Alternative Pollination Methods for California Almond Trees in response to Colony Collapse Disorder

An investigation of potential causes of CCD and alternative solutions to alleviate the rising costs of pollination services due to declining honeybee populations

Tag Words: Colony Collapse Disorder, CCD, honey bees, almond tree, Prunus dulcis, pollination, drone bees
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Summary (JO)/(DM)

The worldwide population of bees has been in decline due to Colony Collapse Disorder (CCD) for quite some time. According to beekeepers in the United States and Europe, bee populations have experienced an annual decline of roughly 30% of their bee colonies [1]. This is disconcerting because roughly 35% of the world's crop production is affected by pollinators, such as bees [2]. Almond trees, *Prunus dulcis,* in California are particularly vulnerable to this decline as they are responsible for producing 80% of the world's almonds and are estimated to use nearly 60% of all U.S. bee colonies for pollination during their bloom from February to March. CCD poses a real and imminent threat to Californian almond crops and because of this it is clear that alternative methods of pollination should be investigated if CCD cannot be stopped, as current alternatives to bee pollination are not effective enough to maintain current crop yields. Actions that should be taken include: developing alternative pollinators, reducing the transportation of bees, both nationally and internationally, and developing a cure for CCD. The community can help by planting more flowers and keeping flowers healthy, so that the bee population can be as healthy as it can be.

Video Link: http://youtu.be/iRrIcm2S4Vo

Colony Collapse Disorder and Potential Causes (DM)/(JO)

Colony Collapse Disorder is an event where worker bees will rapidly disappear from a hive. This can be devastating for the hive and beekeepers can suffer heavy losses. Collapsed colonies are characterized by three simultaneous conditions. The first is that the abandoned colonies contain capped brood. Healthy bees will not generally abandon a hive until these have hatched. Second is remaining food stores of honey and pollen in the abandoned colony which is not robbed by other bees or immediately attacked by other hive pests. The third condition is that the queen bee is still present.

Though the exact cause of CCD is still under investigation, there are several theories. Possible causes include: pesticides, parasites, or pathogens, however, it is most likely that CCD is related to interactions between several of these factors. Neonicotinoids, a class of insecticides, have long been believed to play a role in the occurrence of CCD. A 2013 study on neonicotinoids showed that they can adversely affect the immune system of honey bees, making them vulnerable to infections that

would normally be inconsequential [3]. These pesticides are still in use today, however, actions are underway that aim to suspend their use. The Save American Pollinators Act introduced in Congress by Rep. Earl Blumenauer of Oregon aims to suspend the use of four neonicotinoid insecticides, three of which are already suspended in Europe, until they have been reviewed by the Environmental Protection Agency [4]. The disuse of these pesticides would go a long way towards promoting the safety of honey bee populations but they are not the only factors that have shown a connection to CCD.

In other studies, researchers have discovered a possible link between the honey bee ectoparasitic mite *Varroa destructor* and pathogens that it spreads, specifically deformed wing virus (DWV). In a simulation model of honey-bee populations where parasites that spread DWV were introduced the colonies survived a maximum of two summers before eventually collapsing during the winter season [5]. Another recent study suggests that tobacco ringspot virus (TRSV), which normally infects plants, may be involved. TRSV was also found in *Varroa* mites suggesting they may help to spread the virus [6].

Additionally, a study which examined the effects of pesticide exposure experienced by bees during pollination revealed troubling results. In measuring the pesticides found in the honey of bee colonies of seven major crops researchers discovered 35 different pesticides, two of which were present at a concentration greater than their median lethal dose, and high fungicide loads. Furthermore, they discovered an increased probability of infection by *Nosema ceranae*, a gut parasite, in bees which consumed pollen with a high fungicide load [7]. Clearly, there are a number of intertwining factors which are potential contributors to the incidence of CCD, however, further research is necessary to determine if these correlations are truly the cause of CCD.

Pesticides are used to treat commercial hives for parasitic mites. However, this leaves chemicals in the hive that the honeybees is not able to adequately defend itself from. About 46 of the honeybees genes code for detoxification, which is about half of what most insects have. Researchers have found the chemicals that boosts the detoxification genes, and the most potent of these is p-coumaric acid. P-coumaric acid is found in pollen grains and wild bees gain access to it by simply eating honey. Commercial bees used for pollinating crops are fed high fructose corn syrup, as it is cheaper than honey and provides most of the same nutrients. However, by doing this, the bees are not getting the p-coumaric acid they need to resist the effects of the pesticides. It was found that between bees that were fed sucrose and bees that were fed p-coumaric acid-supplemented sucrose, the supplemented bees were able to reduce 60% more pesticide than the bees fed normal sucrose [8]. Since these pesticides are a great help to prevent the mites from negatively impacting the honeybees, having the bees be able to actually survive the chemicals is clearly necessary.

Another factor found to possibly induce Colony Collapse Disorder is stress. This stress could be built up from parasites, chemicals, pathogens, the weather, habitat loss, almost anything that inconveniences the bees. Once stressed to a certain point, the bees begin to behave erratically. This change affects their mobility and orientation, as if they

were intoxicated. Over the course of time the effects worsen, until the colony simply fails. Normally, worker bees are replaced by bees that take care of the hive. If a worker was injured, then it would be replaced. However, stressed-out bees are treated as normally functioning workers, as they have nothing physically wrong with them. The workers eventually start to die off from natural causes faster than larvae can be born, dooming the hive [9]. The idea that stress itself is causing CCD could be thought of as a way of saying that all possible factors are causing stress. Stress could be considered an umbrella term for all of the other factors.

The closest thing to a cure for Colony Collapse Disorder that has been found is to treat the hives for the various parasites in them and hope that the colony can recover. As previously mentioned, boosting the honey bees' immune system may be the best way to prevent CCD from taking hold. However, some illnesses are too great for simply a good immune system to stop, and, just like it is with serious illnesses and humans, that is when a pesticide, fungicide, or some other chemical is needed. The problem with using a chemical is that the chemical itself may promote CCD, even though it may prevent another cause. Finding the right chemical to use may even be a struggle, and it may be found only when the hive has been lost to CCD. Research is being done to find a cure, but with so many factors, that may take quite some time.

Economic Impact of CCD (JO)

CCD could have a very real impact on both local and global economies. As stated earlier, bees help pollinate roughly 35% of the world's crops. They are also responsible for the production of roughly $150 million in honey and over $15 billion of crops in the United States alone. Due to bee shortages, farmers have had to pay up to 20% more to rent bee colonies to pollinate their crops [10, 11, 12]. One area that has been impacted greatly by the loss of bees is the almond orchards in California. The almond trees are heavily dependent on bees to fertilize. To this end, farmers must import bees from outside California to handle pollinating the acres of land. Due to the declining bee population, the majority of bees within the United States have to be sent [1].

The unusually high winter losses that beekeepers have experienced due to CCD have lead to a significant increase in the pollination costs to California almond producers. In the decade preceding the onset of CCD the average pollination fee per hive charged to almond producers only increased $18.26, from $35.41 in 1995 to $53.67 in 2004. However, in the years following the evidence of CCD in 2005 those numbers rose dramatically. From 2004 to 2005 the average cost increased to $72.58 per hive, an increase of $18.91. California almond producers experienced a greater increase in cost for pollination services in one year due to CCD than they had in total for the previous decade. Unfortunately, this cost continued to increase until reaching a maximum of $157.03 per hive in 2009 and declining slightly to $150.79 the next year. Overall, the cost of pollination for almond producers in California nearly tripled over a five year span after remaining relatively stable for a decade, largely due to the incidence of CCD [13].

This is troubling news for California, as almonds are its largest-value agricultural export (roughly 70% of the almonds produced are exported) and require two hives per acre for pollination. But as bee populations have declined, the acreage of almond groves has increased and thus the number of hives needed: the number of hives required for pollinating California's almond groves increased by 84.5% from 802,000 hives in 1992 to 1,480,000 in 2010. It has become increasingly clear that without a plausible solution, this situation may not be sustainable for an extended period of time. Because of this, there is a clear need to examine both present and future alternatives to alleviate the impact that CCD has on California's almond crops.

Other Economic Impacts on Almond Trees (DM)

Another problem plaguing the almond trees is a severe drought throughout California.
Almond trees are a perennial crop, which means it produces it's harvest over the course of the year, rather than having one specific harvest time, like lettuce. As such, almond trees require water year round, and in case of a drought, need the farmers to provide the water. However, the current drought is so extreme that farmers are having a tough time keeping their many acres of trees properly irrigated. An annual crop's field could be made fallow and then replanted years later to no ill effect. A perennial crop, like almonds, could not be treated the same way, as they require year round care and years of growth to be ready for production. As this is a tremendous investment, farmers can not afford to lay fallow an almond orchard. With the way the price of water is rising, they can not afford to keep their trees either. To make matters more pressing, water is being diverted to help protect an endangered fish species. Many farmers are being forced to lay fallow their annual crops to preserve the water supply for the perennial ones. Even that isn't enough for some farmers, as they are forced to sacrifice some trees to preserve the others [14]. Between the decline of the honeybee population and the increasing scarcity of water, almond farmers are facing rising problems.

An estimated 150,000 acres of the 660,000 acres of almond trees in California are over 20 years old. That means that just over a fifth of the almond trees are entering the end of their life cycles. Within the next few years, farmers must consider replanting their orchards or deal with their current crop, which is struggling with the drought. Getting an early next generation of trees would help the future, but keeping the older trees maintains the present. Another issue, though one that is not as severe, is oversupply. Since almonds are so popular, many farmers have switched over to planting almonds over whatever crop they were farming before. This has resulted in a bit of overproduction, leading to a drop in prices as the demand is being met by the supply [15].

Present Alternatives (DM)
Transporting Bees (DM)

There are a few methods currently in use to help cope with the decreasing numbers of bees, though each one has its flaw. One method is to trade and distribute healthy bees from one area to another, even internationally. However, there is a potential to spread the disorder to new areas, and native pollinator populations, when transporting

honey bees as dead and weak colonies are more likely to border each other suggesting that the disorder is due to something infectious or a common exposure, though no single factor has been found with sufficient frequency [16].

Hand Pollination (DM)

Another method is to hand pollinate. This involves a human harvesting pollen and using a brush to spread it. Hand pollination is currently being employed in Japan and China, among other places. A study conducted by the University of California, Davis on the effects of artificial pollination on the yield of Nonpareil almond trees found that hand pollinated trees produced more fruit per branch than a normally pollinated tree. The study shows that hand pollination is more consistently effective than normal pollination [17]. Despite the efficacy of hand pollination, there are a few issues. Due to labor costs, hand pollination is far more expensive than using bees alone. The great efficiency hand pollination has over open pollination is tempered by it being great only in a small scale. Considering the many acres that bees usually cover, hand pollination is far more small-scale [18].

Crop Dusting (DM)

A third method involves using planes to crop-dust pollen onto crops. This allows the pollen to reach large swaths of land, but this comes at a price. It has been found that crops pollinated via crop-dusting yields 40% smaller and 70% fewer fruits than with regular bee pollination [18]. It should also be noted that synthesized pollen cannot be used due to bees growing sick and dying from using it [19].

Alternative Bee Species (DM)

Another method currently in use is to use other species of bees. The almond trees in California primarily use honey bees to pollinate them. However, honey bees are the species of bee that is in sharp decline. Thus, the use of orchard mason bee species have been put into use. These bees can operate at temperatures lower than the honey bees and are far more efficient at pollinating fruit trees. It has been found that mason bees are fifty(50) times more efficient than honey bees. However, mason bees tend to be solitary and do not swarm. This solitary nature makes it difficult to increase their populations. Yearly, mason bee populations can be increased by a factor of five(5) to eight(8), while honey bee colonies can increase from a few dozen to over twenty thousand(20,000). This makes it imperative to import mason bees to maintain the necessary numbers. All of these factors result in mason bees being only slightly cost-competitive to honey bees [20, 21]. Leafcutter bees have also been used in an attempt to replace or supplement the honey bee population. These bees are far more efficient at pollinating alfalfa than honey bees, allowing for enhanced yields for farmers. However, leafcutter bees are more expensive to use than honey bees and they are not necessarily more efficient at pollinating certain crops, including almonds [22]. Thus, it can be said that the alternatives are not the best options for almond trees, and that honey bees are overall the best pollinators.

A mixture of honey bees and other bees may be the best method to use. It has been found that honey bees tend to enhance their pollination efficiency when in the presence of other bee species. Some interaction occurs between the bee species that has the dominant pollinators, in this case the honey bees, become more effective while unmanaged wild bees are in the vicinity. Research is still ongoing as to why honey bees become better pollinators when in the presence of other bee species, but it is promising information considering almond farmers need to maximize the efficiency of what bees they can get [23].

Robotic Bees (DM)/(JO)

Due to the current methods' various shortcomings, a new approach should be used. Namely, using small uav(unmanned aerial vehicle) equipped with sophisticated artificial intelligence(AI) and special modifications to carry pollen to mimic natural bees. These "drone" bees would be used to replace the fallen bee numbers without a loss in efficiency nor the threat of expanding CCD. There have already been a few projects that involve technology that could be used in creating drone bees. Such projects include: the Techject robotic dragonfly, Dickinson fruit fly robot, the Robert Wood robobee, and in 2011 AeroVironment developed a remote controlled flying hummingbird that can hover and carries its own energy source and a camera, though it can only maintain flight for up to 11 minutes.

The Robert Wood robobee is currently in development as an attempt to emulate the flight capability of bees. It aims to use compact high-energy sources to power it and airfoils to emulate a bee's wing structure. The use of sensors and other such hardware would emulate the bee's eyes and antennae. To tackle the large task of mimicking the behavior of colonies, the use of many coordination algorithms, global-to-local programs, and ways to get the robobees to communicate to either other would be employed [24]. The Techject Dragonfly is similar in that it emulates an insect's flight capability, however it uses four wings instead of two. The Dragonfly is palm-sized, so it is too large to adequately mimic a bee. It is equipped with up to twenty sensors to detect and record sights, as a camera. The battery allows for up to a half hour of flight, thus too brief in order to participate in large scale pollination. However, the Dragonfly is still a step forward in getting a robotic bee [25].

Dickinson's robot fruit fly was developed as a way to measure characteristics of insect flight. It is essentially a pair of ten-inch Plexiglas wings modelled after a fly's with three motors attached to each wing, providing the full range of motion an actual fly could produce. The machine was then placed in oil to simulate the motion in air. Though the machine is enlightening, it is much larger than an actual insect and it was not actually used to fly through air [26]. The AeroVironment hummingbird, like the Techject Dragonfly, carries all of it's equipment, such as batteries, cameras, motor, and it's sensors. The hummingbird is extremely lightweight, coming in at ⅔ ounces. That makes it heavier than the average hummingbird, but lighter than the largest hummingbirds in nature. It has all the maneuverability of a hummingbird, allowing the machine to hover and quickly change directions while in flight. The main issue about repurposing the

hummingbird as a robot bee is that it is slightly too large and it does not currently have all of the sophisticated artificial intelligence programs to undergo pollination routines [27].

Despite ongoing development, the use of drone bees is not currently feasible as many problems are being encountered due to the small size requirements of the drone. The drone must be capable of finding and identifying flowers, taking pollen from them, and then bringing it to another flower all while being small enough to fit in the flowers, which is a difficult task. Many of the parts for something like this need to be designed from scratch due to the unique size constraints and purpose. Current batteries, motors and sensors are either too big, too heavy, or too inefficient [28]. Though pollination by drone bees may be a possibility in the future it is not a solution that is currently viable.

Electrostatic Pollen Sprays (JO)

Another alternative is the use of an aerodynamic-electrostatic spray to transfer pollen to flowers [29]. This approach is based on the hypothesis that electrostatics play a role in the natural transfer of pollen from pollinating insects to the stigma of the flower. Research shows that plants have negative surface charge densities which tend to peak on days which are favorable for bee flight and when bees fly they tend to generate a positive surface charge of roughly 45 pC. Because of this, pollen can potentially jump from bee to stigma over a distance of 0.5 mm [30]. These principles were used to develop a system which atomized and charged an almond pollen suspension to compare it to a conventional spray system. In these tests pollen deposition was markedly increased in the electrostatic spray against the conventional spray showing an average 5.6-fold increase against various target positions and as high as a 12-fold increase in targets that were parallel to the spray's stream. The pollen only maintains 80% germinability through this process, however, but the effects of the increased deposition outweigh this.

If this system could be developed to distribute on a wider scale it could be an effective way of pollinating California's almond trees. As discussed earlier, crop dusting with pollen is not as effective as bees are at pollinating flowers, but in combination with this system it could prove to be an adequate form of pollination. Although standard pollen dusting yields both smaller and less fruit than bee pollinated crops, if the increases in pollen deposition from this system are applicable on a larger scale, then crop dusting could be used for comparable results.

Self Compatible Almond Trees (JO)

Another promising solution for California almond producers is a new variety of almond that can self pollinate. Traditional varieties of almond, such as the popular Nonpareil, require cross pollination for successful harvests. Due to this, almond producers must grow multiple varieties in their groves that produce different types of pollen. A recently developed variety, called the Independence almond, alleviates this issue as it is self compatible and capable of producing profitable harvests on its own. This is advantageous for almond producers as growing a single variety means all of their trees bloom together and can be harvested at the same time. This also reduces the need

for bees for pollination as some Independence growers have opted to not use bees while others use one per acre, at a minimum halving the cost of pollination services [31].

Self compatible almond varieties are not new, however. The Tuono variety has been around for hundreds of years, but does not have many of the characteristics that people enjoy about California's almonds. Tuono's seed coat has a hairy texture and a very thick, hard shell which makes much of the nut inedible as compared to the Nonpareil variety [32] which makes it undesirable to both producers and consumers. In order for the Independence variety to be successful it should have similar characteristics to Nonpareils. Early adopters of the Independence variety have reported favorable characteristics, but some of the characteristics of the tree and nut may not become evident until they are grown on a larger scale or for longer periods [33].

Initial trials on the Independence variety report similar size, color, taste and yield to the Nonpareil variety [34], but these results should be taken with a grain of salt as many of these plants are still very young and could show potential problems as they age. Currently, there are 15,000 to 20,000 acres of Independence almonds being grown in California compared to 300,000 acres of Nonpareil [31], but if the variety holds up over time it may become a larger contributor to almond production in California. Despite promising early reports, only time will tell if Independence almonds will be a suitable alternative for California's almond producers.

Ethical Issues (JO)

Both the current practices and proposed solutions to California's pollinator problems raise a number of ethical questions. To start, the current practice of transporting a majority of the county's bees en masse to California is concerning as the stress of transportation could affect the pollinators physiologically. Research on this subject shows that newly emerged bees had difficulties fully developing their food glands after they experience transportation, which could make it harder for them to nurse the next generation [35].

Effects on Native Pollinators (JO)

The practice of transporting honey bees large distances is not only harmful to the transported bees, but to the local ecosystem as well. Pathogen spillover from managed honey bee populations affects wild pollinators, such as bumblebees, and may contribute to a global decline in wild pollinators. One study revealed that the prevalence of deformed wing virus and the parasite *Nosema ceranae* is linked in honey bees and bumblebees and that honey bees are a likely source for at least one emerging infectious disease in wild pollinators [36].

Impact on Local Flora (JO)

Transported bee colonies can also impact the composition of local flora. A study on the pollinators of the invasive and native species of *Potentilla* shows how non-native

pollinators can affect local plant populations. This study showed that the native species of *Potentilla* was visited more frequently by native pollinators and the invasive species by non-native pollinators. Because of interactions like this, the introduction of a non-native pollinator to an ecosystem could lead to changes in the composition of that ecosystem [37].

The problems associated with honey bee transport make it clear that this practice could have detrimental effects on both the managed bee colonies as well as the ecosystems surrounding the almond groves to which they are transported. This raises ethical concerns about whether this causes more harm than good and makes it obvious that alternatives are quickly needed. Though this practice is currently necessary due to the considerable number of honey bees California's almond groves require for pollenation, interim measures to minimize this damage should be investigated. Perhaps there are better ways to transport honey bees or transportation could be minimized by raising them nearer to California.

Community Action: Promoting the Health of Local Bee Populations through Public Awareness (JO)

Because we are unable directly aid the honey bees responsible for pollinating California's almond trees due to distance, we decided that we should take steps to promote the health of local bee and pollinator populations.

A two-fold plan of community action to promote pollination by bees (JF):
1.Our first idea was to do an awareness campaign to encourage the general public to provide plants with nectar and pollen that would feed and attract bees and to eliminate potential pesticides that may negatively impact bee health and survival. In the summer of 2012, students Raman, Fantasia with Dr. Fagan developed a personalizable pledge to help protect native bee populations by planting pollinator attracting, native plant species and by limiting the dependence on chemical pesticides (in preparation). Their pledge, which was published on the Haycock Community Wildlife Habitat site Haycock survey: http://haycockwildlifehabitat.wordpress.com/page/2/ , read as follows:

- Plant pollinator attracting, native plant species / Use low maintenance flowering ground cover such as clover as an alternative to traditional turf grass
- Leave designated low traffic areas open for ground nesting bee species
- Encourage natural predators of local pests by providing suitable habitat (Birds, bats, predatory insects)
- Use mechanical/manual methods of weed management in order to limit destruction of plants beneficial to pollinators
  - Pulling weeds by hand or "weed whacking"
  - Preventative measures (mulching/sheeting flower beds and gardens, plants that provide shade and limit weed growth, overseeding lawns in fall to limit spring weed growth)
- Use only pest-specific/environmentally friendly controls for cases where certain pests become overwhelming
  - microbial insecticides
  - species specific pheromone traps

- Home Remedies (garlic/pepper sprays, insecticidal soaps, oils)
- Reduce use of high-nitrogen fertilizers to limit weed growth and soil dwelling pests in lawns/gardens, reduce contamination of groundwater
- Take preventative measures to avoid potential disease carrying insects such as mosquitos
  - staying inside during peak mosquito hours
  - protective netting/tents
  - wearing long clothing
  - natural, personal insect repellents
- Eliminate standing water on your property or treat with B.t. larval insecticides to reduce need for adult mosquito spraying
- Write to local Pest Control/Departments of Health concerning spray practices [38]

We decided to rework the survey to make it a bit shorter with less of a focus on the pesticides, and more of a focus on planting plants rich in nectar and pollen that would attract and sustain the bee population. The survey https://www.surveymonkey.com/s/7ZYTKQX is as follows:

- Plant bee attracting flowers in my yard
- Use microbial insecticides to control soil dwelling pests, if needed
- Reduce use of pesticides within garden
- Use eco-friendly weed barriers and/or mulches to keep weeds at bay
- Reduce use of fertilizers to limit growth of soil dwelling pests, weeds, and keep water clean
- Leave exposed earth in weedy areas for nesting bees
- Provide habitats for natural predators of insect pests (Bird houses, Bat houses, etc)
- How concerned are you (on a scale of 1-5) about the use of pesticides around you and the effects they have on the health of people and the environment?
- What kind of pesticides/pest control do you currently use or have used in the past year?
- What types of biological controls do you currently use/ have used to control insects in the past?
- Do you plant any native flowering species in your garden or flower beds?
- Are there any methods you have personally taken to limit pesticide use, and protect populations of beneficial pollinators, such as bees?

We posted it on Survey Monkey but realized that without an audience to view the survey, that it would have little or no impact. We then thought we could get exposure if we provided the survey to the National Wildlife Federation, a National organization with many daily viewers to their site with the that they could post it on their website. We tried on several occasions to contact Patrick Fitzgerald, a NWF employee that works with Community Wildlife Habitats by phone (202) 747-6821, but never got an answer. We then spoke with another NWF employee, Ms Grant (704) 438-6507. She said to send her what we wanted to do by email grant@nwf.org – and also to send it to Mr. mizejewski@nwf.org. We sent the following letter:

To Ms Grant/Mr. Mizejewski,

As you may already be aware, the bee population has been in decline for some years now. The prime cause is placed on Colony Collapse Disorder(CCD). While a cure or fix for CCD is still being researched, some action must be taken. Myself, along with my partner, Jon, and our Professor, Dr. Julie Fagan, have created a survey that could be used to both gauge peoples' awareness of the issue and give some ideas for people to use to help the current bee population. The survey is at https://www.surveymonkey.com/s/7ZYTKQX. However, we currently have no way to get the survey out to a large number of people. Compounding the problem is that even if the survey were to get out, the results would be collected on my Survey Monkey account. I may not be working with the project in a few years and so, I ask of you to use the survey in our stead. As you are a national organization, you would be far better suited to getting the survey out and better suited to using the information gained. I would be able to give the account information so that you may access the results you would gather.

Thank you,
Daniel Mercer, Rutgers Student

We also sent a letter to Ms Jones, a senior manager for campus ecology for the NWF. The letter is as follows:

To Ms Jones,

As you may already be aware, the bee population has been in decline for some years now. The prime cause is placed on Colony Collapse Disorder(CCD). While a cure or fix for CCD is still being
researched, some action must be taken. Myself, along with my partner, Jon, and our Professor, Dr. Julie Fagan, have created a survey that could be used to both gauge peoples' awareness of the issue and give some ideas for people to use to help the current bee population. The survey is at https://www.surveymonkey.com/s/7ZYTKQX, and I have transcribed it at the bottom of this letter. However, we currently have no way to get the survey out to a large number of people. Compounding the problem is that even if the survey were to get out, the results would be collected on my Survey Monkey account. I may not be working with the project in a few years and so, I ask of you to use the survey in our stead. As you are a national organization, you would be far better suited to getting the survey out and better suited to using the information gained. The survey could be made for use on your website. Perhaps you could incorporate the survey into your backyard habitat campaign. As an aside, are you aware of the Xerces Society? They are an organization centered on conserving invertebrates, including bees. They have their own pledge, which is follows: “To Bring Back the Pollinators, I will: 1. Grow a variety of bee-friendly flowers that bloom from spring through fall. 2. Protect and provide bee nests and caterpillar host plants. 3. Avoid using pesticides, especially insecticides. 4. Talk to my neighbors about the importance of pollinators and their habitat”. My survey is somewhat similar, yet more comprehensive. I would be able to give the account

information so that you may access the results you would gather, if you use the Survey Monkey site.

Thank you,
Daniel Mercer, Rutgers Student
The Survey is as follows:
Choose all that apply:

- Plant bee attracting flowers in my yard
- Use microbial insecticides to control soil dwelling pests, if needed
- Reduce use of pesticides within garden
- Use eco-friendly weed barriers and/or mulches to keep weeds at bay
- Reduce use of fertilizers to limit growth of soil dwelling pests, weeds, and keep water clean
- Leave exposed earth in weedy areas for nesting bees
- Provide habitats for natural predators of insect pests (Bird houses, Bat houses, etc)
- How concerned are you (on a scale of 1-5) about the use of pesticides around you and the effects they have on the health of people and the environment?
- What kind of pesticides/pest control do you currently use or have used in the past year?
- What types of biological controls do you currently use/ have used to control insects in the past?
- Do you plant any native flowering species in your garden or flower beds(Yes/No)?
- Are there any methods you have personally taken to limit pesticide use, and protect populations of beneficial pollinators, such as bees?

We suggested that they use our pledge as part of a massive promoting the bee population campaign during National Pollinator week June 16-23, 2014 http://pollinator.org/pollinator_week_2013.htm

To convince them to put it up on their website, we investigated further what information is currently available to the general public to promote pollinators. As it turns out, there is a great deal of information out there. The Xerces Society is an organization dedicated to the conservation of invertebrates, including bees. They have many programs involving the promotion of bees and raising awareness of the plight of the bees. There website can be found here: http://www.xerces.org/
They even have a 4-step pledge: http://www.xerces.org/pollinator-conservation/
http://www.xerces.org/pollinatorprotectionpledge/
There are also some really nice free downloadable brochures.
http://www.pollinator.org/nappc/brochures.htm
We have yet to hear back from the NWF.
2) Our 2nd approach to promoting the bee population, was writing letters to people to limit the intentional and unintentional transport of bees in North America and internationally. Transporting bees can unintentionally cause serious harm to the bees. It was found that bees end up severely stressed when transported. Stress can cause bees to experience behavioral changes, which ultimately leads to their deaths. It was also found

that non-native bees pollinated invasive species of plants in an area, which can disrupt the ecosystem [37].

One group of people could be those of the NAPPC(North American Pollinator Protection Campaign). Information about the campaign can be found here:
http://www.internationalpollinatorsinitiative.org/uploads/9-003.pdf
They have a section on:
"3. Bee Importation Issues
The Bee Importation Issues group will examine intentional and unintentional transport of bees
between countries. This Task Force will examine the implications of bee trafficking and the
policies needed to protect existing pollinating species in any given area. Increased pressure to
allow importation of exotic species such as Bombus terrestris requires that solid science and
policy work together to prevent serious unintended consequences." The task force found that the commercial importation of non-native bumble bees could have far-ranging consequences, as damages caused by invasive species during the last century has been estimated at over $137 billion in the U.S. alone. Based on their findings they recommended the continued prohibition on the importation of bees to North America from other continents (with the exception of the Western Honey Bee *Apis mellifera*) and the export of native North American bees to other continents.
The NAPPC has had several congressional briefings regarding many issues surrounding pollinators, including the limit of transportation of bees. We wrote a letter to them, which follows:
To Whom it May Concern:

As you are well aware, the transport of bees is incredibly disruptive for the insects. The transportation causes undue stress to be inflicted upon the bees, which leads to behavioral changes. These behavioral changes cause the bees to act inefficiently and ultimately die. This kind of stress is considered one of the leading causes of Colony Collapse Disorder. Thus, it is imperative that transporting bees be reduced or otherwise restricted. If it is within your power, get regulations established that stop the unnecessary transportation of bees.

Thank you,
Daniel Mercer, Rutgers Student

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(manuscript in preparation).

Letters to the Editor
DM Sent to the South Brunswick Post, ckim@centraljersey.com
To the Editor:
I am writing to you in an attempt to raise awareness of the problems associated with the decline of the bee populations. The populations of bees, especially honeybees, have been in decline for quite some time. This is mostly attributable to Colony Collapse Disorder and adverse weather conditions. Colony Collapse Disorder (CCD) is when a colony's bees suddenly abandon the hive, including the, usually, still living queen. CCD is found to be caused by a combination of parasites, viruses, and chemicals.
Due to the loss of bees, crop production as been harmed. Bees are responsible for a great percentage of the United States' production. Without large numbers of bees prices of crops, such as almonds, are increased to compensate for the farmer's increased cost to bring in out-of-region bees, which are used to enhance that farmer's personal bee populations.
Presently, a few alternatives are being used until a possible cure for CCD is found. One is the use of hand pollination, which is where brushes are used to emulate bee pollination. Crop dusting is also employed, in which planes dust the land with pollen. One of the alternatives on the horizon is the usage of a robotic bee. This robot bee would be programmed to do everything a bee is needed to do and would be used supplement existing bee populations.
One way people can help with this issue is to maintain gardens. Any help that can be given to the existing bee populations is help well deserved. Perhaps go and volunteer to clean up parks or help plant flowers.
Hopefully, a cure is found and the populations return to their fuller size. Until that time however, we must do what we can to aid the present bees to thrive.
Daniel Mercer
New Brunswick

(JO) Sent to the Targum, oped@dailytargum.com
http://www.dailytargum.com/opinion/letters_to_editor/community-responsible-for-promoting-health-of-local-bee-population/article_fdd88f12-bb9b-11e3-8623-0017a43b2370.html

To the Editor:
Each year, bees pollinate over $15 billion in crops and produce $150 million of honey in the U.S. alone. Bee pollination plays a vital role in the production of our food, but their populations have steadily declined worldwide and in the U.S. they are at their lowest point in 50 years.

One of the major reasons for this decline is the incidence of Colony Collapse Disorder (CCD) in which the worker bees disappear from a colony and leave behind unhatched

brood, food stores, and even the queen bee. Since 2006, when CCD began to appear, beekeepers have reported an average 30% loss of their colonies overwinter, an unusually high amount. Many factors have been associated with CCD, ranging from parasites to pathogens, but neonicotinoid insecticides are believed to be a major contributor. Research published by the Proceedings of the National Academy of Sciences in the United States of America showed that neonicotinoids weaken the immune system of bees and make them more susceptible to infections.

Much can be done by the community to promote the health of local bee populations. By refusing to purchase pesticides that use neonicotinoids we can send the message that these products are not acceptable. Should anyone need to use pesticides that do not contain neonicotinoids, they can minimize damage to local pollinator populations and the environment by practicing the Integrated Pest Management guidelines that are recommended by the EPA. Another excellent way to help is by contacting your representative to show support for the Save America's Pollinators Act which aims to suspend the use of several neonicotinoids until further research is completed by the EPA.

Jonathan Onulak