nests. There is no coordinated action to locate nests; this is typically left to beekeepers and others to arrange themselves. Hence, many nests are reported following chance observations and numbers located are likely an underestimate of those present. Nest densities vary greatly across the department with Donville-les-Bains and Cherbourg-en-Cotentin reporting amongst the highest densities with 14 and over 10 nests per km², respectively, in 2022.
- **Flanders, Belgium:** The first report of an Asian hornet in Belgium was of a male in 2011, but no further sightings were reported until a nest was located in Wallonia, close to the boundary with

Flanders in 2016. The first nests in Flanders were reported in 2017. A citizen science project, Vespa-Watch, was initiated in 2018 through financial support from the Flemish Government to Honeybee Valley and the Institute for Nature and Forest Research (INBO). This has arranged a reporting scheme for sightings, offered training and coordinated activities towards actively searching for nests not that unlike those efforts in Jersey and the UK. Government support for the project ended at the end of October 2022 leading to intense negotiations of how ongoing efforts will be supported (in 2023, up to end May, there have already been 2000 queens caught and 150-250 nest located (Dominique Soete, pers. comm.), indicating a sharp rise in Asian hornets sightings in this year).

- **The UK:** Although there are differences in approaches to managing the Asian hornet population in these regions, it is likely that the lack of a land border and the width of the English Channel is a significant contributor to sightings and nest numbers in the UK not following similar rising trends as seen in these regions. It is testament to the success of the UK's rapid response that a population of Asian hornets does not seem to have established here yet. The UK Centre for Ecology and Hydrology (CEH) ran models to predict the extent of Asian hornets would have spread by 2026 if nests and hornets located between 2016 and 2021 had not been eradicated². The predicted spread indicates that much of southern England and Wales would be highly likely to have been invaded, with the spread potentially extending to northern England and Scotland (see figure below).

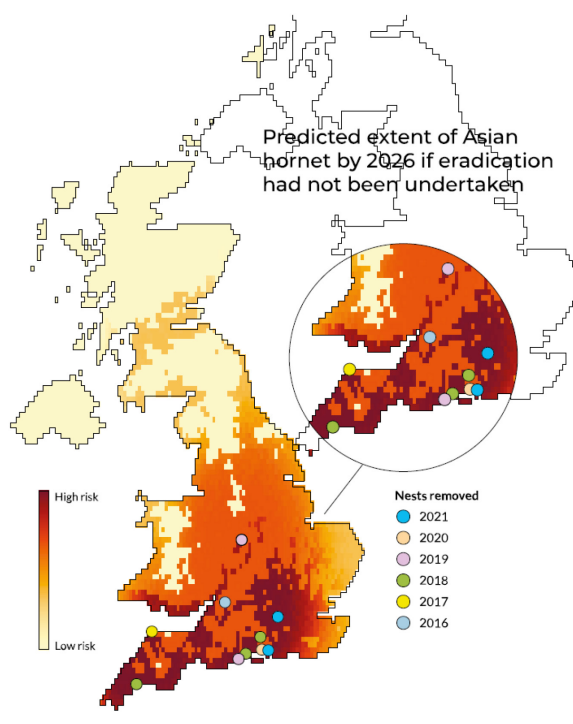


Figure 5. Map of the UK showing the predicted extent of Asian hornet spread by 2026 if eradications had not been undertaken and the location of Asian hornet nests that have been identified and removed between 2016 and 2021. Source: Ref 2.

So far, the UK pest-specific contingency plan for the Asian hornet therefore appears to be working well and the numbers of nests found each year is not increasing, despite the density on mainland Europe increasing many-fold within that time.

Suggestions to strengthen the contingency plan for future resilience

Given the success to date of eradicating Asian hornet nests in the UK when they have been discovered, is the current contingency plan fit for future purpose or does it need further refinement?

The evidence above suggests it is robust, and working so far within the context of the UK, i.e. with no land border with a region in which Asian hornets have become established. Where there is a sea-barrier to dispersal, the success of natural spread via flight will likely depend on distance and weather patterns. The successful eradication of Asian hornets from Balearic Island of Majorca³⁶, approximately 175 km SSE of Barcelona, after concerted efforts by the local authorities to eliminate nests as quickly as possible, likely also benefited from distance minimising the propagule pressure and hence re-invasion⁴. Although Asian hornet workers are capable of flying a total of 10 – 30 km per day³⁷ and gynes an average of 18 km per day³⁸, in the laboratory on flight mills, there is no published data on the maximum length of uninterrupted flights Asian hornets are able to fly (during the flight mill tests, hornets were rested and fed every hour). Marris, Brown & Cuthbertson (2011)¹⁵ refer to unpublished laboratory data that “suggests that males can fly dozens of km in one flight and workers several km” but queens/gynes were untested. Nevertheless, sightings of males at Dungeness (approximately 42 km from France) may suggest that they could use strong winds to aid flight, although it cannot be discounted that their arrival was not partly aided by shipping. On Jersey, there is a strong suspicion that an annual spring influx of spring queens on eastern coastline, following strong easterly winds, is linked with a French Asian hornet population in Normandy, approximately 25 km away (possibly aided by the small islands/rocks of The Écréhous halfway between). Human-mediated dispersal by Asian hornets is likely to contribute to the spread of Asian hornets³⁸, and especially so for countries like the UK prior to the hornets becoming established on the island. Propagule pressure via the multiple routes of entry is likely to increase as the Asian hornet spreads within Europe, especially to those region with which the UK has active trade and tourist connections, making even a low risk of entry more likely in future. There is still opportunity to strengthen the plan, including in regard to the last three objectives when required i.e. containing Asian hornets when established within a defined geographic area, establishing long term management and providing longer term assistance to stakeholders.

Improving the current procedures for preventing establishment:

- **Improve efficiency of finding hornets** by having more robust and widespread surveillance to ensure hornets are sighted. As already identified by the NNSPB, strengthened biosecurity at ports alone is unlikely to make a significant difference to the risk of entry by Asian hornets. The new UK NNS Inspectorate aim to increase border inspections to manage pathways of entry in line with the recent review of unintentional introductions and spread of INNS³⁹, but only one (“other stowaways”) of the 10 priority pathways identified is likely an important pathway of entry for Asian hornets, demonstrating how the Inspectorate’s role is spread thinly across a multiple current and prospective INNS.
- **Widen the publicity campaign:** The Environmental Audit Committee (a select committee of cross-party Members of Parliament tasked with auditing the performance of government departments on issues of environmental protection and sustainable development) has already urged the UK Government to significantly expand its efforts to engage the British public by raising awareness of the impact of INNS, the challenge in preventing their establishment, and the importance of the public’s participation in recognising and reporting their presence. Such engagement needs to be supported with sufficient financial resource to captivate the public’s attention and involvement.

Such engagement should not only target the British public, but also businesses and individuals involved in the importation of goods into the UK. The association of two incursions by Asian hornet queens with the importation of cauliflowers from France has highlighted that more can be done emphasising this and potential similar routes of entry into the UK with both exporters and importers, and to put processes in place to minimise the success of such routes.

- **Automatic detectors:** Technology provides a potential route for automated surveillance to augment citizen monitoring for a variety of INNS, including Asian hornets. An automated device has the potential to be alert 24/7 for the presence of a target species, potentially greatly improving vigilance in key locations (risk areas, locations near recent or past sightings, etc.), but such devices would need to be replicated on an appropriate scale to offer an effective line of defence.
- **Improve efficiency of finding nests:** NBU inspectors have been very efficient, to date, in locating Asian hornet nests. In most cases, local teams have been able to locate nests, without drawing on additional national resource, enabling the NBU to potentially address multiple outbreaks in different parts of the country simultaneously, but drawing them away from their main function in tackling notifiable bee diseases. It is so far untested at which stage their current resources would become over-stretched by multiple simultaneous incursions of Asian hornets in the UK.
- **Broaden the role of other stakeholders:** AHTs already support the activities for NBU inspectors by monitoring for Asian hornets in the vicinity of recent confirmed sightings and providing inspectors with local knowledge when required. There could be an option of providing enhanced training to AHT members, leading to official recognition and potential utilisation alongside NBU inspectors. At present, rights of access to private land would likely remain limited to bee inspectors, but the government may wish to consider utilizing AHT members in public areas, or where permission to access land has already been granted by the land owner.
- **Greater use of quick methods to locate nests:** Radio-tracking hornets tagged with small transmitters has proved an efficient method in locating nests³³, especially in complex environments e.g. woodlands, enabling nests to be located within approximately 3 hours of release of a tagged hornet. Although some countries have used this technique extensively to successfully locate hornet nests (e.g. Switzerland, Germany, USA), there has been a reluctance to use the technique in other regions. In areas with well established populations, the number of nests present would likely make extensive use of the technique prohibitive, but in localised areas and regions where nest numbers are still low the method would prove effective. On Jersey, with an experienced and 'free' (expenses only) volunteer group of visual trackers, the up-front cost of radio-transmitters and unpredictability of determining at the start how difficult (or not) a nest may be to locate has resulted in this technique being underutilised. But in recent years, with high nest numbers stretching the capacity of the volunteers, it is worth considering the extent radio-tracking may have freed some valuable volunteer resource at the cost of a few transmitters.

Moving from containing outbreaks to long term management:

- The current contingency plan sets no threshold at which government action would switch between eradication, containment and long-term management, reflecting how government recognises priorities and resources might change under different and competing circumstances. Nevertheless, this provides other stakeholders little clarity on whether and when they may become expected to manage this threat themselves, or play a substantially more active role in managing

its impact, and thereby prepare for this eventuality. If government agencies withdraw or limit their activities searching for hornets and nests, is there an expectation for AHTs and beekeepers to take on such activities, or would concern over infringement of rights of access to private land still limit their ability to track & trace Asian hornets to locate their nests? A scheme involving authorised, licensed, trained volunteers such as on Jersey has merit and could be trialled in the UK, working alongside bee inspectors. Authorisation could quickly be removed if individual volunteers fail to stick to prescribed approaches and behaviours. Or is the expectation that under long-term management the majority of nest searches would be abandoned and only those nests that are accidentally spotted and reported will be dealt with, as happens currently in much of France, Spain and Portugal? This would place an emphasis on removing nests that are a nuisance or direct threat to people, with a likely focus on urban areas, and leave many more rural areas largely unprotected. Beekeepers would adopt measures to protect their apiaries and adjust their beekeeping in response to the threat of Asian hornets, but native fauna would need to adapt to the presence of this new opportunistic predator & competitor.

Pest controllers would need training and awareness of acceptable control methods for Asian hornets in advance of being required to take over treatment of nests from agency staff. In certain departments of France, pest controllers need to have completed prior training to be placed on a list of approved contractors; their work is validated by sporadic checks by a coordinating organisation and feedback from property owners. Prior to such measures, there was huge diversity in the effectiveness of treatments and pricing between companies. Would a national agency take on such a coordinating role in the UK, and would such treatments be subsidised as in some parts of France? If landowners would be expected to cover all treatment costs, this would likely lead to under-reporting of nests.

- The impact of Asian hornets goes beyond honeybees and therefore training aimed at long-term management of Asian hornets also needs to consider other stakeholders, such as those involved in both commercial and recreational horticulture and silviculture, food processing and retail, as well as emergency services that may be called upon to deal with emergency situations should a nest be disturbed by a member of the public. Although it is hoped that the UK government will justifiably maintain its focus on eradication in response to any incursion by Asian hornets for some time to come, preparing other stakeholders for the potential impact of Asian hornets in advance of this being measurable would be advantageous.

The UK is still in the eradication phase of the Asian hornets invasion curve but procedures to rapidly respond to incursions need to be adequately resourced to remain effective, especially if propagule pressure increases as the invaded range on continental Europe expands. Indicative economic returns per £ spent are estimated at 25:1 in the eradication phase of a generalized INNS invasion curve, but reduce to 5-10:1 in the containment phase and as little as 1-5:1 under long-term mitigation⁴⁰. Consequently, funding especially during the early phases of the invasion curve are well spent, but is sometimes delayed while authorities consider the scale of impacts as uncertain. A major obstacle to effective response and eradication is often timely and adequate funding¹. Improving funding and engagement, as well as preparing stakeholders in advance of transferring between phases of the invasion curve are likely key to the UK's continued response to Asian hornets.

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Appendix 1: UK Confirmed Sightings

Historic UK Asian hornet incursions 2016 - 2022: <https://www.nationalbeeunit.com/diseases-and-pests/asian-hornet/historic-uk-asian-hornet-incursions/>; plus 2023 incursions up to end April 2023:

1. **Tetbury 2016:** A sighting by a beekeeper of an Asian hornet at his apiary on 17 September 2016 was subsequently confirmed by the authorised agency on 19 September 2016; a press release was issued 20 September 2016. At the time, this was the first confirmed sighting of an Asian hornet in the UK. The UK Contingency Plan was immediately rolled out; a large number of staff were deployed to the area to begin searching all apiaries and likely forage resources within a 17.5 km radius of the initial sighting. The nest was spotted nine days later in a tall Cypress tree in a garden (16.8 m high) and destroyed.
 - <https://www.gov.uk/government/news/asian-hornet-identified-in-gloucestershire>
 - <http://www.nationalbeeunit.com/public/News/news.cfm#175>
 - <http://www.nationalbeeunit.com/downloadNews.cfm?id=132>
 - <https://www.theguardian.com/environment/2016/sep/20/threat-honeybees-asian-hornet-arrival-uk-confirmed-defra-invasive-species>
 - <https://www.bbc.co.uk/news/av/uk-england-gloucestershire-37550428>
 - Budge et al. (2017) <https://doi.org/10.1371/journal.pone.0185172>
 - Jones et al. (2020) <https://doi.org/10.1038/s41598-020-76690-2>
2. **Lower Langford 2016:** A hornet caught in a trap by a beekeeper in spring (April-June) 2016 was mistakenly identified as an European hornet and therefore not reported as a potential Asian hornet until 29 September, following press coverage of the Tetbury nest. Likely a single hornet incursion; possibly a queen.
 - Budge et al. (2017) <https://doi.org/10.1371/journal.pone.0185172>
3. **Tetbury 2016:** An importer of green oak timber from France, incl. the Loire Valley, reported, on 7 October 2016, finding a dead hornet in a woodpile in their workshop. It had been dead for some time but genetics suggested it was related to the nest found in Tetbury. The timber had been treated with Boron before importation and had been onsite for several weeks.
 - Budge et al. (2017) <https://doi.org/10.1371/journal.pone.0185172>
4. **Bath 2016:** On 13 October 2016, a family reported finding a dead Asian hornet in a bag they had last used a couple of weeks earlier in the Loire Valley in France. They had seen Asian hornets while on holiday both in the environment and in their tent.
 - Budge et al. (2017) <https://doi.org/10.1371/journal.pone.0185172>
5. **Central belt of Scotland 2017:** The Scottish Government confirmed on 17 March 2017 that a single Asian hornet has been identified at a retail warehouse/supermarket distribution centre in the central belt of Scotland. It was reported by a pest controller. It was presumed to have been accidentally introduced via a lorry delivery from Europe. The hornet had been killed on site and a photo submitted. Likely a single hornet incursion; presumed to have been a queen.
6. **Woolacombe 2017:** A beekeeper reported seeing an Asian hornet hawking at his apiary on 16 September 2017; a local inspector visited on 20 September but, due to weather conditions, could not confirm the presence of Asian hornets. The sighting was later confirmed on 26 September 2017, after the beekeeper was able to take and submit a photograph on 24 September 2017. The nest was located within 3 days by the authorised agency within an Escalonia hedge (1.2 m above ground) and destroyed the next day. Woolacombe is a popular tourist destination.
 - <https://www.gov.uk/government/news/asian-hornet-identified-in-devon>
 - <https://www.somersetbeekeepers.org.uk/members-blog/february-02nd-2018>
 - Jones et al. (2020) <https://doi.org/10.1038/s41598-020-76690-2>

7. **Bury 2018:** A member of the public reported an Asian hornet in a cauliflower. The cauliflower had been purchased at a local farmers' market and the torpid hornet was discovered when preparing the cauliflower in the kitchen. The cauliflower was moved to the outside for better light while photographing the unusual insect, but the hornet then escaped when warmed by the sunlight. The reporter only realised the 'interesting insect' was an Asian hornet when subsequently looking it up on the internet. Likely a single hornet incursion; possibly a queen. The cauliflower was traced to a distributor in Boston, Lincolnshire, but had come from a consignment imported from France.
 - <https://www.gov.uk/government/news/asian-hornet-identified-in-lancashire>
 - <https://www.bromleybeekeepers.org.uk/asian-hornet-found-in-a-cauliflower/>
8. **English Channel 2018:** An Asian hornet was spotted on a passenger ferry travelling from Poole to Cherbourg by a beekeeper on 22 August 2018. This was outside UK territorial waters and occurred on a ferry journey towards France; therefore, strictly not an incursion but demonstrates how shipping traffic may be involved in the spread of Asian hornets.
9. **Fowey 2018:** A beekeeper found 2 Asian hornets in a wasp trap in his apiary on 31 August 2018; the sighting was confirmed on 3 September 2018. Inspectors from the authorised agency used baits to attract hornets and watch their flight paths to locate the nest. The nest was located & destroyed on 6 September 2018; it was later identified as a primary nest.
 - <https://www.gov.uk/government/news/asian-hornet-identified-in-cornwall>
 - <https://www.bbka.org.uk/news/asian-hornet-nest-in-fowey-found-destroyed>
 - Jones et al. (2020) <https://doi.org/10.1038/s41598-020-76690-2>
10. **Liskeard 2018:** A beekeeper found a single Asian hornet (male) on 6 September 2018 in a trap set in her apiary due to her colonies being regularly attacked by European hornets (several nests were suspected in the area); this was confirmed on 7 September 2018. Baits and traps were set in the surrounding area but no further hornets were located. This may have been a male dispersing from the Fowey nests, or else was likely a separate single hornet incursion.
 - <https://www.gov.uk/government/news/asian-hornet-fowey-nest-destroyed-as-two-new-sightings-confirmed-in-liskeard-and-hull>
11. **Cottingham (near Hull) 2018:** An Asian hornet was found on 3 July 2018 inside a home, soon after the householder had returned from a holiday in France. This was likely a single hornet incursion; potentially a queen; no other Asian hornets were found in the area despite subsequent monitoring.
12. **Fowey 2018:** Due to surveillance that continued in the Fowey area even after the primary nest was destroyed, a second nest in the locality was suspected on 20 September 2018. This was quickly located in a nearby Elm tree, within approx. 50m of the primary nest, and subsequently identified as its secondary nest, based on genetic analysis (unknown to the inspectors at the time the primary nest was destroyed, the colony was in transition to a secondary nest location; no eggs or larvae were found in the primary nest when assessed).
 - <https://www.gov.uk/government/news/asian-hornet-second-fowey-nest-destroyed>
 - <https://aphascience.blog.gov.uk/2021/09/08/asian-hornet-week-hunt-for-asian-hornets/>
 - Jones et al. (2020) <https://doi.org/10.1038/s41598-020-76690-2>
13. **New Alresford 2018:** A member of the public had reported seeing Asian hornets in their garden on 22 September 2018. A local bee inspector attended soon after the report and quickly located an Asian hornet nest in a shrub in the same garden.
 - <https://www.facebook.com/groups/454292968397052/permalink/455508031608879/>
 - Jones et al. (2020) <https://doi.org/10.1038/s41598-020-76690-2>

- 14. Brockenhurst 2018:** A member of the public noted unusual hornets visiting fallen apples in their garden and reported these on 26 September 2018, after these were identified as likely Asian hornets by a beekeeper. Inspectors from the authorised agency were able to track hornets to a wooded area, where the nest was located on 28 September 2018 by the combined use of experienced observers, FERA's drone with IR cameras and University of Exeter's radio-telemetry. The owners of the property regularly travelled overseas but the location was also close to shipping lanes servicing major shipping & ferry ports nearby.
- https://news-archive.exeter.ac.uk/featurednews/title_687139_en.html
 - Jones et al. (2020) <https://doi.org/10.1038/s41598-020-76690-2>
- 15. Guildford 2018:** A dead Asian hornet was found wedged in the grille of a new Mini car in the garage of a car showroom. It is uncertain at which stage the hornet got trapped in the grille: soon after assembly in Europe, during transit from Europe, or while parked in the UK prior to delivery at the showroom. The sighting was officially confirmed on 28 September 2018. This was likely a single hornet incursion. Monitoring was conducted in the Guildford area but no further hornets were found.
- 16. Dungeness 2018:** Two male Asian hornets were spotted in Dungeness: one on ivy in a private garden (11 & 13 October 2018) and the other at the Dungeness Bird Observatory (14 October 2018). These were found after a strong south-south-easterly storm; many migratory birds were also noted in the area after the storm, giving some weight to the suggestion the hornets had been blown across the Channel. Searches and monitoring in the area by bee inspectors and local volunteers revealed no further hornets.
- <https://www.bbka.org.uk/news/2-asian-hornets-found-in-2-days-at-dungeness-in-kent>
 - <http://www.dungenessbirdobs.org.uk/2018/10/> (see observations on 11-14 October)
- 17. New Milton 2019:** A member of the public reported finding an Asian hornet, confirmed on 3 July 2019. Visual examination suggests the hornet was likely a queen. Monitoring was initiated in the area but no further hornets were found at the time. This was presumed a single hornet incursion.
- <https://www.gov.uk/government/news/asian-hornet-identified-in-south-hampshire#:~:text=The%20National%20Bee%20Unit%20has,likely%20to%20be%20a%20queen.>
 - <https://www.bbka.org.uk/news/first-asian-hornet-of-2019-found-in-hampshire>
- 18. Drayton Bassett 2019:** A beekeeper reported Asian hornets foraging on fruit trees on 2 September 2019; further hornets were found in the area when bee inspectors attended, which they were able to trace back to a nest high in a Spruce tree. The nest was treated and removed for analysis; monitoring continued in the area and caught a single additional hornet but no more were seen in the area thereafter. The potential route of entry resulting in this nest remains uncertain.
- <https://www.bbka.org.uk/news/asian-hornet-nest-located-destroyed-in-staffordshire>
 - <https://aphascience.blog.gov.uk/2021/09/08/asian-hornet-week-hunt-for-asian-hornets/>
 - Jones et al. (2020) <https://doi.org/10.1038/s41598-020-76690-2>
- 19. Tenterden (near Ashford) 2019:** A single Asian hornet foraging was caught by a fruit farmer in Kent, and reported to the authorised agency. Subsequent monitoring in the area revealed no further hornets, suggesting this may have been a single hornet incursion. Tenterden is approx 15 km from main road & rail transport routes between London and Folkestone/Dover (and consequently mainland Europe), and within 30 km of the south-east coastline (including Dungeness ... but the Tenterden hornet was not closely related to the Dungeness hornets). The fruit farmer also regularly travelled overseas.
- <https://www.kbka.org.uk/2019/09/12/ashford-asian-hornet-confirmed-2/>
 - <https://www.bbka.org.uk/2019-asian-hornet-week?fbclid=IwAR1Dr9k-ymzWz3tIPbnh6MxDvKHyENCWrBuHRoo40AghGgJZntz56fftcLk>
- 20. Christchurch 2019:** A sighting of an Asian hornet by a beekeeper on 1 October 2019 and subsequent tracking activities led to the discovery of a nest high in an oak tree on 3 October 2019. This was

subsequently identified as a secondary nest. Continued surveillance in the area led to the discovery of another nest; the primary nest.

- <https://www.bbka.org.uk/news/asian-hornet-nest-near-christchurch-destroyed>
- Jones et al. (2020) <https://doi.org/10.1038/s41598-020-76690-2>

21. Christchurch 2019: Continued surveillance after the discovery of a nest in Christchurch, revealed activity of further Asian hornets and led to the discovery of nest within a rotten log, at ground level, within brambles (*Rubus* sp.) in a local nature reserve. Subsequent analysis confirmed this to be the primary nest, linked to the secondary nest found nearby.

- <https://www.bbka.org.uk/news/second-asian-hornet-nest-found-destroyed-at-christchurch>
- Jones et al. (2020) <https://doi.org/10.1038/s41598-020-76690-2>

22. Gosport 2020: Two sightings of Asian hornets were reported independently in quick succession on 8 September 2020. A member of the public and a beekeeper separately observed and reported Asian hornets foraging. The team of inspectors triangulated flight directions of marked hornets to locate the nest in an apple tree which was found, treated and removed on 11 September 2020. Gosport is a naval base, popular recreational yachting harbour and close to major shipping and ferry ports in Portsmouth and Southampton.

- <https://www.gov.uk/government/news/asian-hornet-identified-in-hampshire>
- <https://www.swhbk.org.uk/news/asian-hornets-in-gosport-the-story-unfolds/>

23. Ascot 2021: A beekeeper killed and photographed unusual hornets at his apiary on 6 October 2021, which were officially confirmed as Asian hornets on 7 October 2021. Bee inspectors used bait stations, vanishing flight directions and a new Track & Trace app to assist in triangulating the likely location of the nest. Cool, overcast or foggy conditions reduced hornet activity, but the nest was located on 11 October 2021.

- <https://www.gov.uk/government/news/asian-hornet-identified-in-ascot>
- <https://aphascience.blog.gov.uk/2021/09/08/asian-hornet-week-hunt-for-asian-hornets/>
- <https://www.bee-craft.com/bee-craft-extra/articles/ascot-race-to-find-asian-hornet-nest>

24. Portsmouth 2021: A member of the public reported seeing an Asian hornet on 29 October 2021. Bee inspectors investigating easily attracted other Asian hornets to bait and were quickly able to locate the nest in a Norway Maple tree, in a built up area of Portsmouth, given that the tree leaves had already dropped. The nest had reached the stage of development at which it was producing sexual castes but was highly inbred with many offspring triploid. Nevertheless, monitoring in the area continued after nest removal and was repeated in the following year.

- <https://obka.org.uk/asian-hornet-nest-found-in-portsmouth/>
- https://www.bbka.org.uk/2021-asian-hornet-nests-report?fbclid=IwAR24n62B3rYW_6l27By-dmwgUIGIEvwtH_C5Y6RIB7ThBPgElc4CNnqTa2Y

25. Felixstowe 2022: An Asian hornet was reported by a beekeeper in Felixstowe on 26 April 2022. The hornet had been killed in a shed by the partner of a beekeeper, not recognising it for what it was, but was subsequently discovered and reported by the beekeeper. The beekeeper's apiary is part of a sentinel apiary program, distributed near ports and distribution centres across England & Wales. Beekeepers within the program receive extra training, utilise extra vigilance and submit samples on the lookout for exotic pests. Monitoring in the surrounding area revealed no further hornets and it is likely that this was a single hornet incursion. Given the proximity to a major container port, genetic tests were conducted in case this was a new incursion from Asia but tests revealed its origin likely to have been mainland Europe.

- <https://www.bbka.org.uk/news/first-asian-hornet-of-2022-confirmed>
- <https://suffolkbeekeepers.co.uk/IESBKA-2022-Summer-Newsletter.pdf> (see p.2)

- 26. Chelmsford 2022:** Following a report of a male Asian hornet (photograph only) near Chelmsford on 24 August 2022, bee inspectors setup enhanced surveillance in the surrounding area to look for further hornets. None were found, such that this was likely a single hornet incursion. Asian hornets were subsequently seen in Rayleigh, over 15 km away, but likely unrelated due to distance. Chelmsford is approx. 65 km from Felixstowe, but on a major road artery between Felixstowe and London.
- <https://www.bbka.org.uk/news/first-credible-2022-report-of-an-asian-hornet>
- 27. Rayleigh 2022:** A beekeeper reported seeing three Asian hornets at their property in Rayleigh on 27 September 2022. The nest was located in a tree in a garden in neighbouring Hockley. The nest was treated and removed by the authorised agency.
- <https://www.gov.uk/government/news/asian-hornets-identified-in-essex>
 - <https://www.ahat.org.uk/article/confirmed-sighting-of-asian-hornets-in-essex>
 - https://www.echo-news.co.uk/news/22954428.asian-hornet-nest-reportedly-located-hockley-essex/?fbclid=IwAR1_Wv4A8bCO0_w3Cy-Dmle9x_fxgK0mgDTSNGW6YIDjutPPvIMuEjP1DCc
- 28. Dover 2022:** A member of the public submitted a photograph of suspect hornet via the appropriate reporting channels that was subsequently confirmed to be an Asian hornet on 6 October 2022. The hornet had been photographed in the middle of town close to the port. Bee inspectors carried out enhanced surveillance in the area but no further hornets were reported. It is likely to have been a single hornet incursion.
- <https://www.ahat.org.uk/> (entry submitted 6 October 2022)
 - <https://ppconline.org/Insects/asian-hornet-sighting-in-dover->
- 29. Morpeth 2023:** A report of an Asian hornet was submitted by a zoo on 5 April 2023. The hornet had been discovered inside a cauliflower, being prepared as animal feed, and was caught and submitted for analysis. The cauliflower had been produced in France and the hornet is assumed to have remained in the cauliflower while chilled in transit until reaching its destination approx. 10 km north of Morpeth. This is likely a single hornet incursion; likely a queen. Follow up activities will take place to raise awareness with the producer/distributor/seller.
- <https://www.nationalbeeunit.com/about-us/beekeeping-news/asian-hornet-discovered-inside-a-cauliflower/>
 - <https://bpca.org.uk/News-and-Blog/asian-hornet-sighting-in-northumberland--bpca>
 - <https://www.youtube.com/watch?v=PHzDreZsRYg> (see between 01:08 – 04:26)
- 30. Folkestone 2023:** A member of a community group in Folkestone submitted a photograph of an Asian hornet on 13 April 2023. The hornet flew off before it could be captured. Likely a single individual incursion. Beekeepers and volunteer Asian Hornet Teams in the area have been asked to be vigilant and monitor for Asian hornet.
- <https://www.nationalbeeunit.com/about-us/beekeeping-news/asian-hornet-sighting-folkestone/>
 - <https://www.facebook.com/GlassFolks/posts/pfbid0i7dL2hh2LZMFsArqa71Ni3jX1hMHN1s3k5BUPTBt7r6QJRcfQjxgcp7SdTPVfB7SI>
- 31. English Channel 2023:** A clear photograph of an Asian hornet on the deck of a ferry was submitted by a beekeeper on 17 April 2023. The photograph had been taken approx. 20 miles off the coast of the UK, a week earlier (10 April 2023), while travelling from Poole to Cherbourg. The ferry had docked overnight in Poole before departure in the morning. It is possible that the hornet landed on the ferry mid-channel to rest, but local Asian Hornet Teams in the area around Poole have nevertheless increased their vigilance in response to this sighting.
- <https://www.bbka.org.uk/asian-hornet-sightings>
 - https://www.facebook.com/badsbka/?locale=en_GB (see posts from 18 & 19 April 2023)