MSc Research Project Proposal, Biology, Leiden University

Title: Selectivity and effectiveness of spring trapping of the yellow-legged hornet(*Vespa velutina*)

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Abstract:

To combat the pressure the yellow-legged hornet (*Vespa velutina*) places on beekeepers, trapping queens in spring is a common method, since it prevents them from building and maintaining their nests until workers emerge. Previous designs for spring trapping have proven unselective and their effectiveness remains understudied.

In this research, I plan to investigate, with the cooperation of Dutch beekeepers, the selectivity of 3 designs for spring traps and 2 kinds of bait, and whether spring trapping is effective. Selectivity will be determined by the percentage of individuals caught that is not the yellow-legged hornet. By leaving designated areas without traps and counting the caught workers in a second round of trapping, effectiveness will be determined by comparing these counts.

Introduction:

The yellow-legged hornet(*Vespa velutina*) is a hornet species that is not native to Europe, but has spread to many European countries over the last 2 decades. This species has now spread to France (Haxaire et al., 2006; Villemant et al. 2006), Spain (Castro & Pagola, 2010), Portugal (Grosso-Silva & Maia, 2012), Belgium (Bruneau, 2011), Italy (Demichelis et al. 2014), Germany (Witt, 2015), the Channel Islands (States of Guernsey Government 2016), Great Brittain (Budge et al., 2017), the Balearic Islands (Leza et al., 2018), the Netherlands (Smit et al., 2017), Switzerland (Ebener 2017), Luxembourg (Ries et al., 2021), Hungary (Márta & Vas, 2023), Ireland

(Dillane et al., 2022), Austria (Schorkopf et al., 2024) and Czech-Republic (Walter et al., 2024).

The first individuals were found in France in 2004, likely introduced through the transport of pottery(Haxaire et al., 2006; Villemant et al. 2006). After that it had in the first 5 years in France an average dispersal of 78km/year, and seems to be partially aided by human activity such as moving something a queen was passing the winter in (Robinet et al. 2017). And when in 2017, the first individual was spotted in the Netherlands, this has caused quite some concern:

As this species belongs to the Vespidae, its workers have a stinger, which they can use to defend their nests. The yellow-legged hornet has caused a great deal of concern because of its stings.

The yellow-legged hornet has gotten the reputation of being aggressive and more dangerous. One reason for this seems to be that its other name, the Asian hornet, causes confusion with the much larger Asian giant hornet (*Vespa mandarinia*), which has not been introduced to Europe.

However, this reputation does not seem to be accurate as there hasn't been an increase in envenomation incidents that can be related to the introduction of *Vespa velutina* (Haroa et al., 2010). Its venom also seems to be more or less the same as that of *Vespa crabro*, so to call it more dangerous seems inaccurate. Another claim is that this species has the ability to spray venom as a defence mechanism. While *Vespa velutina* does seem to have the ability to spray a liquid, like other Vespids can, this liquid doesn't seem to be (solely) venom (Laborde-Castérot et al., 2020).

As with any non-native species, there are concerns about the effects of this species on native species. For this species in particular, most concerns are about pollination. A colony of yellow-legged hornets can hunt 11kg of prey in a year. As an opportunistic generalist predator, it mainly hunts species that are in higher abundance, like social hymenopterans, and those that are of a decent size (Rome et al., 2021). This means that the effects on native biodiversity are unlikely to be very big. In fact, in Italy, Carisio et al. (2020) show that in the areas in Italy, where *Vespa velutina* has spread, there was no decrease in species richness or wild bee abundance. Such data does not exist for the Netherlands.

The yellow-legged hornet does however, seem to exert pressure on the pollination of flowering plants, by hunting pollinators near them. This can cause pollinators to spend less time on flowers, which can lead to less efficient pollination. This effect can be seen in plants that flower later in the year, like ivy (Rojas-Nossa and Calvino-Cancela, 2020; S. V. Rojas-Nossa et al., 2023).

Another way a non-native species can affect native species would be through competition for resources. Since *Vespa velutina* shares much of its resources with the native *Vespa crabro*, one would expect one of them to get outcompeted (Cini et al., 2018). However Carisio et al., (2023) show that despite expected competition, the European hornet (*Vespa crabro*) did not have a decreased abundance in areas in Italy where *Vespa velutina* has spread. They also found that the presence of the yellow-legged hornet slightly affected the abundance of the German wasp (*Vespula germanica*), but not the common wasp (*Vespula vulgaris*).

Since Rome et al. (2021) found that 38% of the larval food samples contained the European honey bee (*Apis melifera*), beekeepers are quite concerned about the introduction of the yellow-legged hornet .

The yellow-legged hornet has a signature strategy to catch honeybees: A couple of workers will hover around the entrance of an apiary and catch the honeybees as they return to their nest in a behaviour known as hawking behaviour(Bunker et al. 2019).

This hawking behaviour can cause foraging paralysis, where foraging is halted to avoid getting hunted. This can lead to the hive not having enough food supply to last through the winter and die out (Requier et al., 2019).

In response, there is a variety of measures taken against the yellow-legged hornet:

One kind of measure is to protect the entrances of apiaries, with either a muzzle or an electric harp. Another is though extermination, which can either be removing nests when they are spotted or using biocides like Fipronil, Diatomaceous earth, Permas-D and Sulphur Dioxide, i.e. by directly using it on a nest, or by giving it to a worker and letting them take it to the nest.

One of the most common measures taken is spring trapping, which aims to stop the queens of *Vespa velutina* from building or maintaining their nests; *Vespa velutina* queens build new nests every spring (Bunker et al., 2019). This means that you should be able to prevent the building or management of a nest if you can trap the queen and kill it. For each queen you catch you would have one less nest that produces workers that may attack your apiary and one less nest that produces individuals that can procreate. It is for this reason that a variety of traps are set each spring to catch as many *V. velutina* queens as possible.

The majority of designs for these traps, however, are unselective and have large proportions of bycatch: Though selectivity can differ per design, Monceau et al, (2012) show that *Vespa velutina* queens made up only 1.7% of total individuals caught, using 2 types of traps.

Another possible issue with spring trapping is that queens of *Vespa velutina* will sometimes take over the nests of other queens. That means that removing a queen may not always decrease pressure from *Vespa velutina* workers on apiaries (Bunker et al., 2019). Therefore, the effectiveness of spring trapping is still unclear.

That brings me to the goal of this research, which is to determine the selectivity and effectiveness of spring trapping on *Vespa velutina*. For the selectivity, I will be looking at the percentage of caught individuals that are non-target species. For the effectiveness, I will be looking at the amount of workers caught in areas where traps were set, compared to the amount of workers caught in areas where there were no traps set.

This leaves me with the following null-hypotheses:

For selectivity, the null-hypotheses are that there is no difference in selectivity between traps, no difference in selectivity between baits and no difference in selectivity between areas with higher and lower densities of *V. velutina.*

For effectiveness, the null-hypotheses are that there is no difference in effectiveness in areas with or without traps and no difference in effectiveness between areas with higher and lower densities of *V. velutina*.

Methods:

Effectiveness and selectivity will be tested around apiaries in 2 types of areas in the Netherlands:

In the south of the Netherlands, where the density of *V.velutina* is higher, and further north in the Netherlands, which includes Flevoland and possibly Amstelveen. The density of *V. velutina* is much lower here. Another possible location with lower numbers of observed individuals (69 in 5 years, with a grid cell of 100km^2) is Boskoop. Something I want to see is if the selectivity and effectiveness of spring trapping is affected by the density of *V.velutina*: I expect that effectiveness is higher in areas with lower densities of *V.velutina*, since this means that there is a lower chance of the now empty nest being used by another queen. I also expect that spring trapping in areas with lower densities of *V.velutia* will have relatively more bycatch, since these lower densities mean that whatever is trapped has a lower chance of being a yellow-legged hornet

In March, the first round of spring trapping will begin, when mean day temperatures reach 10^{o}C. Then, traps will be placed around the apiaries of 10 beekeepers in each area. However, this number depends on the availability and willingness of beekeepers to participate.

Around each apiary, 18 traps will be placed in a radius of 700 meters(See Appendix figure 1 for an illustration of how these traps will be placed). This is because the majority of *Vespa velutina* workers stay within this range of 700 meters (Poidatz et al., 2018). This range is likely to be quite a bit lower for queens of this species, since going too far from the nest would be more energy costly and would increase the risk of usurpation. Here we estimate that this foraging range for queens is about 200 meters. So, to potentially catch every queen flying with a radius of 200 m, that would eventually result in a nest that would forage with a radius of 700 m, we need the traps set up according to the layout of Appendix figure 1. Though this way of placing traps seems to be ideal, the reality is a bit more complex: Some of the traps may for example end up on places like roads or in the backyards of residents. This means that depending on the locations of the participating beekeepers and their apiaries, trap placements may need to either be improvised or they may require permission from citizens after thorough communication of this research and its purpose.

Selectivity will be tested for 3 different designs of traps (See Appendix for links of the traps and instructions from the NBV):

- From Imkershop: the ‘Aziatische Hoornaarsval Deluxe’, which is the expensive commercial option with caps to adjust the size of the entrance.
- From Doktorbee.nl: the ‘jampotval’ serves as a cheaper alternative
- Lastly I will be using a homemade trap, made using instructions from the NBV, a Dutch cooperation of beekeepers.

2 different baits will be used

- Trappit, the widely used commercial option
- The commonly used homemade bait, made of wine, beer and sugarwater in a 1:1:1 ratio.

This results in 6 combinations, and with 18 traps per apiary, each combination is present 3 times.

Different traps seem to have different rates at which they lose their bait, which also means that they spread less of their bait to the environment. It is for this reason that 3 of the 10 beekeepers in an area will have only one type of trap.

Around the apiaries of 10 other beekeepers in each area, no traps will be placed. This is to be able to determine how effective the spring trapping is. These apiaries will need to be relatively close to each other, so that trapping around other apiaries does not affect the results. Apiaries will also be selected so that there are as little differences between areas with and without trapping as possible.

Traps will be visited daily to have the content killed by using a nitrogen/carbon dioxide spray through the entrance of the trap and covering the exits to prevent insects from escaping. Then, the contents will be placed in a different plastic container with 70% ethanol for each trap, with the use of tweezers. Every other weekday, I will visit each beekeeper in the area with higher *V.velutina* density and on the other weekdays, I will visit each beekeeper in the area with lower *V.velutina* density. There, I will collect the containers with the contents of the traps and at 2 different apiaries, I will empty the 6 traps in the middle myself. The apiaries where I will empty these traps will be selected in such a way that I will have emptied traps around each apiary after 5 rounds of visiting an area. In the two weeks after this, I will be emptying 6 traps in the 'outer ring ', instead of the traps in the center. This will be communicated with the beekeepers, so that they know which traps they don't need to empty and when they don't need to be emptied. When I know where each participating beekeeper and their apiary is located, I will design a set route in which I will visit each beekeeper in an area. In May I will be identifying which species were caught in the traps.

During this period of trapping, to avoid the effects of the locations of each trap and the effects of the overlaps in the ranges in which the traps catch queens, the traps switch locations:

The 12 traps in the 'outer circle' of traps will move clockwise to the location of the next trap.

The 6 traps in the 'inner circle', will move counter-clockwise to the location of the next trap in order to prevent the effects of particular traps affecting each other when placed relatively close to each other. However, the trap in the inner circle that is located northern-most will move to the location of the trap in the center. See appendix figure 2 for a visualization.

The second round of trapping starts in June, when the first *V.velutina* workers start appearing: Around the apiary of each of the 40 participating beekeepers, 1 of each trap-bait combination will be placed in a radius of 10 meters around the apiary. I've chosen a small radius around the apiaries since that is where the workers would cause the most issues, which we may be able to prevent with spring trapping. According to Monceau & Thierry (2016) the first workers mainly forage for a sugar-based diet for about 40 days. So in the second round of trapping, I will continue using the baits from the first round. Its contents will be sent to the labs where I can determine how many yellow-legged hornets were caught.

Then I can compare these between the areas that had spring trapping in the first round and areas that did not, to see if spring trapping causes a significant reduction of workers caught around apiaries.

For both selectiveness and effectiveness there are a number of variables to consider:

- The trap and bait and their possible interaction
- Whether trapping was done or not (This only affects effectiveness)
- The area in which trapping was done: This affects results through *Vespa velutina* density and through regional differences in biotic and abiotic factors
- The person that emptied the trap

Expectations for participating beekeepers

- When the participating beekeepers are known, I will go to each of them and together, we shall place the traps in the optimal locations. These locations will be as shown in figure 1 of the appendix, but adapted to local circumstances.
- Then I will also show how to empty the traps.
- Visit each trap daily, kill the contents using a Nitrogen/CO2-spray and place the killed insects in plastic containers with 70%-ethanol using tweezers. Plastic containers will be labelled for every set trap for every apiary.
- There will be days communicated where I will be emptying the traps in the center. On those days, the beekeepers should not open these traps
- Every week, I will switch the locations of the traps, together with the beekeepers.
- Since the inside walls of the traps can get quite sticky, we will be wiping them with a paper towel every time we switch the trap locations.
- The pieces of cloth used in the homemade trap can get dirty, so together with the beekeepers, I will be replacing them every two weeks.
- Notify me when they are harvesting honey from the apiaries.

Working programme

- February will be used to communicate with beekeepers on how and where the traps will be placed and about what is expected of them. This time will also be used to build the homemade traps
- Mid March until April will be the first round of trapping
- In May, spring trapping will continue, for effectiveness, but identification of the by-catch will only be done of the individuals caught from March-April (only when there were few insects in the traps from March-April, the May content, other than *Vespa velutina,* may be identified as well) and on the 28th and 29th of May, I will take with me the contents of the traps in the center around each apiary, to see if the insects trapped then are different from those trapped in March-April.
- June is when the first workers will start appearing, so this is when the second round of trapping will begin
- July is when the data will be analysed and to finish the report and have the end presentation.

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Appendix

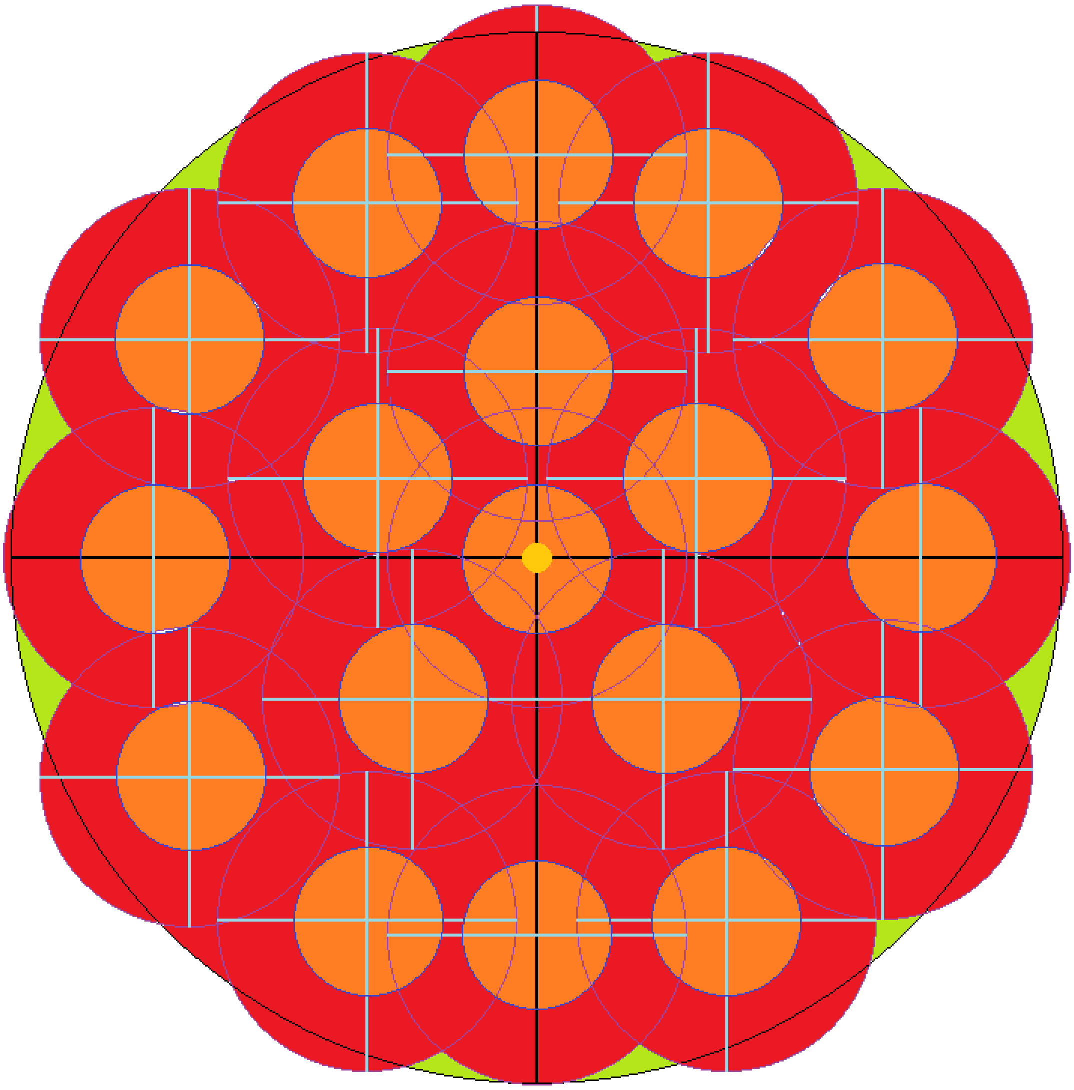


Figure 1: An illustration of how traps will be placed around an apiary. In the middle, the yellow dot represents the apiary, which will have 18 traps placed around it in a radius of 700 meters (green circle), at the blue crosses. These traps will catch the queens in a radius of somewhere between 100 m (the orange circles) and 200 m (the red circles).

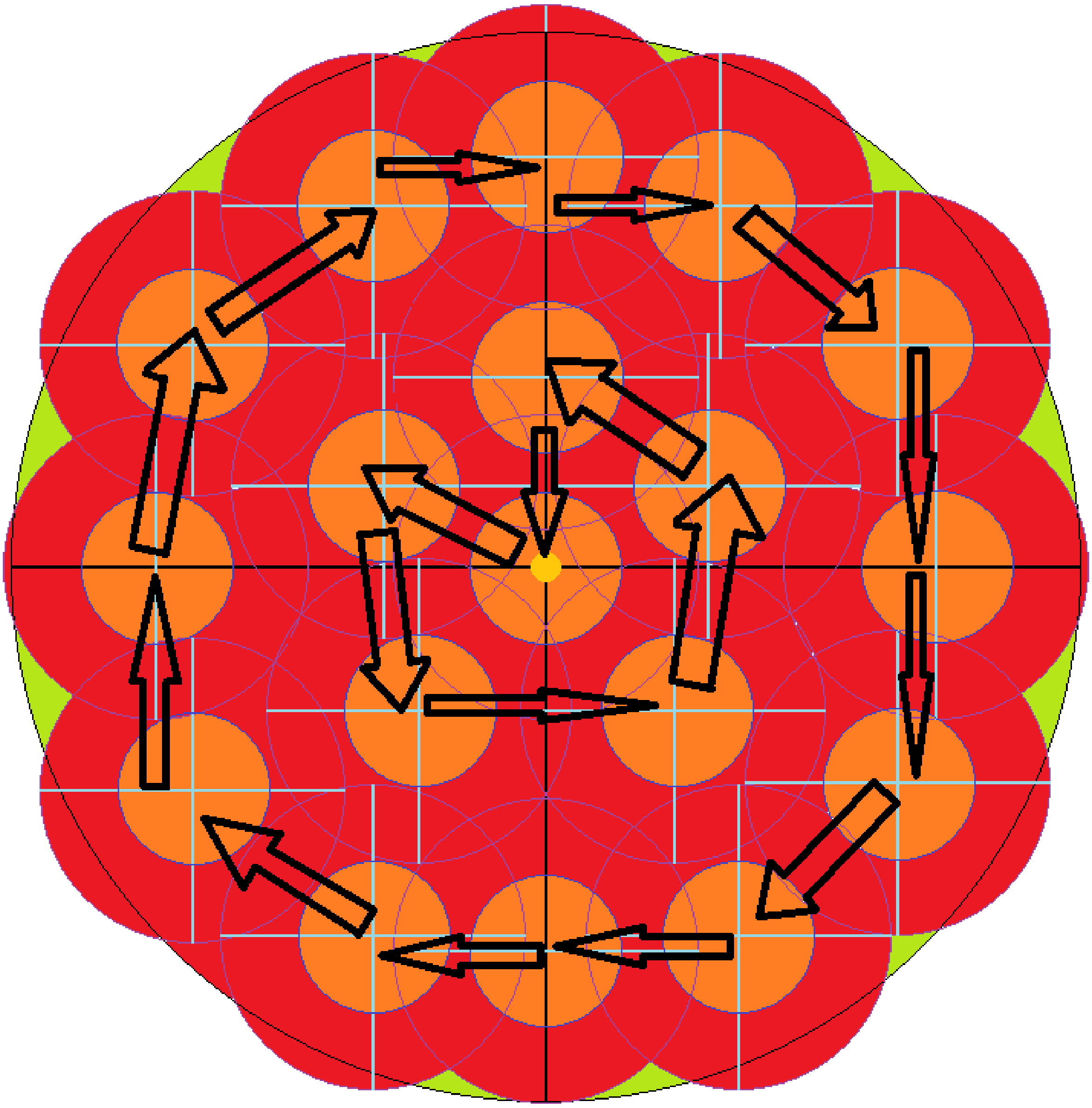


Figure 2: A visualization of how the traps will switch locations. Every time traps switch locations they will move to the next location following the black arrows.

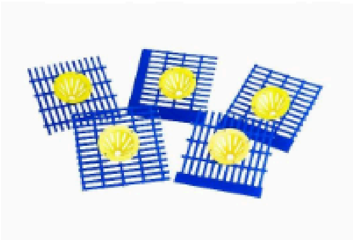
The traps:

- Aziatische hoornaarsval deluxe: https://imkershop.nl/aziatische-hoornaar-en-wespen-vallen-en-lokstoffen/6237-aziatische-hoornaarval-deluxe.html#/377-opties-optie_1
- Jampot val: https://store.dokterbee.nl/selectieve-val-aziatische-hoornaar-model-jampot
- Instruction sheet of NBV (in Dutch): These instructions will generally be followed, with the exception of the part where it says to remove the spring trap at the end of May and the part about what to do after checking the trap will be done differently, as described in the methods.

Maken en plaatsen van een selectieve val met frontjes ter bestrijding van de Aziatische hoornaar

Benodigdheden

- 2 of meer frontjes/ kegeltjes. Geschikte frontjes zijn te koop via: https://www.my-honey.nl/product/frontje-vangkooi-aziatische-hoornaar/?v=796834e7a283, bij de imkershop (https://imkershop.nl/286-aziatische-hoornaar-en-wespen-vallen-en-lokstoffen), Dr Bee info@dokterbee.nl (zij verkopen ook kegeltjes die je op potten kan draaien) of te bestellen bij Rob Voesten (rob_voesten@yahoo.com). Je kunt de frontjes ook zelf printen met een 3D printer zie daarvoor de tekst hieronder.
- Opbergbox, goed afsluitbaar (bijvoorbeeld 6,5 liter van de Action)
- Scherp mesje en aansteker, föhn, verfbrander of Dremel
- Lijmpistool
- Glazen potje met deksel (bijvoorbeeld jampotje/ hakpotje/ honingpotje)
- Spijker en hamer
- Reepje oude dweil/ vaatdoek
- Lokstof: 1/3 blond bier, 1/3 witte wijn, 1/3 suiker of Trappit en eventueel een paar kattenbrokjes



Frontjes

De Frontjes kunnen ook zelf geprint worden met een 3D printer. Zie bijvoorbeeld: https://cults3d.com/en/3d-model/tool/piege-frelon-asiatique-dms88

De beste resultaten zijn met openingen van 8,4 mm zodat Aziatische hoornaars erdoor kunnen en Europese hoornaars niet. Daarnaast moeten er andere openingen zijn van 6 mm doorsnede zodat kleinere insecten er weer uit kunnen.

Voorkeur voor de kleur van de frontjes is geel.

Stappenplan voor het maken van een selectieve val

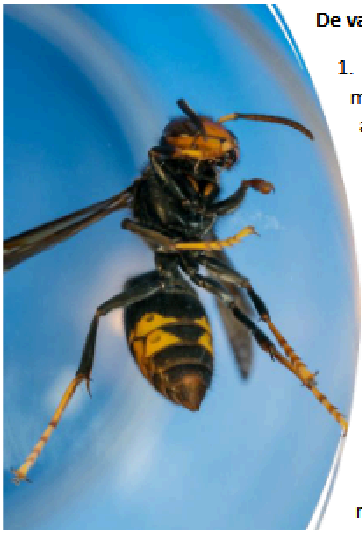
1. Maak een gat ter grootte van 8 x 8 cm (of aangepast aan de grootte van het eigen geprinte frontje) aan de korte zijkant van de opbergbox. Dit gaat makkelijker als je het plastic eerst zacht maakt door het te verwarmen met een aansteker, fohn of verfbrander of maak het gat met een Dremel.

3. Maak een gat in het deksel van het potje met een hamer en een spijker.

4. Vul het potje met lokstof en gebruik het reepje dweil/ doek als lont (wiek) en zet het wiekpotje in de opbergbox. In plaats van een wiekpot kun je ook de lokstof op een schoteltje leggen met wat steentjes erop of op een andere manier aanbieden zonder dat insecten erin verdrinken. Leg eventueel ook een paar kattenbrokjes in de opbergbox. De koninginnen van de Aziatische hoornaars hebben ook eiwitten nodig voor de larven en de kattenbrokje kunnen dus helpen om ze te lokken.

5. Leg iets op de deksel zodat deze donker is, bijvangsten zullen dan eerder de uitgang kunnen vinden (vliegen naar het licht)

6. Plaats de selectieve val bijvoorbeeld bij je bijenstand of ergens anders.



De val geplaatst - Wat nu?

1. Controleer dagelijks (en als de val in de zon staat twee maal per dag) de val op bijvangst. Mochten er alleen maar andere insecten dan Aziatische hoornaars in de val zitten, laat deze dan vrij.
2. Zit er een Aziatische hoornaar in de val? Zet de val een uur in de koelkast. Door de kou zullen de insecten verstillen. Daarna haal je de Aziatische hoornaar eruit met een pincet en stop je haar in een ander potje en in de vriezer om dood te vriezen. Eventuele andere insecten zet je buiten in de zon om op te warmen en weg te laten vliegen.
3. Maak een foto van de Aziatische hoornaar en meld de vangst op: https://waarneming.nl/go/vespa-velutina/?
4. ***Haal de val eind mei weg.*** De val is alleen geschikt om koninginnen van de Aziatische hoornaar te vangen. Eind mei zullen er voldoende werksters in het nest geboren zijn en zal de koningin het nest niet meer verlaten.

Succes!