States of Guernsey
Agriculture, Countryside and
Land Management Services

Asian Hornet Strategy

3-year review: 2019-21

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1. Introduction

Asian hornet (*Vespa velutina*) is believed to have been introduced to Europe in pottery imported from China to southern France in 2004. It readily colonised and has rapidly spread across France and into Spain, Portugal, Belgium and Italy. Since the first confirmed sightings in the UK (September 2016), the Animal and Plant Health Agency (APHA) has recorded *V.velutina* in every year from 2016-21 and most significantly, nests have been found and destroyed annually throughout this period, eleven in total, the most prolific year being 2018 which resulted in four nests.

The first *V.velutina* were detected in Jersey and Alderney in 2016, and in Guernsey and Sark in 2017.

This highly invasive non-native species (INNS) poses an elevated risk to public health. This becomes more significant when *V.velutina* successfully colonise a new area and nest numbers rise exponentially thereby increasing the likelihood of a nest disturbance.

A hornet's behaviours will vary depending on where it is located and its activity. Away from its nest when foraging, the hornet is not aggressive, and attacks are very rare. Here, the risk of stinging is related to picking (or eating) some fruit on which a hornet has landed. However, in following instincts to protect the colony, *V.velutina* will respond to any threat to their nest with a collective attack (stings and projection of venom). It is the collective attacks that are the most dangerous, because even people that are not allergic to hymenopteran venom, will experience distress following insults with dozens of stings. Allergic reactions not controlled in time, may well be fatal.

In addition, a large nest can produce up to 5,000 hornets and a colony has been shown to consume 11.32kg of invertebrates (equivalent to 97,000 prey) in one season (Rome et al., 2021). If they manage to evade control these voracious predators pose a significant threat to our island's biodiversity, in particular native invertebrate populations.

In 2019 the States of Guernsey, Agriculture, Countryside and Land Management Services (ACLMS) implemented The Asian Hornet Strategy (2019-21) with the overall aim to prevent the establishment of *V.velutina* in Guernsey in order to minimize their risk to the public and the island's biodiversity. The objectives were:

- To protect public health through defined responsibilities, development and review of best practice guidance and dissemination of public health recommendations.

- Control and reduce the population of Asian hornet in Guernsey by catching emerging queens (beginning in spring 2019) and treating primary and secondary nests so the number of established secondary nests does not exceed 10 per annum.

- To develop effective data capture, analysis and methods of communication between service areas, the third sector, key stakeholders and other jurisdictions.

To deliver the approved strategy, an Asian Hornet Team (AHT) was established which comprises a Project Coordinator (1 WTE) and a Field and Research Officer (0.5 WTE) employed for the duration of the Asian Hornet Strategy (2019-2021).

Scope of report

This paper provides a detailed review of the three year Asian Hornet Strategy - first implemented in January 2019. It provides evidence of performance against each of the key objectives and evaluates specific components of the Strategy such as the Spring Queening initiative, raising awareness and engaging the public through the Track don't Trample campaign, and locating and destroying secondary nests in a safe and timely manner. The review will also provide recommendations on how the ongoing management of *V. velutina* in the Bailiwick of Guernsey.

Pre Asian hornet Strategy

The first *V.velutina* arrived in Guernsey in 2017. Tracking worker hornets and locating nests during 2017-2018 was carried out by the States of Guernsey Bee Inspector (DH) on a voluntary basis in liaison with the States Plant Pathologist who collated sightings and undertook analysis of hornets found, and ACLMS who arranged 'cherry picker' access, tree surgeons and nest destruction through a private pest contractor (see Table 1 below).

Table 1: *V.velutina* nests destroyed 2017-18, preceding implementation of the strategy.

Key information	**2017**	**2018**
Date of first confirmed sighting	23 July	19 April
Total number of sightings	19	54
Number of secondary nests	2 (destroyed)	8 (2 of which found close to active primary nests)

2. Spring Queening; evaluating this novel approach

2.1 What is Spring Queening?

'Spring Queening' was the name given to the strategic deployment of baited non-lethal traps throughout the island in the spring, with the aim of trapping emerging or incoming *V.velutina* queens to reduce the production of primary and secondary nests. Colony initiation is considered the most critical step in the hornet's life cycle: for every queen caught during this critical time, there is potentially one less nest to control later in the year. Capturing a queen is significantly easier and safer than tackling a large secondary nest in late summer/autumn.

This practice was successfully adopted on Alderney in the spring of 2018, where 55 queens were captured and only 4 secondary nests found later that same year. However, trapping is controversial and studies in France have questioned the relative merits of this approach. Monceau et al (2017) state that spring queen trapping is inefficient as a method to limit the distribution of the *V.velutina* population. They argue that on balance, the trapping of queens in the early spring should be abandoned because the benefits of managing *V. velutina* populations using this method are outweighed by the costs (i.e., effects on entomofauna and logistical concerns). This view is further supported by Budge et al (2017) who stated, *"local control has a limited impact on the spread of V. velutina once established within a region."* However, all the studies on the efficacy of trapping queens are from areas where *V.velutina* was well established, with high population densities in all study areas (12.26 nests/km² as reported by Monceau, 2014) and where inward migration of new individuals was unhampered by geographical isolation. Also contrary to the traps used in Guernsey's initiative, none of the French studies used traps that were in any way modified to mitigate by-catch losses.

Due to Guernsey's geographical isolation and small size (64km^2), there was good reason to believe that the spring trapping of queens could be used as an integral component of a successful management strategy and, with careful implementation, potential impacts of trapping on native fauna could be minimised. Spring Queening was introduced in Guernsey as a novel technique, not previously attempted on an island-wide scale and never before in a region with no self-sustaining population of *V.velutina*.

2.2 Trapping methodology

A grid was devised in order to position traps across the island every 500m, some minor adjustment of trap points was unavoidable (Figure 1). For example, on tracts of arable land and on a large golf course trap spacings exceeded 500m. In total 260 traps were deployed

and monitored by volunteers from April – May (10 weeks) each spring. Modified Veto Pharma traps were deployed and baited with a commercially formulated liquid carbohydrate marketed by Killgerm Chemicals Ltd as 'Trappit', otherwise known as Suterra. The primary tasks for volunteers were to check traps every day and release any non-target species of insect. The same methodology was adopted for each year of the strategy's implementation.

Avoiding by-catch

To reduce the impact on entomofauna each trap was specially modified (Figure 2) by incorporating 6mm escape holes and adding sponges to reduce the likelihood of drowning. Personal observations and volunteer feedback demonstrated that these simple adaptations worked well. Tests conducted with live insects confirmed that whilst *V.velutina* queens were unable to exit through these 6mm holes, social wasps (*Vespa vulgaris)* (predominantly queens) and most dipteran species were able to escape from the traps.

In 2019, it was identified the there was a tendency for volunteers to overfill traps above the top level of the sponges resulting in more drowning of by-catch. This issue was avoided in later years by issuing additional instructions to volunteers.

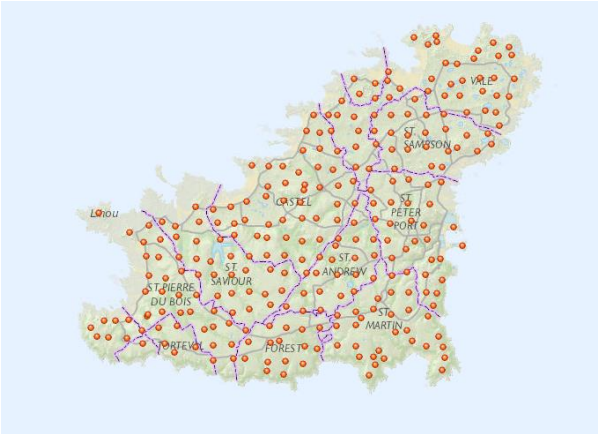


Figure 1: Location of Spring Queening traps.

Figure 2. Modified Veto Pharma trap.

Trap distribution and collection was completed on a parish-by-parish basis by the Project Coordinator and Field and Research Officer. There were inevitable losses and breakages of traps, but these were comparatively low (see Table 5). Collecting traps and any remaining bait at the end of each spring reduced wastage and helped to minimise these losses.

On the neighbouring islands of Sark, Herm and Jethou resident volunteer coordinators were recruited to replicate trapping across each island, to run concurrently with the Spring Queening programme in Guernsey. In the first year that this was implemented each island were supplied with the following number of traps (plus 1L of Trappit bait per trap):-

- Sark – 23,
- Herm – 12,
- Jethou – 2,
- Brecqhou – 2.

These numbers correspond to 500m placement of traps on respective islands. Employees of the States of Alderney have organised their trapping independently since 2018 adopting a similar approach.

2.3 Volunteer recruitment and retention

Volunteers for each trap point were recruited primarily by calling the land owners of the property on, or adjacent to where the 500m point fell. If no volunteer could be recruited by phone, the AHT visited properties and approached the residents. Each trap was identified by a coded reference and the precise locations were recorded in the field using an Android tablet installed with ESRI's Collector application software.

75% of volunteers have looked after traps for all three years and ensure full coverage of the 260 trapping points and continuity of the programme. The overall standard of monitoring and accuracy of reporting potential hornet capture has improved year on year.
An average of 16 volunteers (6%) a year were deemed to be unreliable or negligent in looking after and/or monitoring their traps effectively. Volunteers who were not following the written guidelines e.g., not monitoring traps regularly, were not used again and replacements found the next year.

Where possible email contact was established to facilitate communications and send newsletters to volunteers. It is believed that direct contact with volunteers when issuing/collecting traps contributed significantly to the correct deployment and monitoring of traps and may well be important in retaining the services of these volunteers.

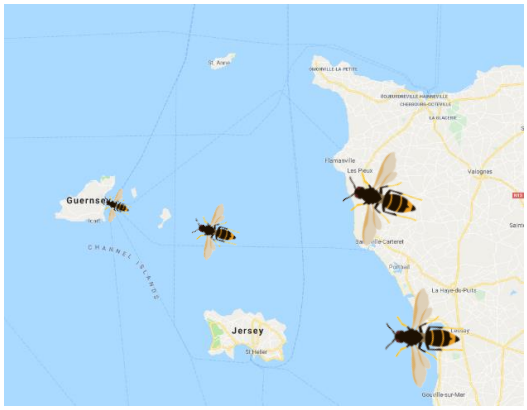
2.4 Trapping period, earliest appearances and timing of queen captures

During each year of the Spring Queening programme, traps were actively monitored over a 10-week period (e.g., March 25th – June 3rd). The start date was chosen to coincide with typical spring emergence of overwintering eusocial hymenopterans e.g., queen wasps. According to the literature, *V.velutina* first emerge from hibernation at mean air temperatures around 13°C.

The earliest records of queens trapped or found (in properties) in Guernsey was as follows:

2019 - April 18th in Vale (trap). Guernsey Met forecast = 21°C;
2020 - April 11th in St Peter Port (found in kitchen). Guernsey Met forecast = 24.5°C;
2021 - April 21st in St Sampson's (trap). Guernsey Met forecast = 13°C

Guernsey's earliest dates for detecting queen hornets each spring have been consistently later than those recorded in France and Jersey. For example, in 2021 Jersey had a confirmed sighting on Feb 24th, twenty-five days earlier than Guernsey's first record in the same year.



One plausible explanation for detection of queens in February or March, is that these queens have overwintered on island (raised from secondary nests the previous autumn) and started foraging earlier, whereas the arrival of new queens on the wing from populations established on the French coast are thought to be delayed due to biological and/or environmental factors. Therefore, it is likely that all the queens detected in Guernsey to date, have not overwintered here.
However, it is noted that detecting early emergent queens is dependent on the public noticing and reporting hornets and/or very early deployment of traps. Thus, it is possible hornets were present on island undetected.

Deciding on the end date for trapping:

The likelihood of by-catch and the inherent risk that trapping will have a significant impact on local entomofauna increases greatly as the ambient temperatures rises and spring gives way to summer. The decision to terminate trapping at the end of May each year was based on two factors;

i) queen hornets cease foraging (and seeking out carbohydrate baits in traps) and remain in the primary/secondary nest once the first generation of workers are produced (typically in June/July) and;
ii) buff-tailed bumblebees (*Bombus terrestris*) are attracted to Trappit bait and readily enter traps around (usually occurs around the end of May, depending on ambient temperatures).

B. terrestris, a relatively small species of bumblebee, has been observed successfully entering traps via the 6mm escape holes drilled in the side walls of the modified traps. As soon as this phenomenon is reported, volunteers were instructed to take down traps immediately irrespective of the date.

2.5 Spring Queening trapping data: Guernsey and other islands (2019-21)

The following data presented in Table 2 shows a breakdown of the queen *V.velutina* captured across the islands during spring months between 2019 – 2021. While it is impossible to know how many of the captured queens would have gone on to produce secondary nests, spring trapped queens have clearly been denied this opportunity. These findings will be discussed more in Section 4 – Population trends.

Table 2: Numbers of captured queens recorded across the islands during April-May (Figures for States of Alderney & Government of Jersey: Pers Comms).

2019				
Island:	**Queens captured in traps**	**Queens captured in properties**	**Queens found at a primary nest**	**Total queens:**
Guernsey	7	2	1	**10**
Sark	7	3	0	**10**
Jethou	1	0	0	**1**
Alderney	6	0	0	**6**
Herm	0	0	0	**0**
Jersey	N/A*	69	27	**96**
*Jersey adopted spring trapping in selected areas from 2020 on.				
2020				
Island:	**Queens captured in traps**	**Queens captured in properties**	**Queens found at a primary nest**	**Total queens:**
Guernsey	0	3	0	**3**
Sark	4	0	0	**4**
Jethou	0	0	0	**1**
Alderney	13	0	1	**14**
Herm	0	0	0	**0**
Jersey	10	32	22	**64**
2021				
Island:	**Queens captured in traps**	**Queens captured in properties**	**Queens found at a primary nest**	**Total queens:**
Guernsey	5	3	2	**10**
Sark	8	1	0	**9**
Jethou	0	0	0	**0**
Alderney	3	0	0	**3**
Herm	0	0	0	**0**
Jersey	53	34	21	**108**

Jersey queen capture

With the exception of 2020, Jersey has witnessed an increase in *V.velutina* queens every spring from 2018 onwards. With Jersey being the closest of all the Channel Islands to the

French mainland, this geographical proximity is one of the main pressures favouring the colonisation.
Despite initial reservations in 2019, due to concerns over by-catch levels, Jersey subsequently deployed a number of modified traps areas in selected areas such as the north eastern end of the island and in vicinities where it was suspected late season nests were missed.
In 2021 a total of 53 queen *V.velutina* were caught on Jersey in modified Veto Pharma traps (with the addition of 6mm escape holes and self-contained wicking pots) and 34 were found by the public, while 21 were destroyed at primary nests.

Queens captured from properties:

The total numbers of queens according to the locations where these were captured in Guernsey, Sark and Jersey are presented in Table 3. The data highlights the percentages of queens taken from domestic properties.

Table 3: Total number of captured queens in traps vs properties (April-May, 2019-21).

Island	Total queens in traps	Total queens in properties	Percentage in properties
Guernsey	12	8	40%
Sark	19	4	17%
Jersey	63* (2020-10, 2021-53)	135	68%

Although the numbers concerned are low, the figures reveal where queen hornets are turning up in the spring. This is more marked in Jersey with greater numbers of queens being captured suggesting even more strongly there is an association with human dwellings. It has been observed in Guernsey and reported on other islands that queens are frequently captured in kitchens (Christie, A - Jersey & Cunneen, P - Sark, Pers. Comms.) which suggests it may not simply be a case of seeking out shelter and warmth but raises the distinct possibility that queen hornets are being attracted into properties by some other stimulant such as the aromas generated by food production or cooking.

In relation to this unexplained phenomenon, Spring Queening as an early season initiative has undoubtedly helped to raise public awareness of this invasive pest via targeted publicity in the spring: social media, leaflets, posters and a short YouTube animation. Consequently, the general public across Guernsey are increasingly engaged and helping to locate hornets in the spring – as evidenced by the unprecedented number of reported European hornets' sightings received in the spring over the past three years.

2.6 Distribution of *V.velutina* captured during Spring Queening

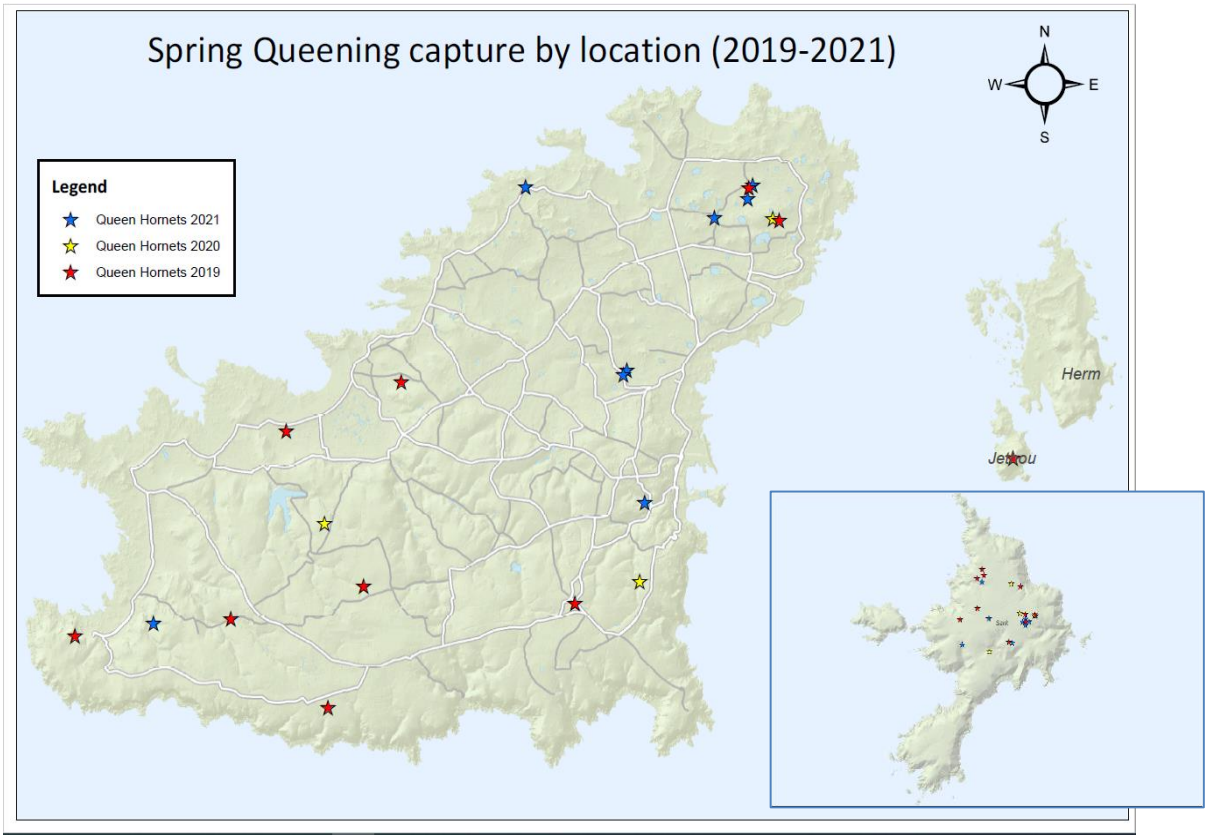


Figure 3: Location of *V.velutina* queens captured in Spring Queening traps and by the public across the Bailiwick of Guernsey (2019-2021) - queens taken at primary nests not included.

Figure 3 shows that the location of captured queens was generally spread quite randomly across Guernsey although the lower lying northern parishes of St Sampson's and the Vale did account for a higher proportion (50%) of captures in 2021. The congregation of records from the Vale over consecutive years is notable but remains unexplained. In general, there were more hornet queens captured around the perimeter of the island and very few along the middle belt.

The dispersal range of queens from a secondary nest is not understood but it is reasonable to expect clusters of overwintered queens and primary nests the following spring, adjacent to any undetected nests. The lack of any obvious concentrations or hotspots would suggest there were no missed secondary nests in preceding years.

2.7 Primary nest data – dates discovered, location and nest development

There have been three primary nests found on Guernsey since 2019 as detailed in Table 4. The two nests located in buildings were observed until the queen returned and then removed with the queens in situ using a glass jar. A nest located inside a bird box was destroyed by removing the whole bird box, which was bagged and taken away after dark

(*V.velutina* are not active at night). The hornets in primary nests are euthanised by freezing the nest or by adding 70% alcohol to a sealed container containing the nest.

Table 4: Date, location and contents of primary nests located in Guernsey[1] from 2019-2021.

Year of Asian Hornet Strategy	Date discovered	Location of nest	Contents of nest	Image
Year 1	May 8th	Underside of front porch. 2.5m high	Diameter = 6cm completely enclosed Comb = 1 Eggs = 11 Larvae = 6 + Queen	
Year 2	none	n/a	n/a	
Year 3	June 6th	Roof tress of tin shed. 2.4m high	Diameter = 5cm Partially enclosed Comb = 1 Eggs = 11 Larvae = 0 + Queen	
	August 2nd	Inside a nest box which had become displaced and was at ground level when collected. Prior to falling, the nest box was attached to a tree, 3m high.	Diameter = 8cm completely enclosed Comb = 1½ Eggs = 29 Larvae = 31 Pupae sealed = 22 Workers 17 + Queen	

2.8 Appearance of first worker hornets

In each year of the Strategy, the confirmed sighting or trapping of the latest queen hornet was followed by a period of absence before there were other positive sightings, presumed to be foraging workers. This observation highlights an important aspect of colony development. Firstly, the apparent absence of hornets for long periods is consistent with a progressive build up in colony density with initially low populations of foraging worker hornets in June and July, while numbers increase rapidly into August/September. During mid-summer, worker hornets expend more effort in collecting wood and nest building than foraging for insects so hornets are less likely to be seen by the public.
This gap in confirmed sightings was 71 days in 2019, 124 days in 2020 and 30 days in 2021, as illustrated in Figure 4. The apparent dearth of hornets predicates a repeating pattern that

[1] The earliest reported primary nest found in Normandy was on March 20th, 2019.

hornet's nests will frequently go undetected for a significant period of time with the risk that they transition to the drone/queen production phase before nest destruction can be completed (see Section 3.3).

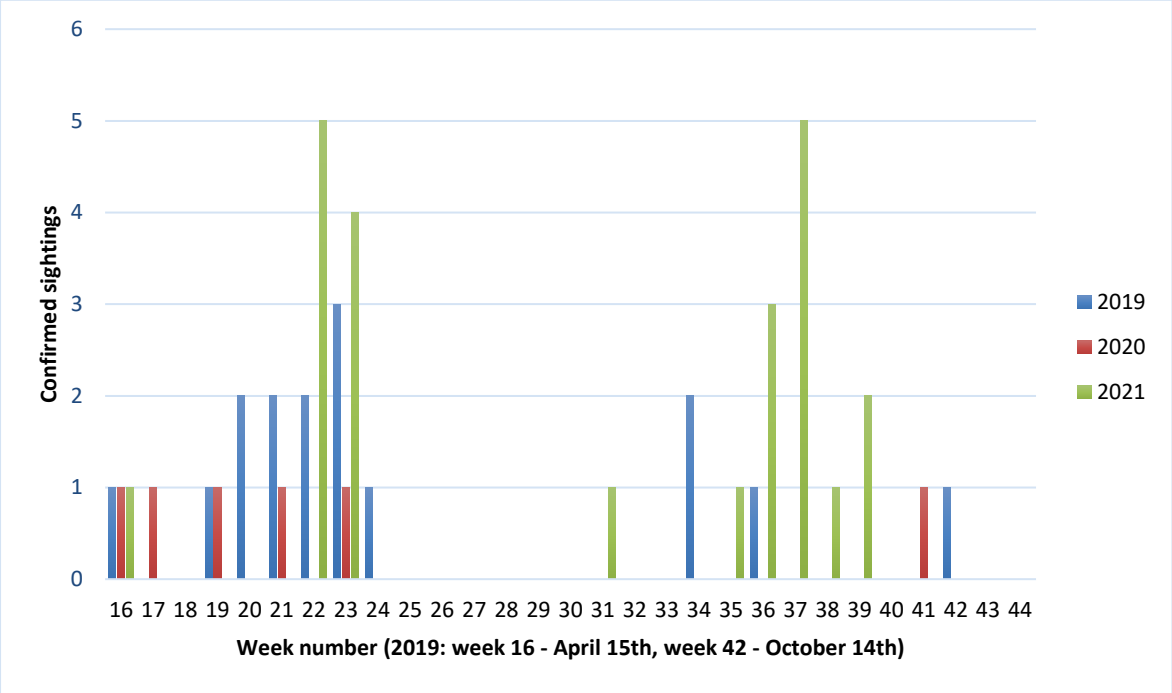


Figure 4: Graph showing the confirmed sightings by week each year during 2019-2021, illustrating a summer gap.

The latest record of a free flying queen hornet was on June 10th 2021, one having entered an upstairs flat window in St Peter Port. Such late arrivals (after Spring Queening has officially ended) will account for the discovery of smaller secondary nests discovered later in the season.

Figure 4 also shows the peaks in confirmed sightings of *V.velutina* (queens and workers) now expected to occur in spring and late summer/autumn month each year. This distinct pattern of seasonal variation in confirmed *V.velutina* sightings provides strong evidence that continual placement of hornet traps (as advocated by some beekeepers) is unwarranted and should be restricted to strategic springtime trapping only followed by active monitoring in the late summer/autumn (see section 3.2). Promoting this approach in Guernsey will prevent unnecessary by-catch of entomofauna in Guernsey.

2.9 Spring queening costs

The cost of implementing island wide trapping of queen *V.velutina*, including initial set up costs for 260 traps, materials, bags, labels and typical consumption of Trappit bait is estimated at £2,684/year. Table 5 shows a breakdown of stock materials purchased and remaining.

The delivery and collection of traps each spring took two staff approximately 200 hrs = £4,000 labour costs and the mileage incurred was approximately 600 miles @ 0.63p/mile = £378; overall combined cost of man hours + mileage = £4,378/year.

Table 5: Stock take and costings of consumables required for Spring Queening over three years from 2019 to 2021.

Stock item purchased Feb. 2019	Unit cost (£)	Quantity	Total cost (£)	Amount consumed, lost or broken	Quantity remaining (Dec. 2021)
Veto Pharma traps	3.09	450	1392	141	309
Trappit bait (litres)	7.16	1350	9669.60	550	705
Sponge (discs)	6.70	10 packs	67.80	25%	75%
Plastic ID labels	0.87	500	435	100	400
A5 flyers Instruction leaflets Posters	n/a	2000 400 250	405	n/a	926 250 187
Brown bags	0.07	750	52.50	720	30

Over three years, a total of 141 traps have been lost/accidentally recycled or destroyed which equates to average annual losses of 47 traps a year (18%).

2.10 Queen identification

Identification of queens

Learning how to differentiate queens from workers is essential in trying to understand what is happening inside the colony particularly as autumn approaches. The AHT experience of identifying queens is based on the assumption that any hornet found on our islands before June 10th was a queen. Every hornet captured in the spring on Guernsey and Sark during the spring queening period (2019-21), plus specimens from 2017 and 2018, has been preserved in alcohol and measured with an electronic micrometre. This expanding database (~930 hornets) is proving to be a very useful resource for the accurate differentiation of *V.velutina* female castes (workers and queens). Males are easily determined using external features – absence of a sting, antennae length and posterior profile and characteristic markings on the ventral aspect of the abdomen.

In the absence of expensive DNA analysis and microdissection expertise to look for indicative fat bodies, V.velutina queens can be reliably identified by measuring different parameters such as wet and dry weight, and morphological features such as mesoscutum width (MW), head dimensions and wing length. The mesoscutum defines the dorsal aspect of the thorax (Figure 9. Images copyright of (a) www.entomologa.ru/boxes/47.htm and (b) https://doi.org/10.1371/journal.pon).

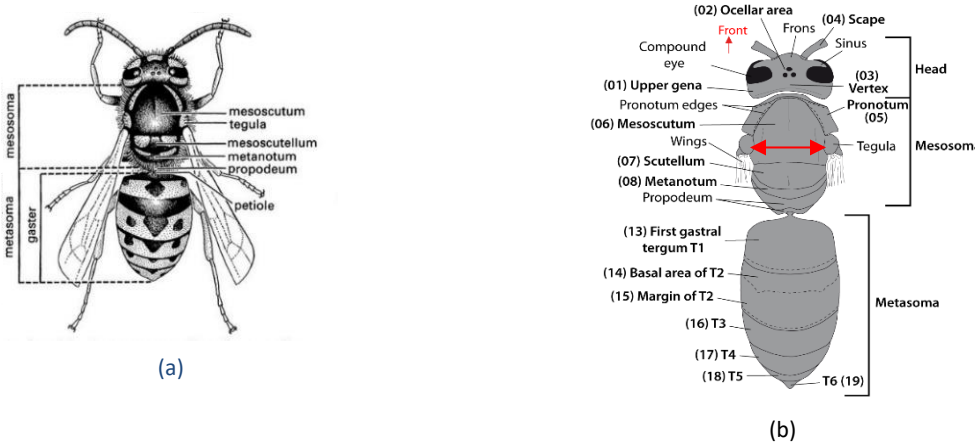


Figure 9: Anatomical drawings of *Vespa* spp.
Mesoscutum measurement is indicated with a red arrow.

Hornets with a MW of 4.5 mm or more are considered to be gynes (female sexuals), while those with a MW of less than 4.5 mm are considered to be workers (Pérez-de-Heredia et al., 2017).

To summarise, from our sample of queens trapped/captured in the spring (2019-21) across Guernsey, Jethou and Sark; queens appear to have longer and wider heads, and longer wings as well as the increased MW width. A total of 35 queen hornets were measured, of which 33 exhibited MW of greater than 4.5mm, and only two had MW of less than 4.5mm. This equates to an accuracy of 94% using the MW measurement.

It is documented that "*it takes around 50 days for the queen to build the first combs that consist of between 35-50 cells in which she will rear the first 10-15 brood into adult workers*" (Martin, 2017). These first generation workers found from early July onwards, are noticeably smaller than those emerging in the autumn from bigger cells that are characteristic of secondary nests. Differentiating late season workers from the new queens is therefore challenging.

Having a reliable diagnostic tool for identifying queens is particularly significant for timing nest control in the autumn. Drones typically appear in the nest two weeks earlier than the first queens prior to mating. Determining exactly when and whether a secondary nest has produced the next generation of queens is crucial in controlling the spread of *V.velutina*. The main objective of nest destruction is to exterminate the entire colony before the new generation of queens have departed.
At this time of year there is an added difficulty in that the presence of larger workers can make the difference in MW a fraction of a millimetre (0.1mm or less). Therefore, when examining hornets from nests collected in the autumn, MW is less conclusive for determining the onset of queen production. This measuring method is further compounded by the presence of emerging or recently emerged teneral queens (where the exoskeleton is yet to harden).

3. Secondary nests

It is not expected the spring trapping will lead to the capture of all queens emerging or arriving in the spring, and so the development of secondary nests is likely and therefore expected each year. This management of secondary nests relies on sighting worker hornets, and then locating and destroying nests.
In early summer it is not unusual to find a primary nest that remains active as the last worker brood are still emerging and very close by there is a secondary nest to which the queen and most of the workers have relocated. The important point here is that when tracking nests, it is important to determine if there may be more than one nest in that vicinity.

3.1 Track don't Trample campaign

Following on from Spring Queening, the next phase of the control strategy is the Track Don't Trample campaign (first established in 2018, see Appendix 1). This is aimed at encouraging the public to photograph, observe and report suspected sightings and not kill insects indiscriminately, which apart from the risk of being stung often results in the unnecessary deaths of important pollinating insects (such as queen wasps and hornet mimic hoverflies) and does not assist in preventing the establishment of *V.velutina*. Instead, by reporting the exact the location and direction of flight of potential sightings, the AHT can begin the process of tracking worker hornets to locate the nest.

Confirmation of positive sightings and nest locations relies almost exclusively on reports received from the general public and so it is vital that all sections of the local community are well informed and remain engaged in this campaign. Since the arrival of *V.velutina* in Guernsey in 2017, considerable efforts and resources have been directed towards raising awareness of the threats posed by *V.velutina*. Useful identification guides and information about *V.velutina* and the Strategy, can be accessed via an official website www.gov.gg/asianhornet and a dedicated social media FaceBook page www.facebook.com/asianhornetguernsey. Information updates for island residents and visitors has also been disseminated through press releases and media interviews. Regular contact has been maintained with other stakeholders, such as the Guernsey Beekeepers Association (GBKA).

It is widely acknowledged that beekeepers can often play a crucial role in observing hornet activity around their hives especially in late summer. The AHT have approached the GBKA with the aim of identifying the owners and mapping locations of all the beehives in Guernsey (this will not include hives kept by non-members). If the necessary permissions are obtained for this data sharing, the AHT would be able to enlist the support of all those beekeepers within 1km of new *V.veluntina* sightings. It is hoped that this new beekeepers alert system will lead to earlier detection of secondary nests.

Negative sightings records are of value as they provide a year-on-year indication of the level of engagement. The low accuracy of the public in identifying hornets correctly highlights the ongoing need for education in correct identification of *V.velutina* (see Table 6). With an ongoing focus on education and awareness raising it is hoped that reported sightings become more reliable.

Table 6: Reported *V.velutina* sightings received from the general public (2019-2021).

Reported sightings - verified by type per year, including Sark & Herm *(percentages represent proportion of the total number)*			
	2019	**2020**	**2021**
Wasp, bees, Eur. hornet	154 (57%)	147(76%)	256 (67%)
Hornet mimic hoverfly	84 (31%)	35 (18%)	81 (21%)
V.velutina (confirmed)	33 (12%)	10 (5%)	44 (12%)
Total number of reports received	271	192	381

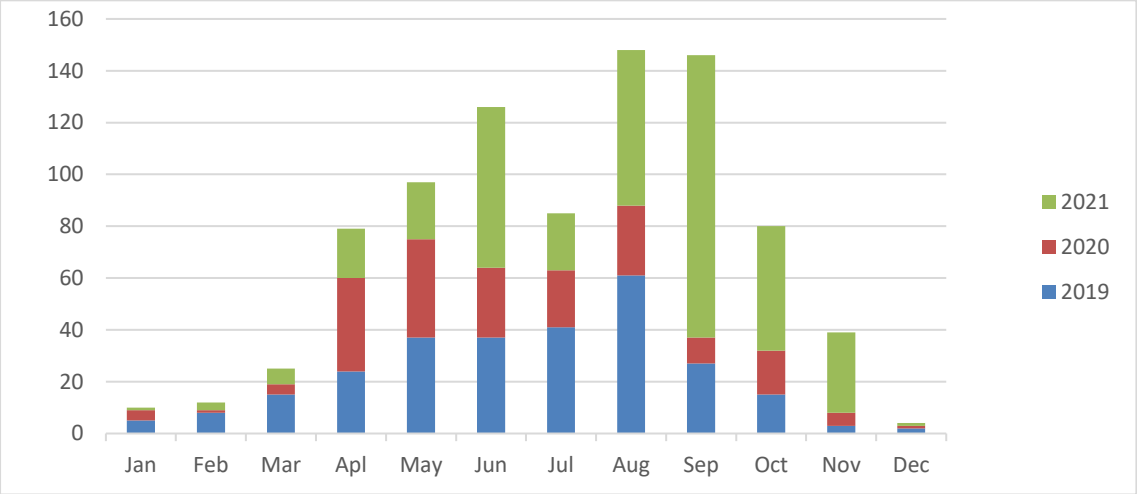


Figure 5: Graph showing when reported sightings were logged through the year.

As illustrated in Figure 5, there has been continued public engagement over the three years of the strategy and members of the public have reported sightings regardless of their accuracy in identification. High numbers of reports whether positive or negative are encouraging as it demonstrates that the public are remaining vigilant and make the effort to report sightings. Figure 5 shows the seasonal variation in reporting with the number of reports typically peaking during August-September.

3.2 Tracking worker hornets to locate secondary nests

Tracking methodology

After verifying a reported sighting by reviewing photographic/video evidence or seeing live or dead specimens, monitored bait stations (plastic containers, open Veto Pharma traps or wicking jars) were placed as close as possible to the original sighting.

These stations were then re-visited 24hrs later to check for visiting worker hornets. When hornets were observed feeding on the bait and returning to their nest, the direction of flight from these stations was plotted manually on printed maps using a compass (to determine the bearing), pencil and ruler.
The critical determinant for locating a nest is getting a prolonged visual fix on a hornet. Observing a repeating pattern of return journeys along the same line of flight, unimpeded by trees and buildings, improves the confidence of the tracker in refining the search area.


A *V.velutina* worker on a wicking bait station

A refined process of triangulation combined with moving the bait stations incrementally down flight lines culminated in the search being narrowed down sufficiently close enough to spot the nests (with the exception of one which was located somewhere deep inside a 6ft granite stone wall). At this stage scanning with binoculars invariably leads to the discovery of increasing numbers of worker hornets in the treetops or entering brambles.

All the tracking of hornets resulting in the successful discovery of nest locations on Guernsey, Herm and Sark has been consistently carried out by the AHT staff. The Field and Research Officer has developed extensive knowledge of hornet behaviour and honed these specialist detection skills over the past 5 years. It is notable that a high proportion of nests were found almost directly on the first confidently plotted line or a few metres either side of it.

Assessing possible nest locations

Wicking style bait stations have now been universally adopted for tracking as they are considered better at dispersing a ‘plume’ of evaporated Trappit, and the bait isn’t consumed as quickly as an open bait. Deploying VetoPharma traps resulted in spillage of bait in high winds and coated the interior of the traps with sticky bait which readily transferred onto the hornet’s exoskeleton and wings. These ‘wet’ hornets often spent a long time self-cleaning before departing for the nest and did not always leave in the same direction – possibly landing in vegetation to continue grooming.

Interestingly, in the UK, the National Bee Unit (NBU) have developed track-and-trace software allowing bee inspectors to coordinate their tracking efforts simultaneously in the field from handheld devices.

Strategic placement of monitoring stations during summer/autumn

The systematic deployment of monitoring stations (wicking style) from August-October/November was introduced in 2021 after an earlier trial. These bait stations were set up at 1km spacings based on a grid designed to ensure island wide coverage. The main benefit of adopting this approach was that it provides a proactive way of continually monitoring for worker hornets across the whole island rather than relying solely on reports

from the general public. Experience has shown that hornets are generally underreported and while *V.velutina* densities are maintained at low levels any opportunity to improve the detection rate should be taken. The bait stations were predominantly monitored by existing volunteers (familiar with Spring Queening) and offer a low cost, low maintenance option to improve the chances of detecting secondary nests.

Range of foraging workers, time taken to locate nests, last tracking dates

All of the confirmed hornet sightings records from 2017 onwards have been logged and mapped comprising a total of 69 reports. From this mapping data, 85% of worker hornets were sighted less than 750m from a known nest, 12% were 750-1,000m and just 3% were further than 1km away. The furthest distance a worker was found foraging away from a nest was 1,443m although it is possible this originated from a different, undetected nest. In practice, most secondary nests have been found within a radius 500m from the first sightings of foraging workers.

The average time taken to locate nests from the first confirmed sighting has improved significantly over time (see Table 7).

Table 7: Time taken to locate secondary nests after a positive hornet sighting confirmed at a bait station (2019-2021).

Year of Asian Hornet Strategy	Nest location & number	Date of first sighting linked to nest	Date AHT started tracking	Date nest discovered	Time taken to locate nest	Notes
Year 1	Guernsey (1)	Aug. 20th	Aug. 21st	Sept. 4th	15 days	
	Guernsey (2)	Oct. 19th	Oct. 20th	Oct. 25th	5 days	
	Sark (1)	Aug. 3rd	Sept. 20th	Oct. 23rd	34 days	Sark volunteers first experiences of tracking
Year 2	/	/	/	/	/	No tracking cases, no nests discovered
Year 3	Guernsey (1)	Sept. 5th	Sept. 6th	Sept. 10th	5 days	
	Guernsey (2)	Oct. 15th	n/a	Oct. 16th	1 day	Nest found by owners in treetops
	Guernsey (3)	Oct. 25th	Oct. 25th	Oct. 27th	2 days	
	Herm (1)	Sept. 25th	Sept. 29th	Sept. 29th	3 hours	
	Herm (2)	Oct. 25th	Nov. 3rd	Nov. 3rd	40 mins	

The latest date for active tracking of workers back to the nest was November 5th, 2021 on Herm. No nests or hornet sightings have ever been recorded later than this date across the Bailiwick.

Limitations of using monitored bait stations

Open bait station + three worker hornets

Monitoring stations inevitably attract other insects in addition to *V.velutina*. The amount of Trappit bait that is consumed by wasps and/or lost by evaporation is relatively low as these devices are typically only deployed for a short time following a positive sighting. Apart from topping up containers, the person monitoring does not have to spend long at each station to confirm the presence of a hornet's nest in the vicinity – any hornets that have found the bait will normally return within 15 minutes and continue to 'work' a bait station for several days until it is removed or depleted.
Several monitoring stations may be required to locate a nest within the search area (typically 1.5km radius) so there is a demand on staff or volunteers time to visit and check every station for hornet activity.

During September/early October 2021, a change in *V.velutina* foraging behaviour was observed in Guernsey for the first time in relation to the use of monitoring stations baited with Trappit. Worker hornets were seemingly disinterested in foraging for carbohydrates and consistently ignored these bait stations. Protein baits were also placed in the vicinity in case workers had switched to foraging for protein; a behaviour which has been frequently witnessed (Leza et al (2021) and National Bee Unit, UK (Semmence, N., Pers. Comms. 2021), however these were not effective in attracting hornets. As many as six wicking stations were positioned within 500m of a medium sized nest, not one of these had attracted hornets. The nest was eventually located by searching suitable trees close to where a single hornet was found trapped against a garage window.

Late nest, Nov.5th; high ratio of pupae

This atypical behaviour, which was also identified in Jersey throughout the same time period, could be related to environmental conditions. One hypothesis which should be considered is the likelihood of colony brood development being delayed as result of a cold spring. Nests delayed in undergoing their rapid colony growth would have greater numbers of mature larvae from which workers could be eliciting sugary secretions much later than in normal years. Workers that are sufficiently nourished in the nest would not need to forage for carbohydrate and focus only on catching prey, thereby not turning up at bait stations containing Trappit. If this supposition is correct, seasonal variations in brood development may mean that tracking will be more

challenging in some years and could easily result in later nest detection and the inherent risks of queen emergence.
Other observations of deformed nests and combs found on the ground underneath nests in tree canopies indicate that normal nest development has been interupted requiring workers to divert energies into repairing wind damaged nests.

Tracking with radio-telemetry

The AHT has at their disposal, specialist radio telemetry tracking equipment purchased in 2018. Although it has not yet been deployed on an actual nest, there will inevitably be situations where conventional track-and-trace methods are not possible. The option of attaching radio tags to robust worker hornets to locate a nest in a complex environment is well documented (Kennedy et al, 2018). For example, in heavily wooded areas or in town centres where conventional tracking may not be possible, necessitating the use of this specialist equipment as a part of the contingency plan.


Radio-telemetry equipment being used to track hornets in Jersey (© Jersey Government , 2019)

Use of thermal imaging devices to find nests

In November 2021 the opportunity arose to test a CAT S60 thermal imaging device in the field. This device produced clear images of individual *V.velutina* workers foraging for nectar on a false castor oil bush (*Fatsia japonica)* – see photo. When the device was tested on a large nest with a clear line of sight (located at the top of a 6m alder tree), it became evident that it is not possible to differentiate any part of the nest from the surrounding foliage due to the insulating properties of the nest material. Therefore, the use of thermal imaging to locate nests concealed in cavities or in treetops does not appear to be an effective tool.

3.3 Secondary nest control – location of nests, treatment and removal

Location of secondary nests

The relocation of the queen with her workers from primary nests (typically in found sheds, <3m above ground level) and the transition to larger secondary nests (typically in treetops >10m above ground level) is poorly understood. In Jersey this year they have reported a continuing trend for finding more secondary nests lower down, i.e. <3m (14 out of 63 =22%) and situated in or on man-made structures (R.Hogge, Jersey Pers. Comms). There have been no discernable trends in Guernsey but this is more likely attributed to the lower occurrence of nests generally.
It is predicted that *V.velutina* will continue adapting to new habitats as it expands its range across Europe (Robinet et al, 2017) and therefore new behaviours are likely to arise. Moving

nests into high trees is an evolutionary trait aimed at avoiding predators and optimising the reproductive capabilities of the colony. Lower sited nests are potentially more dangerous to the public and land managers as they are more likely to be accidentally disturbed. Only time will tell if this trend for lower nests observed in Jersey continues. There is another theory that hornets may put less resources into defensive behaviours if they perceive lower predation pressures in future (Kennedy, P., Pers. Comms. 2021).

Figure 7 illustrates the location of all primary and secondary nests that have been identified and destroyed in Guernsey, Sark and Herm between 2017-2021. A high proportion of all the 2018 secondary nests were found within 2.5km of a very large nest (Guernsey's first) that was destroyed in September 2017 and had already produced queens. This provides strong evidence that, under certain conditions, post-emergent queens may not disperse very far from the nest and may emerge from hibernation to build nests in the areas adjacent to the old nest.

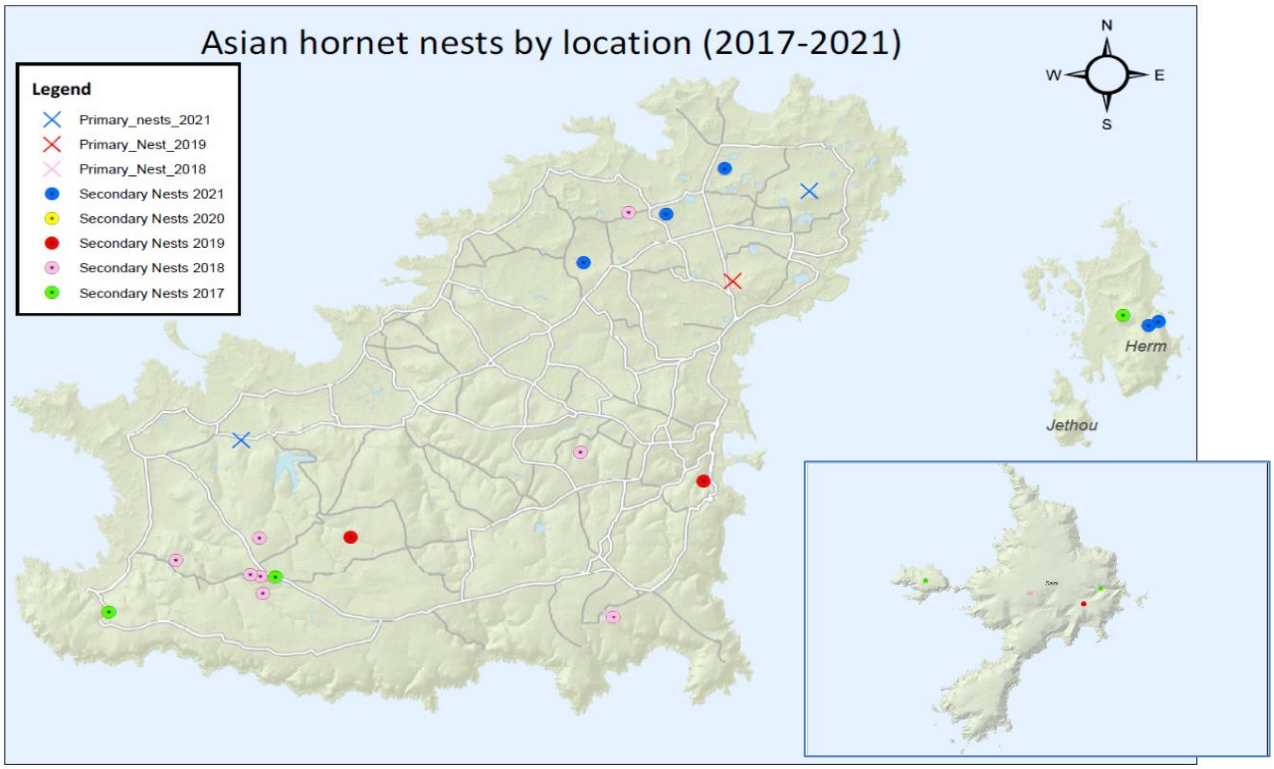


Figure 7: Location of destroyed primary and secondary nests 2017-21.

The specific location of preferred nests sites appears to be completely random as seen in Figure 8 which shows the location of all the nests detected and destroyed across Guernsey, Sark and Herm during 2019-21 (total number of nests = 8). To date, only one secondary nest has been discovered inside buildings (shed - 2018) and none were found in any of the main urban centres.

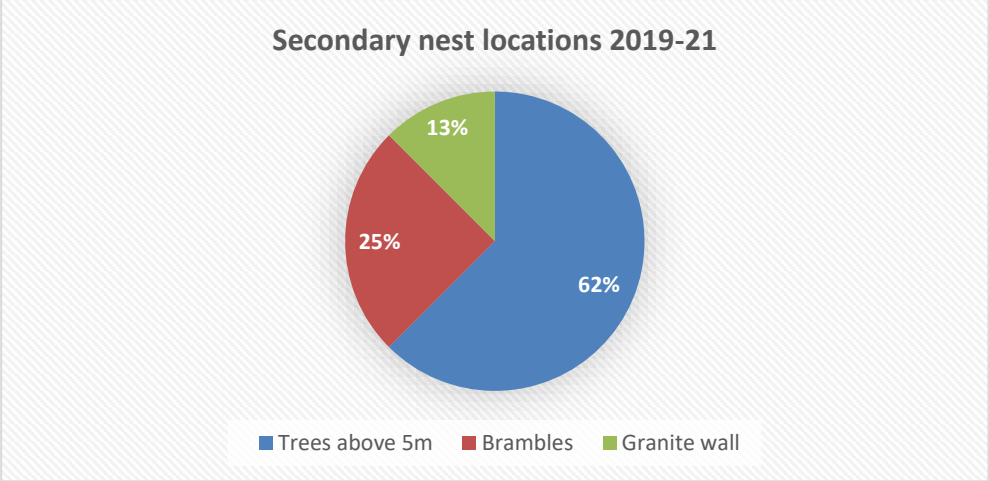


Figure 8: Location of destroyed secondary nests 2019-21

The four tree species in which nests were detected were all deciduous species (alder, sweet chestnut, poplar and goat willow), which represents an important advantage for visual detection of nests by direct observation compared to the denser coniferous species.

There does appear to be some association with human habitation with more nests occurring in gardens and close to properties than in rural areas of countryside/mature woodland but this is not surprising given that a large proportion (roughly 30%) of land in Guernsey is gardens.

Nest location - bramble scrub

Nest location - sallow scrub

Nest location – field/woodland

Treatment (pesticide application) and removal of secondary nests

The primary objective in this vital work is the effective destruction of all *V.velutina* nests in a safe and timely manner before the colony has developed far enough to produce the next generation of queens. Examination of nests over the past three years has shown that in general, the presence of emerging queens is occurring around mid-October which necessitates nest treatment and removal before this date. It is imperative that treated nests are not left in situ for three reasons:

1. The biggest risk of environmental hazards arises from birds such as great tits and woodpeckers (or small mammals) finding nests and consuming contaminated brood;

2. There is an additional risk from treated nests falling out of trees into water courses thereby introducing chemicals into the aquatic environments, and;
3. Even when all adult hornets (and larvae) are killed by insecticide applications, the pupal stages are afforded protection from the silk cappings and continue to develop unharmed into flying adults

To mitigate of the above risks, wherever possible, all destroyed nests are removed within 24hrs of treatment with pesticide. They are double bagged on site, then stored in a chest freezer post-treatment to await dissection and examination at a later date.

Treatment methodology – pest management procedures

The treatment approaches adopted on Guernsey have been adapted from official UK policy as documented in the Pest Specific Contingency Plan - *V.velutina* (Department for Environment Food & Rural Affairs, 2017).

The AHT work according to strict protocols and follow an operational policy which satisfies the requirements of the States of Guernsey Health and Safety Executive and ensures comprehensive insurance protection for operatives and the general public.

The control of *V.velutina* involves several notable risks, primarily to operatives, but also to bystnaders. They include the following;

- being in close proximity to large numbers of defensive stinging insects,
- storage, handling, transportation, and application of insecticides,
- working at heights from ladders and raised platforms,
- working alongside inexperienced operatives who could aggravate hornets,
- working in full PPE in extreme temperatures,
- working in public spaces during nest treatment/removal
- examination of treated nests and potential exposure to insecticides.

All risk assessment templates (see Appendix 2) are approved by the Health and Safety Officer. The AHT are constantly reviewing and revising the risk assessments, for example, they have have further enhanced their working practices and treatment modalities after receiving support and guidance from an external (UK) Pest Control consultant who visited during the summer of 2019 as part of a 2-day work shadowing mission, preparing for the likely arrival of *V.velutina* in Kent.

Step 1. Risk assessment to determine safest means of destruction

Once a nest has been located, a full risk assessment is carried out considering the ease of access, proximity to households, weather conditions etc., to ensure that the nest can be treated and removed as quickly and safely as possible. This initial planning stage often

involves a site visit from a tree surgeon experienced in working alongside the AHT to facilitate an expedient nest removal.
There are no invasive non-native species related powers of entry that are available to the team on Guernsey so all access to private property is negotiated with landowners/occupiers. To date everyone has been grateful and willing to cooperate with this work by granting access for destroying nests.

Step 2. Notify nearby residents
Where a nest is sited close to domestic or commercial properties all residents and employees within a 100m radius are notified in advance of the intended date and time of nest treatment. Letter drops are organised advising residents to shut their doors and windows and remain inside around the time that the nest is being treated. On one occasion where a nest was at the end of a residential cul-de-sac surrounded by 70 properties, Guernsey's Civil Protection Volunteers were enlisted to ensure the area remained secure throughout the treatment operation.

Step 3. Chemical destruction of nests
To mitigate the inherent risks of environmental contamination and to protect the health and well-being of operatives, a decision was made to bring *V.velutina* nest treatment in-house. The Field & Research Officer qualified (Royal Society for Public Health Level 2 Award in Pest Management) in June 2019 and has produced robust risk assessments for all the adopted control methods which require the application of Ficam D within the natural environment.

Ficam D was chosen above other available pesticides in that it does not excite vespids, a characteristic of products that are pyrethrin based. This is important as aggravated aggression of *V.velutina* will increase the risk to operators and the public when treating nests. Following a re-registration of the product (UK-2018-1136), Ficam D can only be used by professional operators for the control of insect pests in and around buildings.


Assembling lance applicator nozzle


Close range treatment inside a wall


Using a long lance from a MEWP

Since 2019 the States of Guernsey Health and Safety Executive have sanctioned an annual 'off-label' approval which grants the AHT permission to use Ficam D to control *V.velutina* outdoors.

The AHT are responsible for leading the chemical destruction of all nests and overseeing their subsequent removal. They are equipped with the necessary PPE and specialist equipment including long pole lances to access nests at height. The dusting lance is powered by a stainless-steel refillable pressure tank and fully extends to 8m allowing some nests to be reached from the ground. Nests that are out of reach are accessed using a mobile elevating work platform (MEWP) or 'cherry picker'. A high degree of skill is required when using this long lance, guiding the end nozzle through the outer wall of the nest and positioning it centrally to ensure precision application of powder across all of the combs.

The application of Ficam D has proved to be consistently reliable resulting in a very effective kill rate. Once a nest has been treated the operator/s withdraw from the area, leaving the cordon and warning notices in place. The nest should be left no longer than 24hours. If the nest is not dead, the traffic of flying workers to and from the nest will be visible. At this point a second treatment of chemical may be necessary.
Since 2019, eight secondary nests have been successfully destroyed using the methods described above. It has been consistently proved that it is safe to destroy the nest in the morning, monitor for activity after 5 hours and then take down nest during late afternoon.

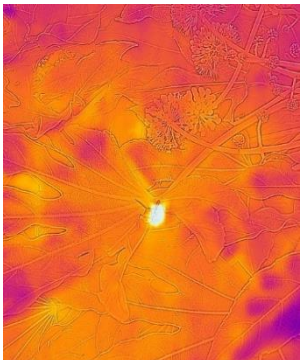
Post-eradication surveillance

Experience has shown it is important to continue monitoring for the presence of *V.velutina* hornets around the nest site up to one week after nest treatment and removal. It is possible that hornets not killed during the nest treatment will build a new nest nearby, but this is also to ascertain that there are no satellite or additional nests nearby. Given the potential nest density identified in areas of high infestation, it is possible that multiple nests may exist in a relatively small area.

To discount this possibility, post-eradication surveillance is carried out by setting out baited traps within a radius of 2km. Registered beekeepers and residents in the area are given guidance on using a trap in their apiaries/gardens with instructions on how to report

'Mopping up' worker hornets

Double bagged destroyed nest



Thermal image of a hornet on *Fatsia japonica*

V.velutina sightings. Stray worker hornets are expected to be 'mopped up' after two or three days. Absence of any sightings beyond this time is usually a good indication that there was only one nest present.

3.4 Nest destruction costs: 2019-2021

Table 8: Cost of nest destruction equipment – hornet suits, applicator and chemical.

Stock item	Unit cost (£)	Quantity purchased (Feb 2019)	Total cost (£)	Amount used to treat 8 nests	Quantity remaining (Dec. 2021)
Ficam-D	33/kg	3 x 3kg	**99**	0.5kg = **£5.50**	8.5kg
Hornet suits	690	2	**1,380**	n/a	n/a
Pesticide applicator kit	1,043	1	**1,043**	n/a	n/a

Table 9: Cost of nest destruction and removal in Guernsey involving external contractors.

Year of Asian Hornet Strategy	Secondary nests destroyed in Guernsey	Date of nest removal	Details of contractor works	Costs of contractor hire
Year 1	1st nest – St Saviour's, nest destroyed in a chestnut tree	Sept. 11th	Tree surgeon + cherry picker hire, two visits in one day am & pm	£355
	2nd nest – Havelet, nest destroyed in a granite wall	Oct. 25th	Not needed - nest at head height	-
Year 2	0 nests	-	-	-
Year 3	1st nest – Sandy Lane, St Sampson's, nest destroyed in a chestnut tree	Sept. 13th	Tree surgeon, pm visit only, ladder	£130
	2nd nest – L'Ancresse Rd, Vale, nest destroyed in a poplar tree	Oct. 22nd	Tree surgeon, am & pm visit + cherry picker am only, pm climbed tree	£305
	3rd nest – Vale, nest destroyed in a sallow bush	Oct. 28th	Not needed - nest accessible from a ladder	-
				Total = £790

In 2018, prior to the implementation of this strategy, external pest controllers were contracted to undertake the nest treatments. The total cost of destruction and removal of eight nests using private contractors and operatives amounted to £2,480 (based on an average cost of £310 per nest.
The decision to bring the nest destruction 'in-house' has reduced external costs as no other pest controllers were required (Table 9). Those nests that were those greater than 8m above ground level, beyond the reach of the dusting lance, required the hire of a cherry picker and the contracting of a tree surgeon. A tree surgeon (wearing a hornet suit) is often needed to remove branches and assist in the safe recovery of the nest working alongside the AHT pest control technician.
The combined costs of destroying and removing five secondary nests during 2019-21 was £790, providing an average of £263 per year (or £158 per nest).

The combined salary and average mileage costs for the Asian Hornet Project Coordinator (1.0 FTE) + Field & Research Officer (0.5FTE) were £50K/year; this includes Spring Queening costs. In section 4.3 a 'doing nothing' scenario is considered along with the implications of failing to manage predicted population growth. Projections on the annual costs of introducing control measures after *V.velutina* has established are explored in detail.

3.5 Examination of nests and colony development data

Examination of nests

Once a nest has been removed it is stored in a freezer until it can be carefully dissected and examined in a laboratory. Photographs are taken to document each stage of the nest examination process and all quantitative data are entered onto a spreadsheet. The following data is recorded:

1. Physical –
    a. External dimensions of the nest,
    b. number and diameter of the combs,
    c. cell counts.

2. Biological –
    a. Queen present,
    b. number of eggs, larvae and pupae per comb,
    c. number of adult workers/drones/queens found dead in the nest (including any fallen adults/larvae).

See Appendix 3 for an example of a nest examination report.

4. Population trends

4.1 Guernsey's Asian hornet status: 2016-2021

Table 10 below, provides the combined totals of queens captured/trapped together with the number of primary and secondary nests destroyed in Guernsey since *V.velutina* were first detected, including the first three years of the strategy (2019-21). Table 2 (p.11) provides a breakdown of the queen capture/trapping data for the period 2019-21, and is illustrated in figure 10..

Table 10. Combined totals of queens and nests destroyed in Guernsey.

Year	2016	2017	2018	2019	2020	2021
Queens	0	0	3	10	3	10
Primary nests	0	0	0	1	0	2
Secondary nests	0	2	8	2	0	3

The table shows that from 2019 onwards, with the introduction of island-wide spring trapping and greater publicity, *V.velutina* queens were captured every spring with numbers reaching double figures in 2019 and 2021. This coincides with a decrease in the prevalence of secondary nests as these were maintained at lower levels in the years following 2018, as described in Section 2. This trend is encouraging and is supported by Beggs et al (2011) wo state that a combination of all available methods in an organised and integrated manner might be the only efficient way of acting to prevent *V.velutina* from establishing. The destruction of queens and primary nests in the spring would appear to be a useful control method resulting in fewer secondary nests being found in the autumn months (see Figure 10).

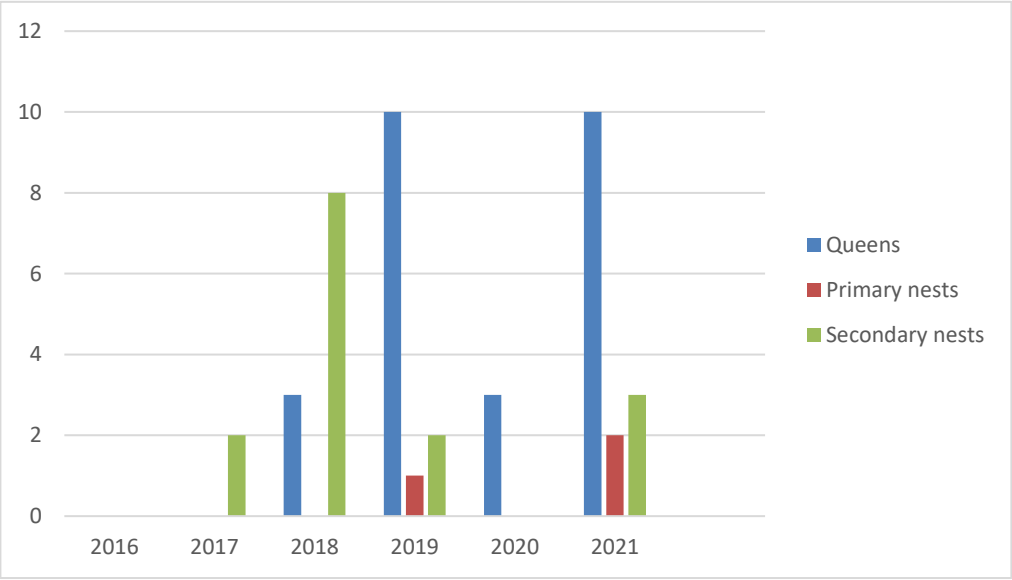


Figure 10: Graph showing *V.velutina* numbers in Guernsey between 2019-21.

Although the invasion pressure is anticipated to remain with spring incursions becoming the expected norm, in the absence of evidence (e.g., missed nests in autumn or early detected queens) to indicate that queens have emerged and potentially overwintered in Guernsey, it is likely that the *V.velutina* has been effectively eradicated or held at sub-optimal levels annually in recent years (this is comparable to the situation in the UK).

4.2 Channel Island population trends on the spread of *V.velutina*

Figure 11 below, shows the relative geographical positions of the Channel Islands and their proximity to the French mainland. Guernsey is the second largest but the furthest west of all the islands from France and this geographical factor is likely to be most significant when considering the ever-present threat of colonisation. A queen hornet flying at 5m/s (18kph) departing from France, could reach Guernsey (31km) in 2.8hrs. With the added assistance of an 18kmph easterly tail wind, which equates to an additional 5m/s, this travel time is effectively halved so the journey could be completed in 84mins.

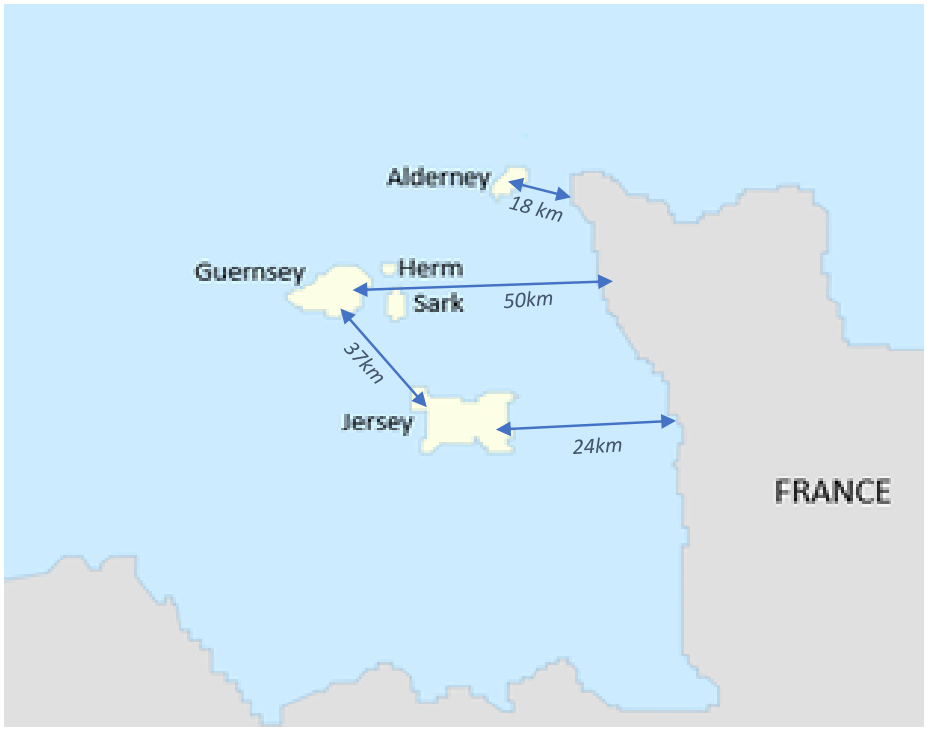


Figure 11. Natural incursion routes of *V. velutina* to the Channel Islands from France and their distances.

When considering potential invasion from other islands in close proximity to Guernsey, the effectiveness of control strategies adopted by each of the islands and thus their *V.velutina* population levels becomes particulary important. The islands may act as 'stepping stones' increasing the spread and potential incursion of queens each spring.

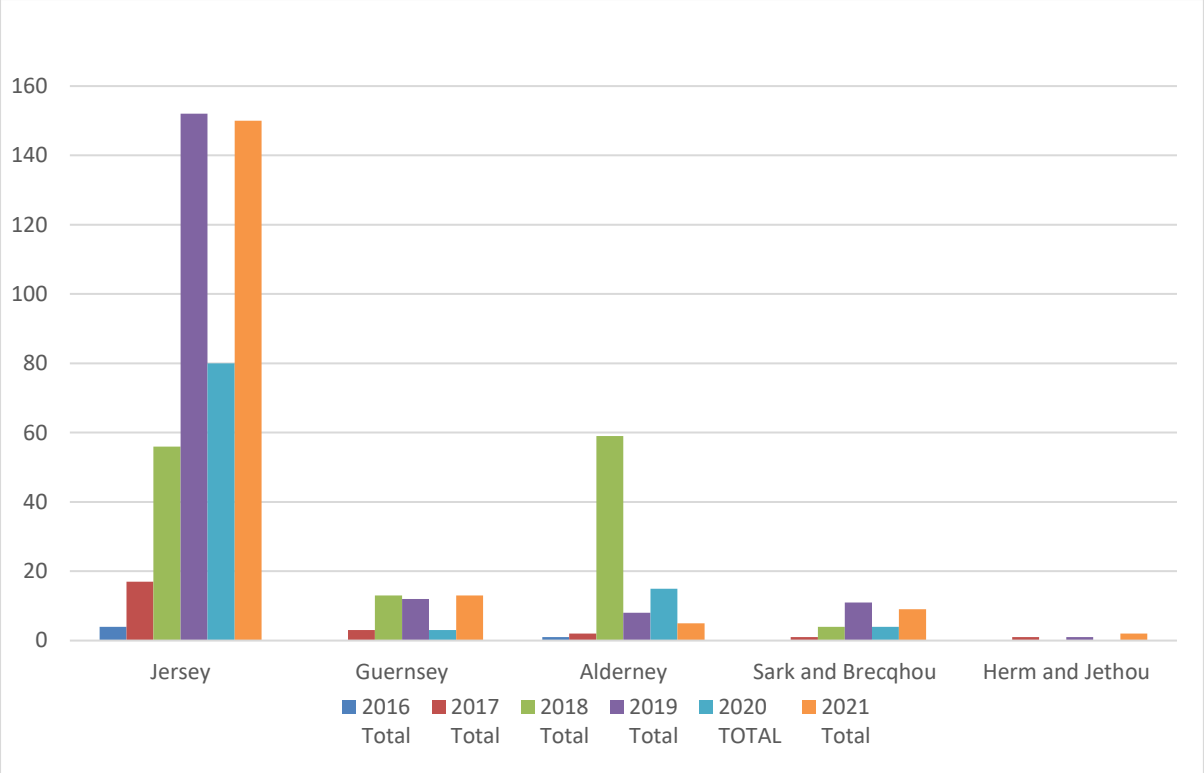


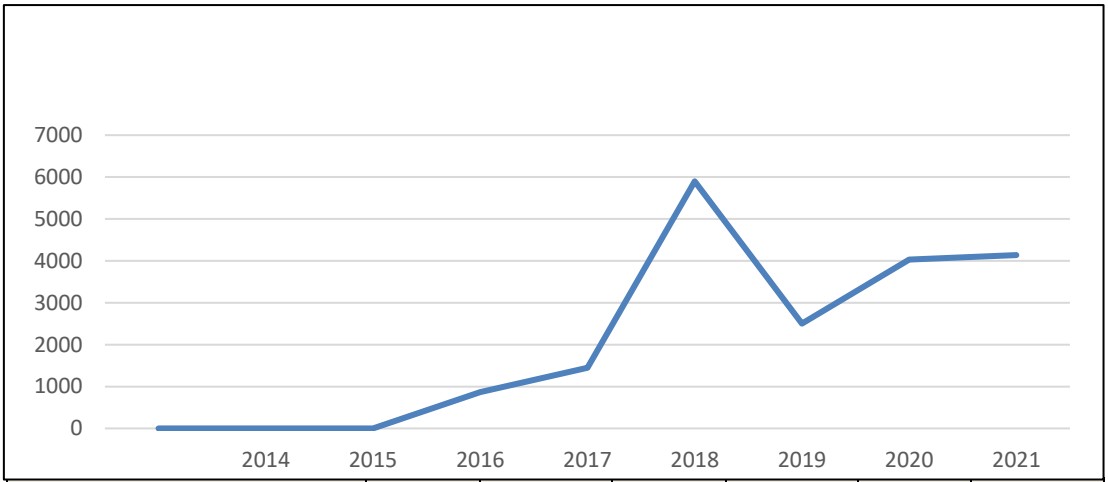
Figure 12. Total numbers of queens, primary and secondary nests recorded across the islands to date.

Figure 12 represents the combined totals of queens, primary and secondary nests which have been officially verified and recorded across the respective islands since *V.velutina* first arrived. It is encouraging to note that since the implementation of the strategy in 2019, Guernsey's overall numbers have not continued to increase unabated. After an initial surge to eight nests in 2018, the average number of nests destroyed from 2019-21 is 1.6 per year. Jersey have experienced higher numbers in recent years but the rate of increase has levelled off indicating that the control measures are helping to prevent an escalation in populations.

Status of V.velutina in France, adjacent to the Channel Islands

The status of *V.velutina* throughout Normandy (first recorded in the north Cotentin peninsula in 2013) is of particular interest and relevance as these are the closest hornet populations to the Channel Islands. The Asian Hornet Coordinator employed by the Government of Jersey has been proactive in maintaining a dialogue with department officials working for Fédération Départementale de Défense contre les Organismes Nuisibles de la Manche (FDGDON).

Their 'collective effort control program' against *V.velutina* was implemented in 2016 with the main aim to reduce hornet numbers. The objectives are surveillance, protection of beehives, reporting and identification and nest destruction. Annual reports from the FDGDON provide an insight into the scale of the problem in this region of France, just 'across the water' (Figure 13).



	2016	2017	2018	2019	2020	2021
No. of secondary nests recorded	**869**	**1447**	**5898**	**2503**	**4034**	**4139**

Figure 13. Table and graph showing annual records of V.velutina on the Cotentin peninsula, Normandy 2016-20.

To date, the year 2018 is a significant reference year, with the highest number of nests recorded in the Departement of La Manche, this is consistent with the picture in Guernsey and Jersey. There is no explanation provided to explain the dip in 2019 but it is possible there could be 'good' and 'bad' hornet years related to environmental factors. Worryingly, in terms of the optimal control period, the number of nests reported in November in the region of Normandy is very large, accounting for more than 20% of the season's nests. By the time these late season nests were reported it is most likely that they would have already released new queens.

4.3 Predicted invasion rates in a 'do-nothing' scenario

V.velutina continues to spread across Europe colonising suitable environments at an estimated rate of 78km/year (Robinet et al, 2017), with nests found as far north as Hamburg, Northern Germany.

Where control measures have been unsuccessful, populations of hornets in France have increased to an average of 5 nests/km^2 in rural areas to 15 nests/km^2 in urban areas (Franklin *et al.*, 2017). In Andernos, a region of south-west France, the number of nests increased regularly since they were first detected in 2007. After eight years, a total of 545 secondary nests were discovered within an area of 9.05 km² (Monceau and Thiéry, 2017), which equates to an average of 7.5 nests/ km^2.

The numbers in Table 11 demonstrate just how rapidly *V.velutina* numbers increased in different regions since they were first detected there. Interestingly, a successful eradication was achieved on Majorca in 2018 (Leza et al, 2021) after a peak in secondary nest

destruction in year three (20 nests). This was achieved by an annual programme of spring trapping followed by strategic monitoring with sugar and protein bait stations in areas where reported sightings were confirmed.

Table 11 Annual increase in *V.velutina* nest numbers since first detected in four different locations in Europe.

Location and year first detected	Numbers of secondary nests found in the three years after *V.veluntina* was first detected		
	Year 1	**Year 2**	**Year 3**
Andernos – SW France (2007)	**4**	**27**	**82**
''Serra de Tramuntana" – NW Majorca (2015: eradicated 2018)	**1**	**9**	**20**
Jersey (2016)	**4**	**11**	**38**
Guernsey (2017) (hornet strategy implemented 2019)	**2**	**8**	**2**

In Guernsey's original Strategy document, a 'do nothing' option was considered to try and understand the implications of not developing contingency plans to control *V.velutina*. While it is impossible to predict the long-term population trends of *V.velutina*, projected densities based on an area of established colonies in France can be applied to Guernsey, which has an area of 65 km^2. Based on 10 nests/km^2 recorded in France by Franklin et al *(*2017), it is predicted that 650 nests per year could become established in Guernsey by 2030.

An estimate of the annual costs of removing these nests (based on 2018 costs - relying on private contractors) is £201,500, not including staff time (or mileage expenses) spent locating the nests, and additional equipment or PPE which may be required. This represents a significant increase when looking at the comparable costs of maintaining *V.velutina* at low densities during the years 2019-21, where the destruction of a combined total of 5 secondary nests was £790 (see section 3.4). Thus, the cost of prevention is significantly outweighed by the cost of management should *V.velutina* become established.

Massin et al (2020) looked at the economic cost of controlling Asian hornet in Europe. They estimated the total annual nest destruction costs once the hornet has established; €11.9M (£9.8M) for France and €8.6M (£7.1M) for the United Kingdom.

V.velutina spotted at Guernsey airport

All of these projections highlight the risks of facing a *V.velutina* population explosion and having to address some of the more serious consequences such as public health, impacts on biodiversity and economic costs. Living with hornets at high population densities would inevitably lead to difficult decisions regarding how to deal with the emerging situation, e.g., which areas to prioritise for targeted nest, who will carry out this work, who will pay for it etc.

5. The importance of communication

5.1 Public awareness, media engagement and networking

Public awareness

As previously mentioned in Section 3.1 which relates to the Track don't Trample campaign, providing accurate information to the general public and other agencies is essential for raising awareness and ensuring an effective response in preventing the spread of *V.velutina*. Accurate information is important for educating the public to correctly identify and report sightings in a timely manner. Balanced reporting is always encouraged so that the perceived threat level is not exaggerated which could easily add to prejudice against 'scary' insects resulting in needless persecution of other inveterates such as common wasp (*Vespula vulgaris)* and hornet mimic hoverflies *(Volucella zonaria*). In this regard overseeing appropriate use of social media and producing balanced media releases and web-based material has been crucial.

Throughout the past three years the Strategy Coordinator and Field Officer have participated in environmental science workshops and BioBlitz's, displayed information at shows and talked to many primary and secondary school children.

The response from the general public in reporting *V.velutina* has been excellent and the various initiatives to maintain this engagement and improve on identification of hornets have worked well in the absence of widescale formal monitoring. There is no doubt that the continued vigilance and support of the public is the most valuable asset in the detection of *V.velutina*.

Fatsia japonica – autumn food plant for Asian hornet workers

Media involvement and other initiatives

The AHT have placed special emphasis on developing material for media releases every year, to coincide with significant events, such as the Spring Queening campaign, finding the first primary nest or observing late season hornet foraging on specific food plants (e.g., *Fatsia japonica*). A short (1min) Spring Queening animation was commissioned to promote the aims of the Spring Queening programme on social media. The video release in 2019 coincided with posters, flyers and broader media coverage on TV and radio.

During 2019-2021, Guernsey's Asian hornet control programme featured in 34 articles in the local press, 20 interviews on local radio, five interviews with the BBC/Channel TV with seven stories picked up and covered by the UK National news outlets.

An innovative idea to print a hornet alert message onto beer mats came to fruition in July 2021 following a partnership with a local independent brewery. 15,000 beermats were distributed across establishments on Guernsey and Sark at a cost of £252. This initiative attracted interest in the UK and the story was featured in *Beecraft* – the UK's leading beekeeping magazine.

Beer mat awareness initiative

<u>Public perception survey</u>

In November 2021, the AHT supported a comparative survey that was conducted in Guernsey and Kent as part of an MSc. research project investigating public awareness and perceptions of *V.velutina* and their management in these two regions.

The initial findings of this unpublished research (Rose-King in prep, 2022) reveal a marked difference in the relative success of the public awareness campaigns and in the ability of respondents to correctly identify this invasive pest when presented with a number of frequently misidentified species, such as the hornet mimic hoverfly.

Figures 14, 15 and 16 show some of the data from the preliminary stages of this interesting research. The early indications from this research are that the various campaigns adopted on Guernsey have been successful in raising public awareness.

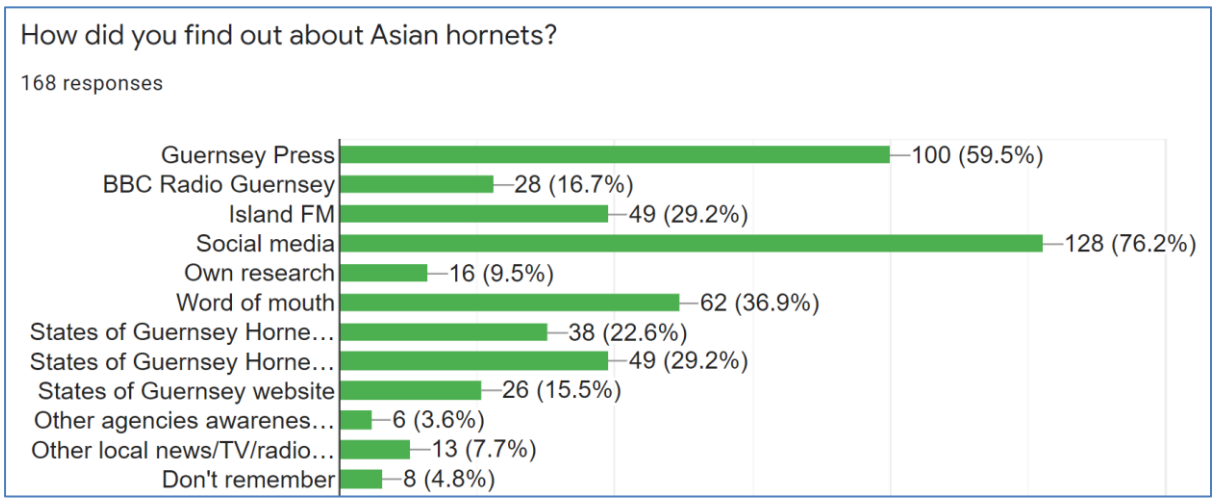


Figure 14. Comparison of the different media used to raise public awareness in Guernsey (Rose-King, in prep 2022).

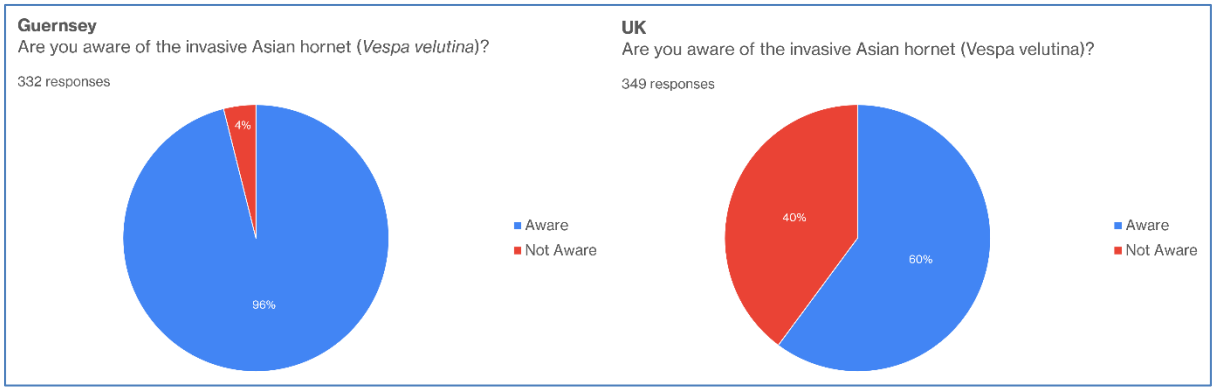


Figure 15. Comparing public awareness of Asian hornets across two regions (Rose-King, in prep 2022).

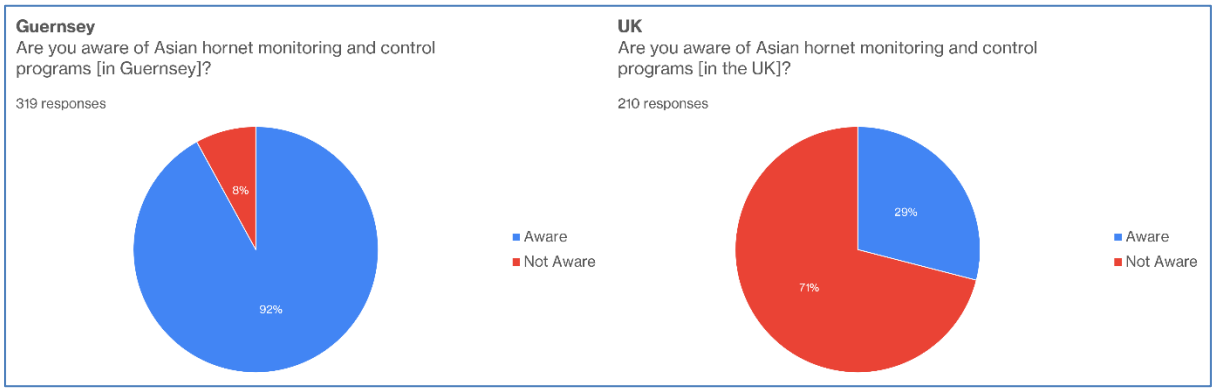


Figure 16. Awareness of the management of *V.velutina* across two regions (Rose-King, in prep 2022).

Networking on island and further afield

Close links have been forged with the various stakeholders and presentations given to the Guernsey Beekeepers Association, La Société Guernesiaise, and the Parish Douzaines/Constables.

<u>Inter-island cooperation</u>

In common with Jersey and Guernsey, all of the other (smaller) islands face the same challenges in managing the imminent threat of *V.velutina* and controlling their numbers, albeit with less resources. There is no doubt that there will be additional colonisation pressures from neighbouring islands should hornets become established there, due to their proximity to Guernsey.

Over the past three years another important goal of the strategy has been to develop close relationships and effective communication networks with key individuals across all of the Channel Islands. The obvious benefits of this approach have been the sharing of expertise

and information e.g., modifying techniques to improve spring queening success, improvements in hornet tracking, and supplying equipment such as PPE, traps and bait.

International collaboration

In 2020 the Project Coordinator was named as the designated contact to represent the States of Guernsey on the newly formed British Irish Council (BIC) Asian Hornet Taskforce. Virtual meetings are held four times a year to enable information sharing and to ensure each jurisdiction has an Asian hornet contingency plan. The taskforce collates statistics on an annual basis and reports directly to the Minister for the Environment. Both Guernsey and Jersey play an active role in these meetings having direct experience of controlling hornets.

Another beneficial collaboration has been the establishment (in 2021) of an informal pan-European Asian hornet forum that meets four times a year on Zoom, hosted by Jersey's Coordinator. The group consists of individuals who have an active role in practical aspects of hornet control and includes representatives from government agencies and universities including the UK, Jersey & Guernsey, Belgium, Germany, Denmark and Spain. The particular focus is on learning from each other with general discussions and information sharing looking at:

- Hornet activity/nests update in your area
- Trapping techniques
- Attractants/baits
- Technology to assist finding nests/latest research
- Reporting systems
- Pesticides/destruction methods

6 Protecting the public from getting stung

6.1 Emergency services in Guernsey

Due to the significant public health implications of an attack by *V.velutina*, other service areas were identified as potentially having an integral role in the delivery of the Strategy. One of the key objectives outlined in the Asian Hornet Strategy was to define responsibilities especially in relation to protecting public health. In 2019 the Project Coordinator held meetings with representatives from all the emergency services – Fire and Rescue Service (Head of Operations and Training), St. John Ambulance (Transformation and Development Manager), Police (Neighbourhood Policing Team) and Joint Emergency Services Control Centre (JESCC Head Controller). The main aim of these meetings was to ensure a coordinated rapid response from the emergency services in the event of a serious incident arising from an accidental nest disturbance. These meetings provided service leads with information on the current threat level and covered some of the scenarios and risks that hornets could pose to the public and emergency responders. It was agreed that the Fire and Rescue Services were best placed to deal with an emergency and would respond by developing protocols to deal with a hornet related emergency e.g., adapting PPE and using specialist equipment to facilitate rapid removal of a victim(s) from the scene of an incident.

Due to the significant public health implications of Asian hornets, another service area that would have an integral role in the delivery of the strategy are the Committee *for* Health & Social Care – responsible for the dissemination of information regarding public health risks and for ensuring capacity to respond to medical incidents.

While hornet numbers and incidences of stings remain low there has been no formal engagement with either the Fire and Rescue services or the Public Health Department, however this would become a priority if hornet populations in Guernsey were to increase significantly.

Reports of hornet stings – Guernsey/Sark/Herm

During all the successful nest removal/destruction operations carried out by the AHT, there have been no incidents resulting in either the pest control technician, tree surgeon, lift operative or landowner being stung by *V.velutina.*

Jean-Pierre Muller-Getty images

An awareness raising session was well attended by States Works Department in 2019. This was designed to address the potential risks amongst the gardeners and grounds maintenance staff employed by the States of Guernsey.

Public information has been widely disseminated to raise awareness of the possible presence of hornet's nests in trees, hedges and gardens; and the associated risks of accidentally disturbing a nest. Further training sessions targeting private landscape contractors, tree surgeons and gardeners, have proved more challenging owing to the large number of smaller businesses in operation.

Reports of hornet stings – Normandy/Jersey

With the FDGDON recording 4,139 *V.velutina* nests across the Cotentin peninsula in 2021, it is unsurprising that there have been a relatively large number of people attacked (Table 12). The year with the highest number of victims relates directly to the year in which hornet numbers peaked (2018). The first fatality and the most people having an anaphylactic reaction also occurred in that year. In 2021 a greater proportion of nests were discovered at ground level which could account for a doubling in the number of sting victims.

Table 12. Recorded numbers of *V.velutina* stinging incidents in Normandy 2017-21.

Human health monitoring – La Manche	**2017**	**2018**	**2019**	**2020**	**2021**
No. of victims with stings	65	311	152	109	252
No. of victims with at least 10 stings	5	9	6	4	4
Max No. of stings on a victim	12	20	20	17	23
No. of victims of venom squirting	1	3	0	0	0
Total No. of known victims	66	314	152	109	252
No. of victims with anaphylactic shock	*1*	*4*	*2*	*3*	*0*
No. of deaths	*0*	*1*	*0*	*0*	*0*

Since *V.velutina* were first reported in Jersey (2016), there have been several reported incidents where operatives or general public have been stung and required emergency treatment (these figures are anecdotal and not a complete record).

Table 13. Recorded numbers of *V.velutina* stinging incidents in Jersey 2017-21 as reported by Government of Jersey (Pers. Comms).

Reported incidents involving stings - Jersey	**2017**	**2018**	**2019**	**2020**	**2021**
No. of victims with stings	5	5	7	7	7
No. of victims with at least 10 stings	0	0	0	0	0
Max No. of stings on a victim	6	2	6	1	3
No. of victims of venom squirting	0	0	0	0	1
No. of victims with anaphylactic shock	0	1	1	0	0

From the figures detailing who was stung on Jersey (Table 13); 22 were either pest controllers or volunteers, and nine were members of the general public - accidentally stung when a nest was disturbed.

7. Review of key objectives documented in the Strategy

7.1 Review of the Asian Hornet Strategy objectives

Objective 1

- To protect public health through defined responsibilities, development and review of best practice guidance and dissemination of public health recommendations.

There is only one confirmed report of a member of the public getting stung and that was in a homeowner's garden where a primary nest in a bird box had fallen to the ground. The middle-aged adult had a single sting on their arm resulting in localised inflammation only.

Reviewing practice

The reviewing of practice is a process of continual development and reflection as we gain more experience and learn more about *V.velutina* behaviours and ecology. Every nest destruction was followed by a team de-brief and a careful review of the risk assessment forms. Regular in-house team meetings in addition to liaison and discussions with other government agencies (primarily in Jersey and UK) and a leading pest control consultant ensures Guernsey *V.velutina* control measures remain safe and effective.
A full report has been produced on an annual basis since the strategy was first implemented. These reports document significant developments and provide evidence for any improvements or modifications to practice.

Objective 2

- To control and reduce the population of Asian hornet in Guernsey by catching emerging queens (beginning in spring 2019) and treating primary and secondary nests so the number of established secondary nests does not exceed 10 per annum.

It is only at the end of each season that the success of the previous year's population control measures can be assessed, and estimates made regarding the number and location of nests which are likely to establish the following season. After reviewing three years of the trapping/nest destruction data, it is believed that the integrated approach of trapping queens in the spring followed by prompt and effective control of secondary nests in summer/autumn has prevented the establishment of *V.velutina* populations in Guernsey. The most reliable indicator of an established population is the increase in nests year on year. This scenario is predicted to occur as a direct consequence of failing to locate and destroy secondary nests. There is most likely a window of opportunity (possibly 2-3 years) after which time eradication attempts would be unsuccessful.

The maximum number of secondary nests destroyed (including those missed or suspected) in any year of the AH strategy was three (in 2021) compared to eight in 2018, the year before the strategy was introduced. The target of not more than 10 secondary nests per annum was chosen to demonstrate no significant increase on 2018 nest numbers. This figure in general was provided to measure success and identify when a change in approach may be required. This target has been consistently met and by a considerable margin which improves the confidence in stating that the *V.velutina* has not become established in Guernsey.

Objective 3

- To develop effective data capture, analysis and methods of communication between service areas, the third sector, key stakeholders and other jurisdictions.

A considerable amount of scientific data has been accumulated since 2019, building a clear timeline for what has occurred since *V.velutina* first appeared. Compiling a comprehensive database of reports enabled detailed analysis of confirmed sightings and nest locations. All these locations have been accurately mapped using ArcGIS software to identify any trends or patterns.
Photographic records of nest dissections and detailed measurements of morphological features has enhanced understanding of colony development and led to clearer differentiation between queen, male and worker hornets.

Robust working relationships have been established with key stakeholders on island and across the other Channel Islands, predominantly via phone or email, with occasional Zoom meetings. Useful correspondence networks have been established with the UK, arising from visiting specialists e.g., Asian Hornet Action Team (AHAT) lead for Somerset, Co-editor of Beecraft magazine and a leading Pest Control Consultant from Kent.

The Project Coordinator seeks to acquire new knowledge and further their understanding of *V.velutina* by reading scientific publications and attending international conferences such as the BBKA Asian Hornet conference and Atlantic Positive Project *Vespa velutina* symposium (2021). The aim of this study is to improve the effectiveness of Guernsey's hornet control strategies and ensure evidence-based practice whenever possible.

Summary

Given the above evidence, it is concluded that all of the key objectives have been achieved. The evidence presented in population trends from 2017-21 (Figure 11), indicates that Guernsey's Asian Hornet Strategy has been a success. Its implementation has halted the trend of increasing populations and reduced the prevalence of *V.velutina* in Guernsey (and all the allied islands adopting the same approach) to a manageable level, effectively eradicating them on an annual basis, thus reducing the public health risk to a minimal level.

8. Recommendations

The threat of *V.velutina* becoming established remains constant, and the associated risks are more clearly understood as new evidence emerges. However, the threat levels in Guernsey can be balanced by the successes and significant gains in experience and expertise from the past three years.

In concluding this review, a number of recommendations are made with the expectation that the original objectives of the Asian Hornet Strategy (as reviewed in Section 7) can be achieved longer term.

This summary of some key points provides the basis for the recommendations.

Key points

- Regardless of the successful eradication of hornets each year, Guernsey (and all the other islands) will continue to be faced with an ever-present threat of hornets – most significantly through regular incursions of queens each spring (recurrent invasion).
- The presumed low populations of *V.velutina* revealed from our annual data show we are still working in an early stage of invasion, where the density of nests is very low compared to other regions across Europe. This increases the likelihood of eradication, albeit annually.
- There have been no developments in France (or anywhere else) to show that it is possible to control the spread of this invasive pest once it has become established in a region (using tools such as targeted trapping with selective baits, biological control agents, disrupting hornets' reproductive cycle, etc.). Therefore, prevention is the best line of defence.
- A resource commitment (technical expertise, manpower and equipment) that will enable proactive surveillance and management is essential, and especially important where hornet populations are maintained at sub-optimal levels, thereby facilitating annual eradication.
- Early detections of hornets are crucial to minimise their impacts, and this relies on education and awareness campaigns and efficient reporting systems to verify sightings.
- Engaging the public in citizen science projects such as spring queening has been shown to be a valuable resource.

R1 Implement long term management programme

Unlike the original Strategy, which was limited to a three-year term, this new programme should not be time restricted, but rather look at ongoing management in perpetuity. This is in recognition of the continual threat of establishment, and that the techniques being deployed are no longer considered novel but have been tried and tested over the past three years.

The objectives of the management programme are recommended to be; capture queens in the spring, detect and track worker hornets and to locate and destroy all nests.

Annual eradication is the desired outcome and where this is not achievable, the number of secondary nests should not exceed five per annum.

- Implement island wide spring queening (see R3).
- Maximise efforts to detect worker hornets by deploying strategic monitoring with 'wicking' bait stations from August-November; absence of evidence should never be interpreted as evidence of absence.
- Retain option of using Ficam D to destroy nests, restricting the use of this pesticide to approved licenced pest control technicians.
- Develop working protocols for safer working with Guernsey Civil Protection volunteers during nest treatment.
- Maintain strictest safe working practices (as documented in risk assessments) when handling hornets or destroying nests to protect the public, pest control technician, tree surgeons and other operatives.

R2 Review process

A built-in review process is necessary to assess how effectively the desired control aims are being achieved. Instead of a set review period, triggers such as the failure to achieve annual eradication or the occurrence of a critical incident/near miss will necessitate a review of this management programme.

- Build in a continual review process which responds to 'triggers' e.g., public health risks, environmental risks.
- Operational reviews should be undertaken to enable modifications or minor changes e.g., adapt risk assessments in light of incidents or modify trapping/treatment in light of new knowledge.
- Strategic reviews should be undertaken to enable a fundamental change of approach depending on the data e.g., if nest numbers exceed specified levels. The review should also take into account lessons learned from outbreaks in other areas and feed into the annual review document.

R3 Enhance annual spring queen trapping

With better understanding of the spring migration of *V.velutina* queens and closer observation of local weather patterns it is likely that the island wide trapping can be delayed until optimum environmental conditions are reached. While committing to a programme of spring queening, improvements in trap design and having more selective baits should be adopted in order to continue to reduce potential by-catch. The aim is to improve the methodology of spring trapping to minimize the effects on entomofauna.

- Continually assess trap design/modifications to make improvements where possible.
- Evaluate and trial new baits as these become available (e.g., Killgerm 'Fly & wasp bait': introduced - 2021).
- Reduce trapping period by delaying start date for optimal environmental conditions of air temperature, wind direction etc. (dependent on seasonal variations).
- Investigate means by which capture of bumblebees could be reduced. Which, in turn, would allow trapping to continue into June (start later, finish later – except where nests were missed the year before).
- Build on existing data and utilise software to map locations of hornet sightings, queens captured and primary nests.

R4 Maintain public engagement and share information

The experiences of controlling *V.velutina* in the Channel Islands are of international importance to jurisdictions across the British Isles and other European nations where hornet have yet to colonise. In implementing a novel island-wide queen trapping programme as part of an integrated control strategy, Guernsey is leading in this field. Engaging island residents, gathering information and sharing this with wider community is integral to the success of the control strategy and to supporting other jurisdictions.

- Maintain efficient reporting systems by responding to reported sightings within 1 working day, thereby ensuring early detection and rapid response.
- Develop effective data capture to promote scientific enquiry and further understanding of hornet ecology and population trends.
- Facilitate and support scientific research relevant to *V.velutina* control and/or ecology.
- Maintain communication with other agencies and key stakeholders to share information and knowledge.

R5 Maintain Bailiwick wide approach to *V.velutina* control

The success of the Asian hornet strategy in Guernsey will be greatly enhanced by preventing establishment on all of the adjacent islands. To date this has been partially achieved, the aim is to achieve consistency of approach and ensure best practice is followed on all islands.

- To coordinate hornet control programmes by providing training and support to coordinators/volunteers etc., ensuring continuity of approach and best practice on the other islands (Herm, Jethou, Sark, Brecqhou, Alderney).
- Maintain high profile public awareness campaigns to include other islands (posters, flyers, SofG AH social media posts, beer mats etc.).
- Explore opportunities to promote *V.velutina* awareness on inter-island transport links.

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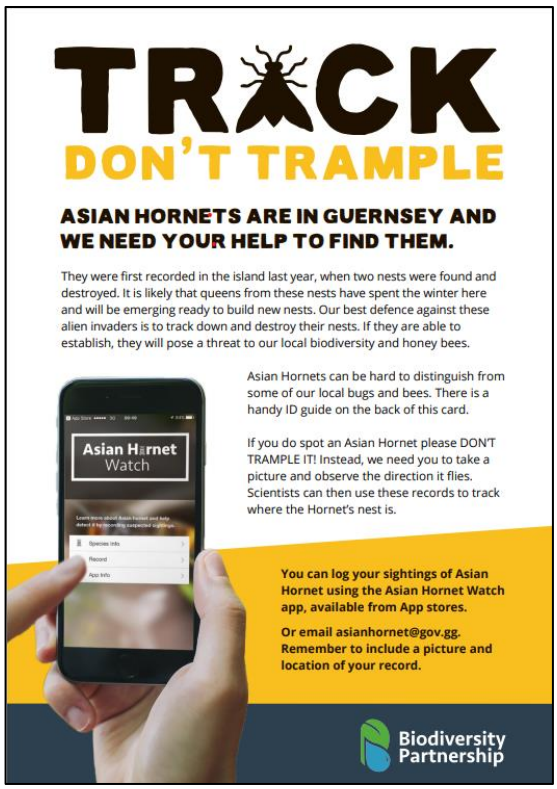
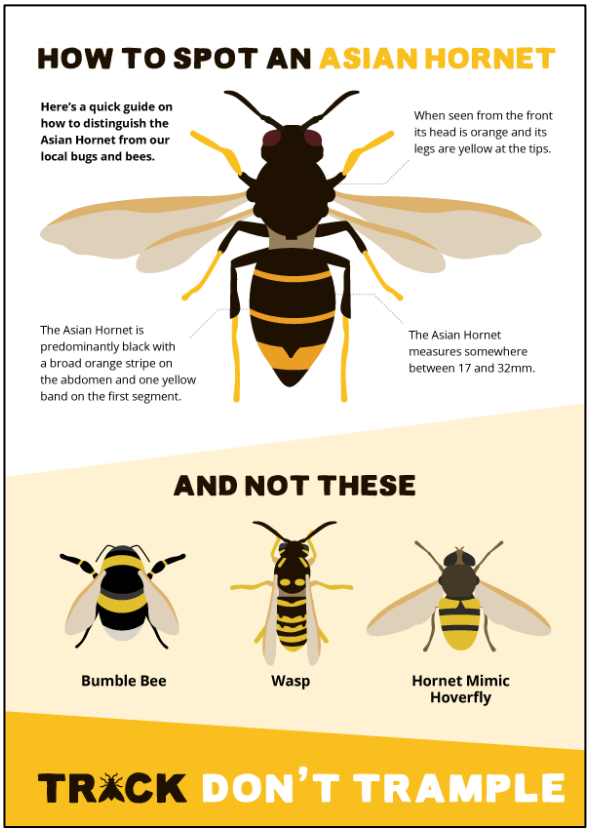
10. Appendices

10.1 Appendix 1 - Track Don't Trample flyer





10.2 Appendix 2 – Risk assessment for secondary nest destruction

Risk Assessment: Asian hornet nest removal **TEMPLATE TO BE REVIEWED PRIOR TO NEST REMOVAL**										
Location of nest:					**Pest control contractor:**			**Tree contractor/cherry picker operator:**		
Date & time of first treatment:					**Date & time of second treatment (if required):**			**Date & time of nest removal (where possible):**		
Risk assessment carried out by:					**Risk assessment seconded by:**					
Hazard & explanation of risk	**Who might be harmed and how?**	**Severity of impact** *(1 = least severe, 5 = most severe)*	**Likelihood of impact** *(1 = unlikely, 5 = highly likely)*	**Risk without control mechanism** *(severity x impact)*	**Risk control measures required before nest treatment or removal**	**Action required by who?**	**Done** *(initial)*	**Severity of impact once controls in place** *(1 = least severe, 5 = most severe)*	**Likelihood of impact once controls in place** *(1 = unlikely, 5 = highly likely)*	**Risk with control mechanisms in place**
Fall from height – AH nests likely to be in high location, e.g. up a tree or high in/outside a building.	Pest controller and/or cherry picker operator.	5 – Possibility of fatal injury.	4	20	A cherry picker will be used to access areas where the length of the application pole and a short (10ft) ladder are not sufficient to reach the nest. The operative will be harnessed in to the cherry picker, which will be operated from the ground where possible. Ensure that operative is securely harnessed to cherry picker. No lone working.	Cherry picker operator.		5	1	5
Accidental disturbance of the nest when precise area is not known and subsequent attack by insects.	Operative or person looking for the nest.	5 – Possibility of anaphylaxis if person is allergic to hornet sting.	3	15	Consider the use of a drone to locate the nest if feasible. Persons seeking to locate the nest must be protected with a hornet suit or bee suit + thick layers of clothes. Every person within 25m of where the nest is believed to be located must be protected by a hornet or bee suit. Ensure that PPE is fastened correctly and handheld wasp killer is on their person. No lone working. In the event that emergency medical treatment is required, dial 999.	Operative or person looking for the nest.		5	1	5
Accidental disturbance of nest during treatment and subsequent attack by insects.	Pest control operative, cherry picker operative, observers.	5 – Possibility of anaphylaxis if person is allergic to hornet sting.	5	25	Asian hornet nest to be treated with long lance pesticide applicator in order to minimise disturbance. Every person within 25m of where the nest is located must be protected by a hornet or bee suit. No lone working. In the event that emergency medical treatment is required, dial 999. Pest control operative to have on their person a handheld wasp repellent to destroy individual insects which might try to attack.	Pest control operative and cherry picker operative.		5	1	5
Members of the public/ bystanders stung by disturbed insects.	Observing members of the public/media.	5 – Possibility of anaphylaxis if person is allergic to hornet sting.	4	20	Cordon off 25 meters around nest in place for duration of treatment. Only people allowed to observe within this range if wearing a protective hornet suit or bee suit with additional thick layers of clothing, or are in a vehicle or building with all doors and windows shut.	Operative/s to ensure that there are unprotected bystanders. ACLMS staff.		5	1	5

10.3 Appendix 3 – Nest examination

Asian hornet secondary nest examination – September 14th, 2021

First sighting: Sept. 5th – single live worker hornet located inside a garage window, verified by photograph. Sept. 6th bait stations in garden and adjacent property.

Location: Andesa, Sandy Lane, St Sampson's, GY2 4RN

Nest site: Found Sept. 10th (DH), located in mature sweet chestnut tree ~10m

Nest destruction: Early morning (13/09) - x2 Ficam D applications, nest removed 5hrs later.



Follow up monitoring: Immediately after treatment, dying larvae were observed repeatedly falling from the hole made by the lance in the bottom of the nest. A total of 49 workers + approx. 50 larvae were collected in surrounding area, the furthest dead worker was found 132m on a driveway.

Nest dissection: Completed at RFH Sept. 14th

External diameter = 30cm, Height = 35cm, Number of combs = 4, Widest (comb 2) = 25cm
Queen = 1
Workers = 197
Drones = 2
Eggs =?
Larvae = 185
Sealed pupae = 976
Total adult population = 200
Total population if all larvae & pupae emerged = 200 + 185 + 976 = 1,361
The indications suggest that the nest was destroyed before the release of any new queens.

Estimating productivity of colony during the season:
The largest comb was 25cm in diameter and applying the formula established by Latter (1935): $N = ((3n/2) + 1) \times n/2$

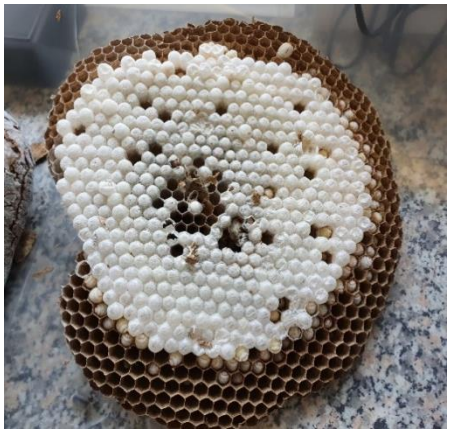
where ‘N’ is the total number of cells of a given comb, and ‘n’ is the number of cells counted along its longest diameter (25cm), the largest comb was estimated to contain 481 cells.
The presence of x2 meconia pellets (larval excrement) throughout cells in the older combs indicates two generations of workers were previously raised from these cells.
The theoretical number of individuals produced by the colony equates to around 3,848 hornets.

Nest dissection photos: (note: numbering from top down, earliest built comb = 1)


Starting dissection


Combs 2, 3 & 4


Combs 1 & 3


Comb 2

What did we learn?
The largest nest ever destroyed was from Sark on Oct. 23rd, 2019 = 45cm wide x 50cm deep. It had already produced drones and had many flying queens present. In comparison, this medium/large sized nest, chemically treated on Sept. 10th demonstrates the importance of locating and destroying nests as early as possible - only 2 drones and no new queens were found.
Although nest development is always weather dependent, our data shows that the earlier the queen commences nest building, the larger the nest will become with greater numbers of queens being raised by late autumn.

10.4 Appendix 4 – Outstanding research questions relating to hornet ecology

Scientific research into the ecology and behaviour of *V.velutina* is key to furthering our understanding of the many factors that influence its success and spread in a novel environment such as Guernsey. Monceau & Theiry (2017) note that the main problem is that reliable information on the ecology and the behaviour of alien species is often lacking until they become invasive.
In writing the review a number of unexplained phenomena and questions have arisen, some of which could provide interesting areas for research.

1. Origins of Guernsey's queens: post hibernation dispersal or autumn migration

Supporting evidence on the origins of Guernsey's queen hornets

Since the beginning of the Strategy all queens captured in the spring are assumed to be newly arrived in Guernsey, having dispersed from France (possibly Jersey). The evidence to support this theory is;

1) All of the summer/autumn hornet sightings have been successfully linked to specific secondary nests, all of which were located and destroyed before queen production occurred (confirmed by nest dissection).
2) No visible secondary nests were found in the treetops over preceding winters
3) Captured queens do not appear in traps or buildings before mid-April
4) The incidence of *V.crabro* queens records (not known to have ever nested in Guernsey) consistently coincides with the timeframe when *V.velutina* queens are captured.
5) Trapping dates reveal distinct waves or phases in activity that do not appear to be linked to anything obvious, such as suitable foraging weather e.g. in 2019 all of the queens captured on Guernsey and Sark were between April 18-21st, May 2-14th, May 18-23rd and May 28-June 5th . The data suggest a staggered dispersal of queens that overwintered in France (possibly Jersey) where their arrival and capture on Guernsey is coinciding with favourable invasive conditions - easterly winds have been postulated as a causal link.

Assuming that normal development is not disrupted by inclement weather, queen hornets that emerge from hibernation early will be at an advantage, replenishing depleted body fats and starting nest building sooner. Thus, they have the potential to produce larger and more productive secondary nests by the autumn.


Q.Rome

Population studies on the expansion of *V.velutina* across Europe indicate that they advance at around 75km a year over land. Queens expanding their range, by migrating (post-hibernation) from France into the Channel Islands would need to replenish depleted body fats before they move to new regions and begin nest building, thereby increasing their chances of success. They would also be dependent on suitable weather and may delay departure waiting for optimal conditions (e.g., wind speed and direction) before attempting to cross 48km/30miles of open sea to arrive in Guernsey. The precise mechanisms by which these invasive hornets extend their range into new regions is unknown and there are many outstanding questions.
How far do newly mated queens disperse? Do a proportion of explorative, 'opportunistic' mated queens actively disperse further away from nests in the autumn, or do they face less risks by waiting until the following spring (when they can better assess their body condition and environmental conditions more suited to migration)?

Over the past three years there has been only one record of a solitary hornet discovered in Guernsey in autumn months (L'Ancresse beach café - Oct. 3rd, 2020), with no nests subsequently found in comparison to 25 queens found in spring months. This late autumn insect was only photographed so it was not possible to determine if it was a worker, drone or queen (it is not known whether drones or mated queens disperse between islands.

2. Explorative behaviour of V.velutina and possible implications for Guernsey

It is interesting to consider the continual efforts of *V.velutina* to expand their range and colonise the Channel Islands over recent years since they were first observed in 2016. In this regard, the movement ecology framework is a valuable tool. As described by Joly (2019) an organism's lifetime movement is organised around three main functions—exploitation, exploration, and relocation—which are associated with specific behavioural mechanisms and spatio-temporal scales. Related to these aspects of exploration and relocation, studies by Brodin et al (2013), Cote et al (2010) and Stratton et al (2021) provide evidence to support a new approach. When looking to identify the characteristics that predispose a species to becoming a successful invader, they examined how individual variation in traits *within species* were correlated with dispersal behaviours which influenced invasion dynamics.
These researchers demonstrated that one of the key mechanisms influencing invasion dynamics is personality-dependent dispersal: the tendency for dispersers to have a different personality type than the average from a source population. They contend that bold or aggressive animals tend to be dispersers to new habitats. Cote et al, (2010) noted that the tendency for bold individuals to disperse only arises if dispersal requires overcoming challenging barriers or if dispersal *per se* is viewed as a particularly dangerous activity. The

Gulf of St Malo would constitute such a challenging barrier as Guernsey lies some 50km from the coast of Normandy.

To date, all of the studies on dispersal success of invasive species have looked at fish, amphibians and mice; none demonstrate personality-dependent dispersal in an invasive wasp species such as *V.velutina*. Whilst it can only be speculative, the implications for Guernsey and the other Islands (UK mainland) are that those hornet queens that survive the sea crossing and commence nest building could be considered 'super' invaders. If such behavioural/personality traits are inherited by their offspring, then future generations of *V.velutina* could be predisposed to quickly attaining high densities and exerting large impacts, e.g., exploiting the ecological niche that exists in Guernsey in the absence of native (*V.crabro*) hornet populations.

3. Increase in European hornet (Vespa crabro) spring sightings

There have been more confirmed incidental sightings of *Vespa crabro* reported to the Asian Hornet Team between 2019-21 than the combined total of records held at the Guernsey Biological Records Centre since it was established in 2003 (with historical records dating to 1964). All of the reported sightings coincided with the spring queening trapping period (April-June), some of these insects were found in traps.
The inference is that queen *V.crabro* are arriving on island within the same timeframe as the *V.velutina*.

The increased prevalence of these European hornets could be an observational bias in that more people are looking for and reporting hornets. Alternatively, environmental factors such as climate change could be a contributing factor leading to more sightings (cf. UK where *V.crabro* continues to spread northwards out of southern counties). There is no definitive evidence that *V.crabro* has ever nested successfully in Guernsey, unlike *V.velutina*. The availability of suitable mature deciduous woodland may be the limiting factor for *V.crabro*.

V.velutina are perported to emerge from overwintering before *V. crabro* (Monceau & Thiery, unpublished data) which may confer a potential advantage in accessing the most suitable nest sites first. A possible consequence is that *V. velutina* may be forcing *V. crabro* foundresses to disperse. The possibility that *V.crabro* queens are being forced off the French mainland could explain why increasing numbers may be arriving in Guernsey. More radically, could there be an interspecific migratory association where the movement of *V.velutina* to new regions outside of France is encouraging a similar invasive migration by pioneering *V.crabro* queens?

4. Initiation of queen production

Important information has been gained from dissection of late nests in relation to colony development. During the summer months there is a steady expansion in the external dimensions of the secondary nest which affords space for the increasing number of combs being constructed internally. New generations of worker hornet are raised in succession until something triggers a significant shift in brood rearing that results in the production of large numbers of males. This is followed some two weeks later by the production of new queens. Physical examination of nests on destroyed on Guernsey, Sark and Jersey reveal that this transition occurs sometime around late September-early October depending on the season. The environmental or physiological cues which trigger commencement of sexual reproduction are currently unknown.

Later generations of workers are noticeably larger insects than those raised in the early season. The same combs and larger cells that produced late workers are utilised to raise queens (and drones) so there are no discernable visual clues to indicate when (or where in the nest) this transition is occurring. Developing a reliable method to identify when queen production has commenced would be an invaluable diagnostic tool for hornet control. This knowledge would help to identify the window for nest destruction on a seasonal basis and provide more certainty that a nest has been destroyed before new queens have been raised.

Our nest dissection studies in Guernsey have provided some evidence of a rapid dearth in foraging workers in the nest as soon as the males and queens appear in significant numbers. This phenomenon also has important implications in that very late nests are much more difficult to discover as there are considerably fewer foraging workers visiting bait stations.