A citizen science study of wild colonies of honey bees

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Fig. 1. Nest site in the wall of a farmhouse in Brooktondale, New York State, USA. Entrance is at the center of the red circle. This site was occupied continuously by wild colonies from some time before June 2010 (establishment date unknown) to September 2018.

Being beekeepers, we are apt to wonder, whenever we spy honey bees working on flowers far from our hives, where is the *hive* from which these small ramblers have come? It may be, though, that these bees have come not from a beekeeper's hive, but from a hollow tree, rock crevice, or nook in a building. If so, then these bees have come from a wild colony.

There is much about the lives of wild colonies that remains mysterious. How abundant are they? Where are their nests? How long, on average, are their nesting sites continuously occupied? Why haven't all the wild colonies been killed off by the parasitic mite *Varroa destructor* and the viruses that it spreads? When do these colonies cast their swarms? How many swarms does a wild colony produce each year? What level of trapping of their swarms is sustainable? Who are these wild colonies, genetically speaking? And how do their lives unfold differently, over summers and winters, compared to the lives of the colonies that we keep in our hives?

This article is an invitation to contribute to a collaborative — "citizen science" — study that aims to get solid answers to three of these questions about wild colonies: How abundant are they? Where are their nests? and How long, on average, are their nesting sites continuously occupied?

This study will focus on the wild colonies of European honey bees that are living in Europe and in North America. I hope, though, that this study will lead eventually to similar studies being conducted in other regions within the broad geographical range of the western honey bee, *Apis mellifera.*

What will participation in this study involve? Four things: (1) *finding* wild colonies living in hollow trees, rock cavities, and buildings; (2) *describing* each colony's nest site; (3) *inspecting* each nest site three times a year for several years, to determine the probabilities of colony mortality over summer and winter; and (4) *reporting* the results in a standardised way, so that all the findings can be pooled for statistical analyses. I will explain how these four activities are to be done, but before we consider these matters, let's address a fundamental question: Do wild colonies of European honey bees still exist?

Do wild colonies still exist?

From time to time, I will hear somebody declare that the wild colonies of European honey bees in North America have been killed off by the deadly duo of the *Varroa* mite and the deformed wing virus, and that the few wild colonies still found are just hopeless, short-lived things started by swarms from managed colonies that receive treatments to control *Varroa*. In other words, the claim is made that self-sustaining populations of wild colonies of European honey bees no longer exist in North America. I know, however, that this is not true.

My knowledge on this matter comes partly from a 7-year study (from 2010 to 2016) in which I monitored 33 nest sites occupied by wild colonies. These nest sites were in hollow trees, farm houses (**Fig. 1**), and a hunting cabin, all located in the wooded countryside south of the small city of Ithaca, in New York State (Seeley 2017). This investigation revealed that if a wild colony survives its first summer and winter, then on average its nest site will be occupied continuously for another 5.2 years. This means that some sites will be occupied for less than 5.2 years, while other sites will be occupied for more than 5.2 years. One site that I have followed from spring 2010 to fall 2019 has (so far) a nine-year history of continuous occupation. This information about the lifespans of wild colonies, combined with additional information about their rates of reproduction, have shown that this population of wild colonies is self-sustaining (for details, see Ch. 7 in Seeley 2019).

A second indication that self-sustaining populations of wild colonies of European honey bees still exist comes from studies that I and others have conducted of the wild colonies living in the 15-square-kilometer Arnot Forest. This is a forest that is owned by Cornell University and is located about 25 kilometers southwest of Ithaca, New York (see Chapter 2 in Seeley 2019). I began these studies in the late 1970s, which was long before *Varroa destructor* arrived in New York State (NYS) in the mid 1990s, and I have continued these studies to the present. One thing that these studies have revealed is that in both the late 1970s (ca. 15 years *before* the arrival of *Varroa* in NYS) and the early 2010s (ca. 15 years *after* the arrival of *Varroa* in NYS), there were wild colonies living in

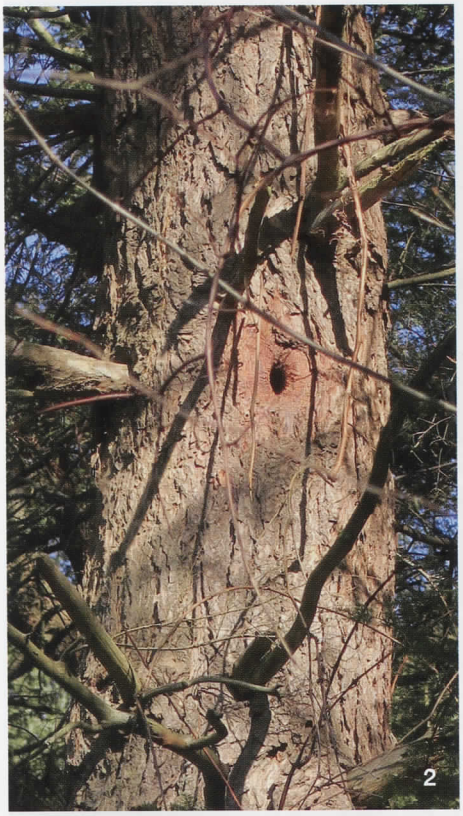

Fig 2. Entrance opening of a wild-colony nest site in an eastern hemlock tree (*Tsuga canadensis*) in the Shindagin Hollow Forest, an old-growth forest about 16 km southeast of Ithaca, New York State, USA. Photo taken on cold day in November 2017, when bees were not flying.

Fig. 3. Entrance of a wild-colony nest site in a red maple tree (*Acer rubrum*) near Stonington, Connecticut, USA, discovered during a walk in the woods. Photo provided by Bruce Fellman.

the Arnot Forest at a density of one colony per square kilometer. Genetic studies of the bees living in this forest have revealed two things about who they are: (1) the wild colonies living in tree cavities in this forest are genetically distinct from the nearest managed colonies living in bee hives outside this forest (Seeley et al. 2015); and (2) the bees in the Arnot Forest were (in the 1970s), and still are (in the 2010s), almost entirely of European descent (Mikheyev et al. 2015). It is clear, therefore, that these survivor colonies are *not* Africanized honey bees.

The density of the wild colonies in the Arnot Forest appears to be typical for the forests in southern New York State and in western Pennsylvania, the state just to the south of New York. I can make this statement because in the summer of 2017, a friend and fellow hunter of wild honey bee colonies, Dr. Robin Radcliffe, conducted a search (by means of bee lining/hunting) for wild colonies living in the woodlands on his farm and in the part of the 21-square-kilometer Shindagin Hollow State Forest that borders his farm. This State Forest lies about forty kilometers east of the Arnot Forest. Robin conducted his bee hunting within a five-square-kilometer area and he found five wild colonies; four were in cavities in old-growth hemlock trees (*Tsuga canadensis*) (**Fig. 2**) and one was in the wall of a hunter's cabin (Radcliffe and Seeley 2018). Therefore, he too found one wild colony per square kilometer.

A third survey of wild colonies of European honey bees living in a forested landscape has been made by a team of biologists who worked in and around the Powdermill Nature Reserve (part of the Carnegie Museum of Natural History, in Pittsburgh), which is in the Laurel Highlands of western Pennsylvania (Rangel et al. in press). This team found thirty-two wild colonies, so they too found a density of approximately one colony per square kilometer.

The studies just described show us that populations of wild colonies of European honey bees still exist in the heavily forested regions of southern New York State and western Pennsylvania. One wonders, is this also the case elsewhere in North America and in Europe? I hope that over the next several years, with the help of some of you who are reading this article, we will learn about the density and persistence of wild colonies in other *rural* places in Europe and North America where the honey bees are of European ancestry. To show how you can help, I will explain first how you find wild colonies of honey bees. Then I will explain what data are to be collected from the wild colonies that you find, and how to collect these data in a standard way so that your findings can be pooled with those from others.

Finding and describing the nest sites of wild colonies

There are two ways to find wild colonies of honey bees. Both are fun, for each is a form of treasure hunting. The first method is simple: go on walks and be on the lookout for honey bees flying to and from cracks and knotholes in trees; openings in the walls, roofs, and chimneys of buildings; and entryways in stone walls and rocky hillsides (**Fig. 3**). The power of this method can be multiplied by asking friends and neighbors if they have spotted honey bees flying in and out of trees, buildings, stone walls, and other places. The second method is more complicated, but is also potentially more powerful: bee lining/hunting. This is a fascinating outdoor sport, and its methods are explained in detailed in three books: Edgell 1949, Donovan 1980, and Seeley 2016.

Once you have found the nest site of a wild colony, you will need to describe your find. Do so by writing the information in a notebook dedicated to this project; this will ensure that your findings are safely recorded. Here is the protocol:

1. Give the nest site a name (e.g., Robin's Bee Tree).
2. Record the date you discovered the nest site.
3. Record the location of the nest site, by referring to an address (if in a building), recording landmarks (location along road, near a building, etc.), noting GPS coordinates, or all three.
4. Record whether the nest site is in a tree, a rock crevice, a building, or some other man-made structure (e.g., a wall, a log hive, etc.)
5. Describe the nest site's habitat: within a forest, beside a field/meadow, along a river, etc.
6. Record these details about the entrance opening(s) of the nest site:
    A. height above ground: measured either with a tape measure or by triangulation; see https://www.wikihow.com/Measure-the-Height-of-a-Tree
    B. compass direction in which it faces: measured with a magnetic compass
    C. area of the opening: measured with a tape measure and perhaps a ladder
7. Photograph three things about the nest site: its entrance opening, its structure (e.g., tree, rock wall, building, or log hive), and its surrounding habitat (woods, village, fields, etc.).
8. Record how you discovered the nest site: by bee lining/hunting or by chance.

This distinction is essential to a meaningful statistical analysis of the data from many sites. Nest sites found by bee lining/hunting tend to be a *random* sample of the occupied nest sites in an area. Nest sites found by chance, however, tend to be a *non-random* sample of the nest sites in the area, because those found by chance are usually more conspicuous than average. For example, the nest sites of wild colonies found by chance tend to have low entrances because sites with low entrances are especially likely to be found by chance.

9. Record what (if anything) you know about the history of the bees' occupation of the site.

When possible, record whether the site is known to be newly occupied (i.e., somebody observed that a swarm moved into site during the current summer) or continuously occupied since at least the previous summer. A newly occupied site houses a "founder colony" whereas a site that has been occupied since the previous summer (or earlier) contains an "established colony." The distinction between founder and established colonies is important because their probabilities of survival over winter can differ greatly. Sometimes, though, you will not know if a wild colony is a founder colony or an established colony, and in this case it is important to record that its colony type is ambiguous.

Checking the survival of wild colonies

Once you have found the nest site of a wild colony, you will need to inspect this site at least three times a year (spring, summer, and autumn), and you will need to do so for several years. You should aim for a five-year program of inspections, at least.

Whenever you inspect a site that housed a live colony the last time you checked it, your inspection will reveal whether the colony that had been living there is or is not still alive. Seeing bees

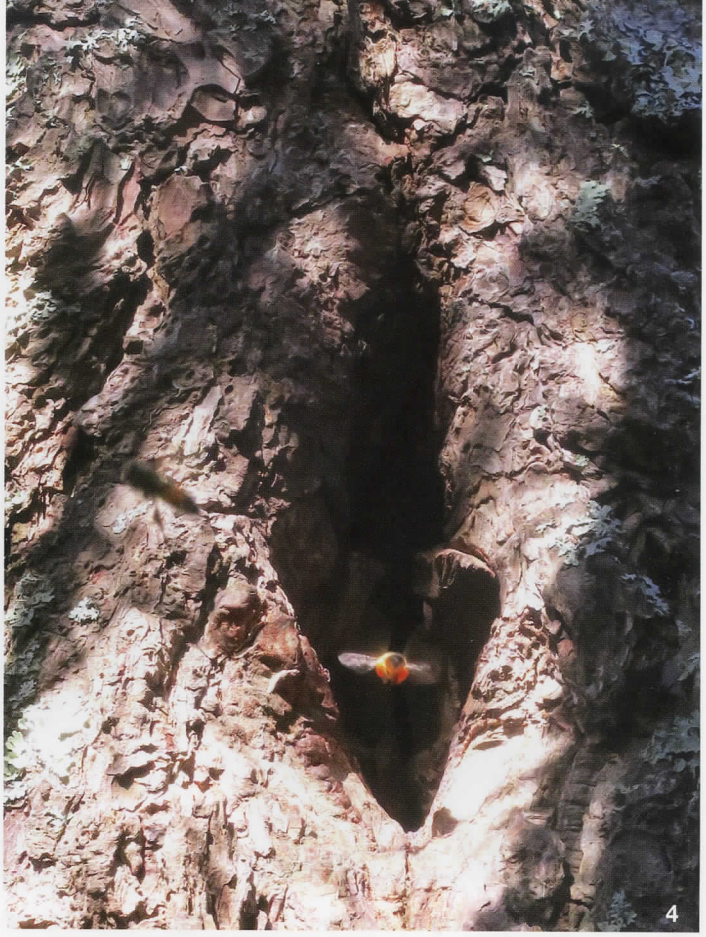

Fig. 4. Bee bearing pollen loads as she flies into the entrance of her bee tree home. Her pollen loads show that there is still a live colony at this site.

flying in and out of a nest entrance is not solid evidence that there is still a live colony at this site; the flying bees might be robbers or nest-site scouts investigating the home of a colony that has died. Only if you see bees carrying in loads of pollen can you be certain that this site contains a live colony. Inspections of nest sites with high entrances require binoculars.

It is essential that you time your nest-site inspections carefully in relation to the swarming season for your location. Here is the schedule.

1. Spring: the first round of inspections should be made *before the start of the swarming season*. This is important, for it enables you to avoid the mistake of thinking that the colony at a site has survived winter, when actually the colony that had been living there has died out and has been replaced by a swarm.
2. Summer: The second round of site inspections should be made *after the end of the swarming season*. This enables you to know which sites that were vacant in Spring have been occupied by swarms.
3. Autumn: The third round of site inspections should be made shortly *before the end of the "bee season"*, that is, shortly before the bees stop flying from their homes for the year. This enables you to detect where colonies have died out over the summer, and where empty sites have been occupied by late-season swarms.

There is one small complication in this inspection scheme. It is this: when you add a new site to your list of nest sites to be monitored, often you will not know if this site has been occupied only recently, in which case the colony is a "founder colony", or if this site has been

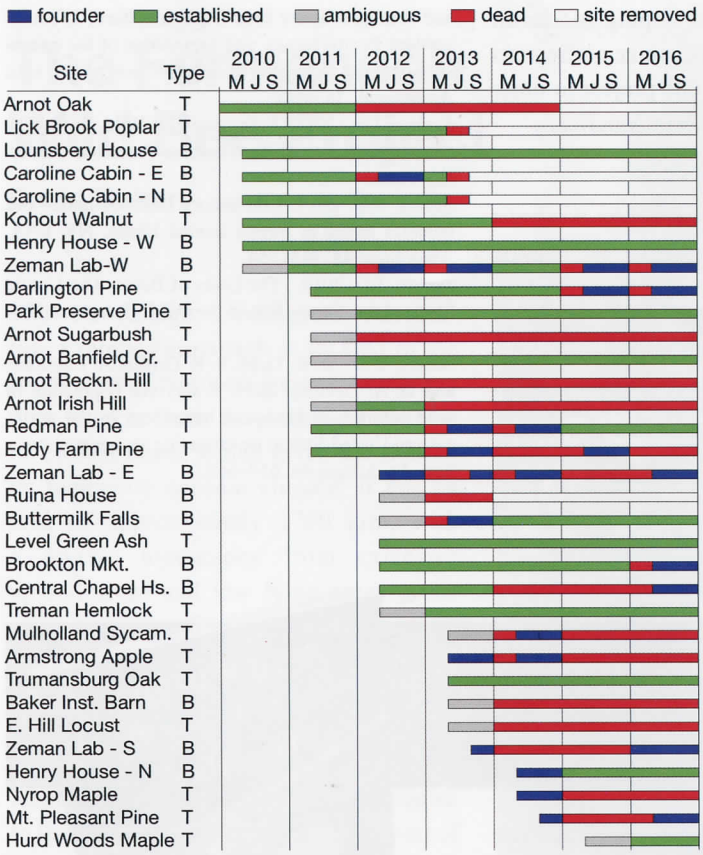

Fig 5. Results of a 7-year program of inspecting 33 wild-colony nest sites in rural places south of Ithaca, New York, USA. Inspections were made in early May, late July, and late September. Colored bars indicate type of colony that occupied a site: Blue = founder colony, Green = established colony, Gray = ambiguous colony. Red indicates where colony died, so site no longer occupied. White indicates site removed from study because it was damaged (tree fell over, site destroyed by black bear, etc.) and so was no longer a suitable nest site.

occupied for the past year (or more), in which case the colony is an "established colony." If you are lucky, somebody has already been watching the site and can tell you if a swarm has recently moved into it (hence it is a founder colony), or if a colony of bees has been living there since the previous year (hence it is an established colony). Usually, however, you will not know which kind of colony it is when you discover a wild colony. In this situation, you must record it, at first, as an "ambiguous colony" (see Fig. 5).

Reporting your results in a standardized way

Fig. 5 shows how I organized the results of my inspections of thirty-three nest sites that were occupied by wild colonies at various times between May 2010 and September 2016. I recommend that you also use this system, for it works well. That said, I recognize that the three inspection times that have worked well for me in New York State (early May, late July, and late September) will need to be adjusted to fit around the swarming season where you live.

This table shows that each site was given a name and was classified by a type (tree or building). Also, the status of the colony—founder, established, ambiguous, or dead—was noted for each inspection. Different nest sites were discovered in different years, and few were inspected across all seven years.

Calculating the probabilities of wild colony survival, for summer and winter

Two things that you can calculate using your data are the probabilities of colony survival in summer and in winter. To calculate these probabilities, you first make a table in which you write down how many colonies survived and how many died during each season (summer or winter) for each year that you have tracked your colonies. When you do this, you should analyze separately your data from the founder and the established colonies, because their situations are so different. Where I live, founder colonies have a low probability of winter survival, whereas established colonies fare better. This difference is shown in Table 1, which shows for the seven-year period of 2010-2016 the numbers of wild colonies that survived or died, over summer and winter, for both founder and established colonies. Founder colonies had a high probability of survival over summer (P=1.00), but a low probability of survival over winter (P=0.25). The situation was markedly different for established colonies. They had a high probability of survival over both summer (P=0.96) and winter (P=0.83).

	Summer		Winter	
	Founder	Established	Founder	Established
Survived	26	76	5	54
Died	0	3	15	11
Survival probability	1.00	0.96	0.25	0.83

Table 1. Summary of the numbers of wild colonies that survived or died, during the summer or during the winter, for the seven-year period of 2010-2016. The counts for founder (first-year) and established (second-year and beyond) colonies are shown in separate columns.

Three final points

1. To make a meaningful contribution to this study, *you must be able and willing to invest considerable time to it.* At first, you will need to devote time to finding wild colonies living in rural locations. Then, once you have located a set of sites occupied by wild colonies, you will need to devote time to inspecting each site at least three times a year, as discussed above.
2. It will be best if the wild colonies that you monitor live far from artificial sources of colony mortality (pesticides, pest control operations, tree felling, etc.).
3. You do not need to find and monitor a large number of nest sites occupied by wild colonies. If you can find just three or four sites, and you are able to inspect these sites three times a year for at least five years, then I encourage you to participate. Your findings will be valuable contributions to this study of the honey bee colonies that are living all on their own.

If you are interested!

If you are interested in participating in this study, then write to me at my email address: tds5@cornell.edu. Please provide me with information on the following five points.

(1) your location (town, state/province, country),

(2) your level of experience as a beekeeper,

(3) the risk of pesticide exposure for bees in your location,

(4) your reasons for wanting to participate in this study, and

(5) how many, if any, wild colonies you know of already.

I will then get back to you. Starting this Spring, I will resume monitoring the nest sites of approximately fifteen wild colonies living in trees and buildings in the countryside around my home in Ithaca, New York. I am hoping to recruit about twenty dedicated citizen scientists who will help expand this project to other places in Europe and North America.

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