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Northern Giant Hornet (*Vespa mandarinia*) and Yellow-Legged Hornet (*Vespa velutina*), Potential Pests of Honey Bees

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Exotic hornets present a significant threat to apiculture. Recent introductions of the northern giant hornet (NGH) to North America and the yellow-legged hornet (YLH) to Europe, both known to attack and destroy honey bee colonies, have made it critical for beekeepers, regulators, and the general public to be able to detect and identify these exotic hornets. A basic understanding of hornet biology and diagnostic characteristics will help with early detection and management to minimize the potential impacts on apiculture in the eastern United States if they are introduced to the region.

Introduction

The Importance of Apiculture

Worldwide, western honey bees (*Apis mellifera*) are critical for modern agriculture, pollinating many crops and producing tangible goods such as honey, beeswax, and other hive products. In the United States, western honey bees are essential pollinators of almonds, cherries, blueberries, and several other fruit crops. Western honey bees also increase the production and profitability of many other crops and livestock forages, contributing more than $20 billion to the US economy.[1] Honey bees are important to South Carolina, which has a growing apiculture industry and hosts dozens of commercial migratory beekeepers who manage thousands of beehives. In recent decades, the number of honey bee colonies in the United States has declined due to several factors, including the introduction of exotic pests such as small hive beetles and varroa mites.[2] Beekeepers manage current pests, but there is concern that the introduction of other exotic pests of honey bees could further contribute to colony losses and increase beekeeper management expenses.

Predators of Honey Bees

Honey bees have many predators. Numerous birds, reptiles, mammals, spiders, and other insects eat honey bees, preying mostly on worker bees while they are foraging.[3] Healthy honey bee colonies can overcome these losses, so most predators do not negatively impact honey bee colonies. A few predators brave the defenses of the honey bee colony to target the larvae. In the southeastern United States, only black bears and striped skunks attack and destroy honey bee hives for their contents.[3] The only other predator of honey bee larvae present in the southeastern United States is the small hive beetle, *Aethina tumida*. The small hive beetle is an exotic pest of honey bees that was introduced to the southeastern United States in 1996 and subsequently spread across the nation and into Canada and Mexico. This exotic beetle has become one of the most significant pests of western honey bees in the United States.[3] Because of the damage caused by small hive beetles and other exotic pests, beekeepers are very concerned about the introduction of other exotic pests and predators.

Exotic Hornets Pose a Threat to US Apiculture

Two species of hornets, the northern giant hornet (NGH), *Vespa mandarinia*, and the yellow-legged hornet (YLH), *Vespa velutina nigrithorax,* are of great concern to beekeepers worldwide. Both species are known to cause honey bee colony losses in their native ranges, and both species have been spread by human commerce to foreign locations.[4,5] Insects in the genus *Vespa* are known as the “true hornets” and are exceptional predators. Hornets are social insects, living in family groups that establish territory and coordinate hunting for other insects by marking prey with pheromones to direct nest-mates to the food source. Hornets are large enough to overpower most other insects and have an exoskeleton thick enough to ward-off other stinging insects. Most hornets prey on other insects’ larvae, and many species of hornets target nests of

other social bees and wasps. Hornets also can sting, which makes them some of the most formidable predators in the insect world.

The genus *Vespa* contains about two dozen species worldwide.[6,7,8] All but two of these species are native to southern and eastern Asia. The European hornet (EH), *Vespa crabro,* has a home range across Europe and western Asia. The Oriental hornet, *V. orientalis*, is found in the Middle East, the eastern Mediterranean, and across northern and eastern Africa. No true hornet species are native to North or South America; however, a distantly related group of North American wasps, the yellowjackets (*Dolichovespula* and *Vespula*), are sometimes called "hornets" by the general public. One species, commonly called the bald-faced hornet, *Dolichovespula maculata* (figure 6), is not a true hornet. The bald-faced hornet is more closely related to yellowjackets. It is much smaller than most species of *Vespa* and does not attack honey bee colonies.

Several species of hornets have expanded their ranges, mainly due to human assistance. In the 1800s, the EH was introduced into the United States, where it quickly spread across eastern North America.[6] The EH is now commonly found from the southeastern United States north to Canada and west to the Rocky Mountains. In 2003, the YLH, originally from southeast Asia, was introduced to Japan and the Korean peninsula, where it is killing honey bee colonies.[9] In 2004, the YLH was introduced in France. It has spread to neighboring countries where it is killing honey bee colonies and has become one of the greatest threats to apiculture in Western Europe.[10] In 2016, the greater banded hornet, *Vespa tropica* (L), was found for the first time in Guam. The greater banded hornet is known to attack the nest of other social Hymenoptera, including honey bees, but the impact of the greater banded hornet on Guam's native ecosystems is yet to be determined.[11] Most recently in 2019, the NGH was found in North America.[4]

The Asian Giant Hornet in North America

The NGH, a well-known pest of honey bee colonies in eastern Asia, was detected in North America for the first time in September 2019 on Vancouver Island near Nanaimo, Canada. An active nest was located and destroyed. Later in 2019, a dead specimen was found in Blaine, Washington, near the Canadian border, and the Washington State Department of Agriculture recorded credible attacks on honey bee hives.[4] More recently, over the summer of 2020, multiple live NGHs have been caught in northwestern Washington, and in October 2020, the Washington Department of Agriculture successfully located an active nest using a tracking device attached to a trapped hornet, confirming that the insect is established in the United States. The nest, which contained new queens, was destroyed. The Washington Department of Agriculture has provided a summary of this situation which includes a media release and videos (https://agr.wa.gov/hornets).

Beekeepers in the United States are very concerned about the spread of NGHs and the introduction of YLHs because both species can destroy entire honey bee colonies in a matter of hours.[5] The introduction of NGHs into North America has the potential to damage American apiculture, much like the YLH is damaging European apiculture. Because the spread of the NGH or introduction of the YLH would threaten apiculture in North America, authorities are monitoring both species closely. To date, YLHs have not been found in North America, and NGHs are limited to a small area in the pacific northwest. Washington state is the only state in the United States to have confirmed the presence of NGHs.

Although the Pacific Northwest and the southeastern United States are similar in climate and percentage of forest cover and could serve as suitable habitats for NGHs, it is not likely that NGH will migrate across the continent to the southeast. These hornets would have to traverse several unfavorable ecosystems (e.g., plains, desert, high mountains, etc.) to migrate eastward. The more likely method for introduction to the southeast would be through human transport. Because human transport is the most likely method for the introduction of hornets to the southeastern United States, then it is safe to assume that YLHs are just as likely to be introduced from Europe or Asia as NGHs would be from Asia or the Pacific Northwest. Beekeepers and regulators across the United States should learn to identify both species of exotic hornets, be able to differentiate them from the already present European hornet and remain vigilant. Early detection is critical for controlling exotic hornets if they begin to spread.

Neither the NGH nor the YLH is found in South Carolina. The only true hornet presently found in the eastern United States is the European hornet, and it is not a threat to beekeeping in the region.

In order to assist beekeepers and regulators with differentiating the EH from the NGH and the YLH, this document describes the diagnostic features of each species to enable early detection and eradication efforts. Table 1 and figures 1, 2, and 3 illustrate the anatomical features useful for differentiating these hornets. For a complete identification key for the world's hornets (*Vespa* spp.), refer to Smith-Pardo et al., 2020.[6]

Table 1. Comparison of characteristics of *Vespa mandarinia*, *V. crabro*, and *V. velutina nigrithorax*.

	Northern Giant Hornet *Vespa mandarinia*	**European Hornet** *Vespa crabro*	**Yellow-Legged Hornet** *Vespa velutina nigrithorax*
General color Figs. 1a,b,c, 3c *general color can be variable within a species and among castes[7]	bright yellow head, a dark thorax, dark legs, and a dark abdomen with narrow straight yellow bands on abdominal segments	reddish/orange head and thorax, light-colored legs, and sinuous yellow bands on abdominal segments	dark head, mostly dark thorax, yellow-tipped legs, and a dark abdomen with yellow bands narrow in front and wider toward the tip[12]
Size Figs. 1a,b,c	queens about 5 cm (2 in) workers about 3.5 cm (1.5 in)	queens about 3.5 cm (1.5 in) workers about 2 cm (0.8 in)	queens about 3 cm (1.2 in) workers about 2 cm (0.8 in)
Genae (shape of the cheeks) Figs. 2a,b,c	genae pronounced, head rounded, nearly as wide as it is tall	genae not pronounced, head more rectangular, taller than wide	genae not pronounced, head more rectangular, taller than wide
Color between antennae Figs. 2a,b,c	space between antennal bases same color as the rest of the head	dark band between antennal bases	space between antennal bases with or without dark band
Clypeus (shape of the upper lip) Figs. 2a,b,c	clypeus deeply incised	clypeus not deeply incised	Clypeus not deeply incised
Mesonotum (back between the front wings) Figs. 3a,b,c	back entirely dark	pair of yellow patches	variable, but the subspecies introduced into Europe has an entirely black thorax (*V. velutina nigrithorax*)
Legs Figs. 1a,b,c	generally dark, front legs sometimes lighter	legs generally light, similar color to head and thorax	dark leg bases with bright yellow tips (tarsi)

Figure 1a. Lateral view of northern giant horneta northern giant hornet body showing even narrow bands. The genae are pronounced. Image credit: Allan Smith-Pardo, Invasive Hornets, USDA APHIS

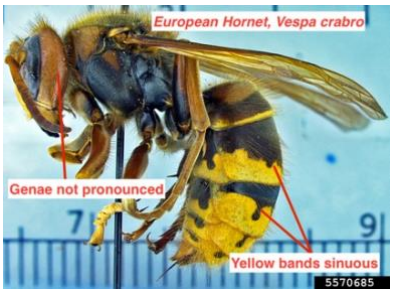

Figure 1b. Lateral view of a European hornet body showing sinuous yellow bands. The genae are not pronounced. . Image credit: Allan Smith-Pardo, Invasive Hornets, USDA APHIS PPQ, Bugwood.org.

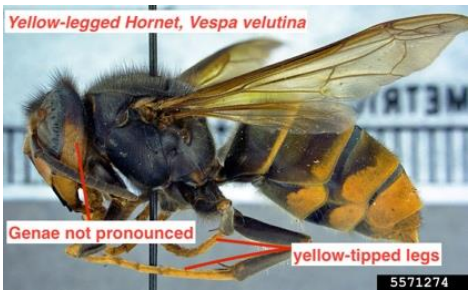

Figure 1c. Lateral view of a yellow-legged hornet body highlighting yellow-tipped legs. The genae are not pronounced. Image credit: Allan Smith-Pardo, Invasive Hornets, USDA APHIS PPQ, Bugwood.org.

Figure 2a. Frontal view of a northern giant hornet head showing a deeply incised clypeus. The genae are pronounced. Image credit: Allan Smith-Pardo, Invasive Hornets, USDA APHIS PPQ, Bugwood.org.

Figure 2b. Frontal view of a European hornet head showing black band between antennal bases and a shallowly incised clypeus. The genae are not pronounced. Image credit: Allan Smith-Pardo, Invasive Hornets, USDA APHIS PPQ, Bugwood.org.

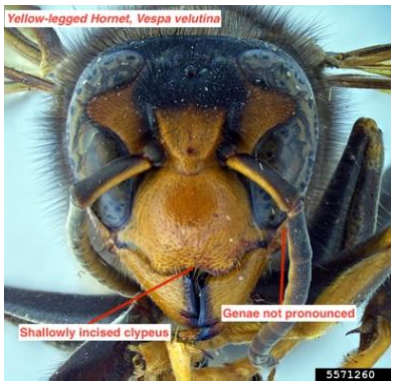

Figure 2c. Frontal view of a yellow-legged hornet head with shallowly incised clypeus. The genae are not pronounced. Image credit: Allan Smith-Pardo, Invasive Hornets, USDA APHIS PPQ, Bugwood.org.

Figure 3a. Dorsal view of a northern giant hornet thorax showing mesonotum without yellow patches. Image credit: Allan Smith-Pardo, Invasive Hornets, USDA APHIS PPQ, Bugwood.org.

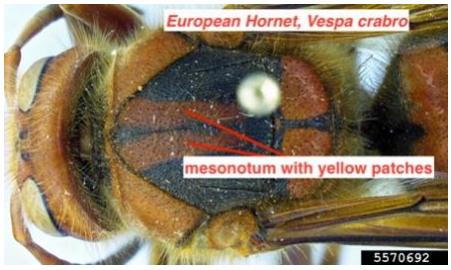

Figure 3b. Dorsal view of a European hornet thorax highlighting mesonotum with yellow patches. Image credit: Allan Smith-Pardo, Invasive Hornets, USDA APHIS PPQ, Bugwood.org.

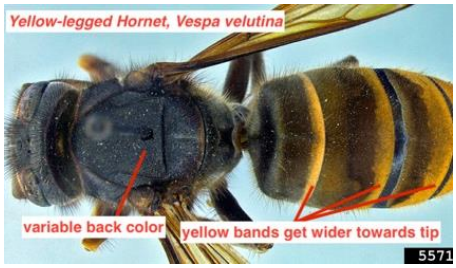

Figure 3c. Dorsal view of a yellow-legged hornet thorax highlighting variable back color and yellow bands which get wider towards the tip. Image credit: Allan Smith-Pardo, Invasive Hornets, USDA APHIS PPQ, Bugwood.org.

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Annual Life Cycle and Nesting Behavior

All hornets (*Vespa* spp.) are social, meaning each colony has a queen, workers, and drones that live together in a nest. Queen hornets are produced in the fall of the year and then disperse to find winter hiding places. The workers and drones then die, and only the queens survive the winter. In the spring of the year, the queens become active and search for new nesting sites. Old nests are not reused. The NGHs usually nest in the ground in old rodent burrows or rotten tree stumps, much like native yellowjackets (*Vespula* spp.), but they can nest in above ground cavities.[12,13] European hornets tend to nest in protected cavities such as tree holes or human structures, either below or above ground. The YLHs usually nest above the ground in exposed, paper nests, similar to our native bald-faced hornets, *Dolichovespula maculata*. European beekeepers report YLH nests to be on tree limbs and in open human structures such as barns and stables.[14]

Once the queen hornet finds a suitable nesting site, she begins building the paper comb and producing workers. She chews bits of wood from trees to construct a papier-mâché material with which to build the nest. Even though each hornet species builds nests in different locations, the structure of the nest is similar. The nest consists of a series of horizontal combs where brood-rearing occurs surrounded by an elliptical envelope to protect the brood from predators and excess moisture (figure 4). By mid-summer, the workers take over the foraging and nest-building activities, and the queen focuses on egg-laying. Most people notice the hornets in mid-summer when workers begin to forage. In the fall, the colony reaches maximum size, and this is when attacks on honey bee colonies are most likely to occur. As winter approaches, the colony produces new queens that disperse to find winter hiding places. The colony then dies, and only the queens survive to repeat the process in the following year.[14]

Figure 4. European hornet (*Vespa crabro*) nest. Image credit: Terry Prouty, www.bugguide.net.

Foraging

Adult hornets feed on sweet substances, sometimes visiting fruits, flowers for nectar, or tree sap (8). The NGHs have an affinity for citrus and are attracted to orange juice as well as vinegar. The YLHs are attracted to ripening fruits. Both NGHs and YLHs feed on honey collected by honey bees.

Hornet larvae are carnivorous and eat insects that are fed to them by adult hornets. Queen and worker hornets collect insects, chew them into a paste and feed them to their larvae. The NGHs target beetle larvae, especially longhorn (Cerambycidae) and scarab (Scarabaeidae) beetles.[5] European hornets and YLHs have more general feeding preferences. Both NGHs and YLHs have a high affinity for honey bee colonies because they contain both sweet fluids for adult workers and bee larvae to feed their young. European hornets will attack individual honey bees outside of the hive, but they do not destroy entire colonies.

Attacks on Honey Bee Colonies

Both NGHs and YLHs easily overcome honey bee defenses. Honey bees might be able to fend off a single hornet by "balling," a behavior where large numbers of honey bees surround the hornet and generate heat by vibrating their flight muscles, effectively killing the hornet.[16] Balling is a behavior best displayed by eastern honey bees (*Apis cerana*), which occupy the same native range as the NGH and the YLH. Western honey bees did not co-evolve with Asian hornets and did not develop this defensive adaptation; therefore, they cannot fend-off multiple hornet attacks. Giant northern hornets mark beehives with a pheromone that attracts other NGHs, which aids in recruiting more hornets to the attack. Eventually, attacking hornets kill the defending honey bee workers, usually by decapitating or crushing them with their mandibles, leaving behind headless and mangled bee carcasses at the hive entrance and bottom board.[5] It is this carnage that has

earned the NGH the nickname “murder hornet.” After destroying the workers, the hornets then collect the honey bee larvae. Giant northern hornets can destroy a honey bee colony in just a few hours.

European hornets do not display the same hive-killing behavior as NGHs or YLHs. European hornets may capture worker honey bees while foraging or sometimes attack them at the hive entrance but rarely do EHs enter hives unless the hive is already weak or has been abandoned.

Human Health

Hornets sting, but they are not necessarily more lethal to people than stings of native social wasps. The venom of the NGH is about as potent as the venom produced by native wasps and is less toxic than the venom of western honey bees.[17] Reactions to hornet stings are similar to those of other social bees and wasps, typically localized pain and swelling. Most human deaths associated with hornet stings occur in individuals who are stung many times and have other underlying health issues such as anaphylactic reactions to insect stings.[18] In general, about 5% of the general population suffers from systemic (life-threatening) reactions to insect stings,[19] and this is consistent with the systemic reaction rates for NGH.[19,20,21] Hornets are not defensive while foraging unless they are injured or trapped. Hornets defend their nest if it is disturbed and react much like yellowjackets or paper wasps, defending a small area usually no more than ten to twenty yards from the nest. Although hornets can inject more venom than other stinging insects, they tend to produce fewer individuals per colony than yellowjackets. Accidental disturbance of a hornet colony usually results in fewer stings than disturbing a yellowjacket nest.

If a person accidentally disturbs a nest site of any social stinging insect, the following steps should be taken:

1. Pause briefly to locate the direction of the nest,
2. protect the face to avoid injury to the eyes, and
3. quickly create distance from the nest site.

If a person stung by a wasp, yellowjacket, bee, or hornet begins to suffer from shortness of breath, swelling on parts of the body away from the sting location, accelerated heart rate, severe headache, or dizziness, they should seek medical attention immediately.

Possible Misidentifications for Asian Giant Hornet or Yellow-Legged Hornet

Several insects in South Carolina may be mistaken for NGH or YLH. These include the European hornet (figures 1b, 2b, and 3b), the cicada killer wasp (figure 5), the bald-faced hornet (figure 6), paper wasps (figure 7), queen yellowjackets (figure 8), wood wasps (figure 9), and robber flies (figure 10). The most reliable trait that differentiates these insects from the NGH or YLH is size. Each of these insects, except for the European hornet, is considerably smaller than either the NGH or the YLH.

Figure 5. Cicada killer wasp (*Sphecius speciosus*). Image credit: Russ Ottens, University of Georgia, Bugwood.org.

Figure 6. Bald-faced hornet (*Dolichovespula maculata*). Image credit: Johnny N. Dell, Bugwood.org.

Figure 7. Paper wasp (*Polistes spp.*). Image credit: David Cappaert, Bugwood.org.

Figure 8. Queen yellowjackets (*Vespula spp.*). Image credit: Lisa Ames, University of Georgia, Bugwood.org.

Figure 9. Wood wasp (*Sirex spp.* and *Eriotremex formosanus*). Image credit: Steven Valley, Oregon DA, Bugwood.org.

Figure 10. Robber fly (Asilidae). Image credit: Johnny N. Dell, Bugwood.org.

Trapping and Monitoring

Early detection of exotic hornets is critical for controlling them if they do make it into South Carolina. Ports of entry are inspected for a variety of insect pests, including hornets (*Vespa* spp.). State apiary inspection programs across the nation also are developing monitoring programs for NGH and YLH. The US Department of Agriculture provides guidance for trapping and controlling hornets in their bulletin on northern giant hornets (https://cms.agr.wa.gov/WSDAKentico/Documents/PP/PestProgram/Vespa_mandarinia_NPRG_10Feb2020-(002).pdf).

If South Carolina residents encounter hornets and suspect them to be NGH or YLH, they can submit pictures to their county Extension office (https://www.clemson.edu/extension/co/index.html), the Apiculture and Pollinator Program (bpowel2@clemson.edu), or the Plant and Pest Diagnostic Clinic (ppclnc@clemson.edu). A specimen will be needed to confirm any suspected exotic hornet sightings. Residents are urged to be cautious when approaching hornets to avoid being stung.

Preventing Hornet Attacks on Honey Bee Hives

While trapping may indicate if hornets are present, it is unlikely that trapping alone will provide satisfactory control of hornets in bee yards. Use of trapping in the spring and early summer to target and control queen hornets may reduce the development of hornet colonies later in the year. By mid-summer and fall, traps will mostly catch worker hornets and have little effect on the overall hornet population. In late season, traps will be more useful for monitoring hornet activity than controlling hornet populations.

The most effective method for controlling attacks by NGH and YLH is to prevent their access into the bee hive by altering the entrance. Anti-robbing screens mounted over the hive entrance can prevent hornet entry (figure 11), as long as the entrance holes are too small for the hornets to use but large enough to allow bees to enter and exit without knocking pollen off of their legs. Beekeepers also need to screen the vents in the inner cover if the vents are large enough to allow hornets access through the top.

Figure 11. Anti-robbing screen over hive entrance Image credit: Ben Powell, Clemson University.

The ApiShield hive mounted trap uses both trapping and exclusion to manage hornets in Langstroth hives. The ApiShield trap is installed below the first brood box and serves as a bottom board, allowing honey bees to access the normal front entrance while also providing access through larger holes along the sides (figure 12). Hornets attracted to the hive are not able to enter the front entrance used by the bees but can enter the larger holes in the sides and back. Once the hornet

enters, it becomes trapped in a screened chamber below the beehive. This trap uses the natural odors of the hive as the attractant and does not require any additional lures or baits. The device also doubles as a screened bottom board for monitoring varroa mites. The ApiShield trap may restrict bee movements and cause entrance congestion, so it would be best used only when NGH or YLH are most active in late summer and fall.

If beekeepers need additional guidance for managing predators of honey bees and other hive pests, they are encouraged to contact the Clemson Apiculture and Pollinator Program (bpowel2@clemson.edu).

Figure 12. ApiShield Hornet Trap. Image credit: Vita Bee Health.

Additional Resources

USDA New Pest Response Guidelines for Asian giant hornets, *Vespa mandarinia*
https://cms.agr.wa.gov/WSDAKentico/Documents/PP/PestProgram/Vespa_mandarinia_NPRG_10Feb2020-(002).pdf

Washington State Department of Agriculture, Invasive Hornets Website
https://agr.wa.gov/hornets

Washington State Department of Agriculture, Pest Alert, Asian Giant Hornet
https://s3.wp.wsu.edu/uploads/sites/2091/2020/01/PestAlert-AsianGiantHornet.pdf

Washington State Department of Agriculture, Trapping for Asian Giant Hornets
https://agr.wa.gov/departments/insects-pests-and-weeds/insects/hornets/trapping

VespaVelutina.eu/en-us Website for Yellow-Legged Hornet Information in Europe
https://www.vespavelutina.eu/en-us/

Clemson Cooperative Extension, HGIC, European Hornet Factsheet
https://hgic.clemson.edu/factsheet/european-hornet/

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