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Cover Page Footnote

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Factors Affecting Honey Bee (*Apis mellifera L.*) Health as Perceived by South Georgia Commercial Beekeepers

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Abstract. Honey bees (*Apis mellifera L.*) are critical to the pollination of many crops. Bee-oriented organizations survey beekeepers annually to gather information about colony loss and contributing factors. Unfortunately, these surveys provide insufficient data from sideliner and commercial beekeepers in Georgia. Through a survey to better understand South Georgia beekeepers' perceptions of honey bee health, this project engaged a previously underrepresented group of sideliner and commercial beekeepers.

INTRODUCTION

The phenomenon called Colony Collapse Disorder (CCD) became mainstream news in 2006 (National Pesticide Information Center, 2015); since then, researchers and beekeepers alike have been investigating issues that may be negatively affecting populations of *Apis mellifera* L.—honey bees. CCD and general colony loss are ultimately multifactorial issues stemming from a combination of pests and diseases, lack of diverse forage, and negative impacts from certain classes of pesticides. The main pests affecting honey bees are varroa mites, also known as *Varroa destructor* (Arachnida: Acari: Varroidae) and hereafter referred to as *Varroa* (Anderson & Trueman, 2000; Steinhauer et al., 2018). *Varroa* often feeds on the bee's fat body, which is a source of stored energy and contributes to the immune system (Ramsey et al., 2019). *Varroa* also carries viruses such a deformed wing virus, a virus that causes wing deformities and even death in honey bees (Gisder et al., 2009).

Multiple organizations have attempted to gather data from U.S. beekeepers concerning various aspects of colony loss and management decisions. Over the past five years, there have been relatively low response rates from commercial beekeepers in national beekeeping surveys, especially from the state of Georgia. For example, the Bee Informed Partnership (BIP) Management Survey collected 486 total responses from beekeepers in Georgia between 2015 and 2020 (BIP, 2020). Of those responses, only 20 were from commercial beekeepers and 25 were from sideliner beekeepers. This low response rate indicated a potential gap in important data, especially considering that commercial beekeepers manage most colonies in the United States and experience greater financial impacts due to colony loss and bee health.

According to the U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) data, there are 361 reported beekeeping operations and over 72,226 managed colonies in the Southeast, South Central, and Southwest USDA agricultural districts in the state of Georgia (Figure 1) (USDA, 2020). This statistic does not include the number of colonies from counties where data was withheld by NASS to avoid disclosing specific numbers for individual operations. The "South Georgia Attitudes and Outlooks on Bee Health and Pesticides: Sideliner to Commercial Scale" survey was intended to narrow the gap between the number of Georgia's sideliner and commercial beekeeper responses to the BIP's National Management Survey and the estimated number of beekeepers in South Georgia. For the purposes of this project, *sideliner* refers to a beekeeper with more than 50 colonies for whom beekeeping is not their main source of income. *Commercial* refers to a beekeeper who operates a sufficient number of colonies to serve as their main source of income.

The main objective of the commercial beekeeper survey was to capture data concerning their experiences with pesticide exposure and how they perceive various factors that can have a negative impact on honey bee health. This information will be used to inform future research and better target local Extension programming.

The survey developers had two key hypotheses: a) the number of responses from South Georgia sideliner and

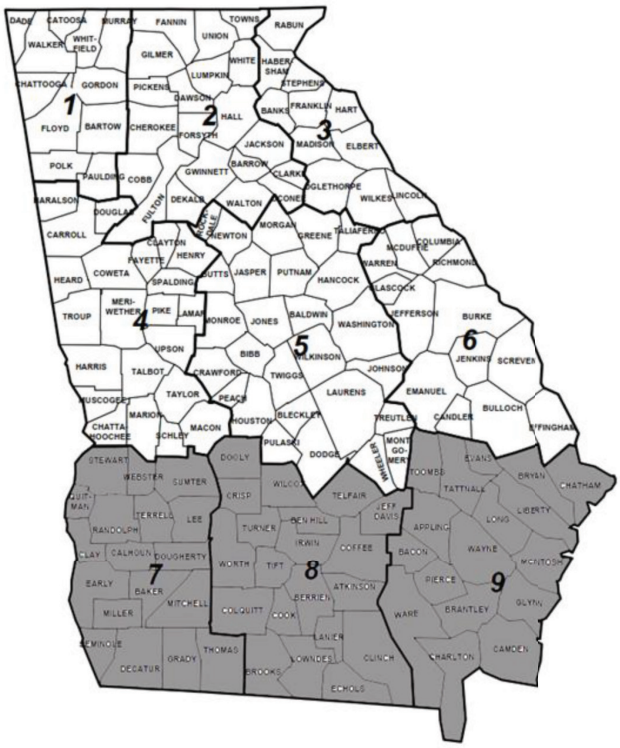

Figure 1. Southeast, South Central, and Southwest USDA Agricultural Districts in Georgia. Shaded regions denote the specified regions.

commercial beekeepers would exceed the total number of five-year responses from Georgia (25 and 20, respectively) reported in the BIP management survey; b) Survey responses would show that beekeepers consider *Varroa* to be a larger issue than pesticides in regards to colony losses.

MATERIALS AND METHODS

The survey, titled "South Georgia Attitudes and Outlooks on Bee Health and Pesticides: Sideliner to Commercial Scale," included questions about pesticide awareness, pesticide experiences, pesticide actions, pesticide outlook, and the relative rankings of the impact of *Varroa* against other factors in colony loss. Most questions were five-point Likert scales (1 = *strongly disagree*, 2 = *disagree*, 3 = *unsure*, 4 = *agree*, and 5 = *strongly agree*) or direct answer (i.e., *yes*, *no*, or *unsure*). The section addressing *Varroa* and other factors asked beekeepers to rank 14 factors that can have an impact on honey bee health from 1–14 (where 1 = *biggest impact on bee health* and 14 = *least impact on bee health*). The factors were:

- pesticides alone (defined as "insecticides, herbicides, and fungicides collectively"),
- adjuvants alone (defined as "substances added to a tank that will enhance the performance of the pesticide; these primarily include surfactants, activators, wetters, stickers, spreaders, etc."),
- pesticides and adjuvants acting together,
- *Varroa* mites,
- small hive beetle,
- Nosema,
- Israeli acute paralysis virus,
- other viruses or diseases,
- stress from hauling/relocation,
- not enough forage/habitat,
- low quality forage/habitat,
- poor queen quality,
- mite treatments, and
- other bee medications/treatments.

We initially distributed physical, paper copies of the survey to participants in a commercial beekeeping meeting in South Georgia and sent others to Extension offices for staff to distribute. Then, we converted the survey to an online format, using a Qualtrics survey that could be completed via computer or smartphone. This conversion allowed a wider audience to submit responses—especially because the link could be posted on popular social media pages focused on commercial beekeeping. We required online respondents to answer whether their beekeeping operation was located in the target agricultural districts of Georgia; responses from beekeepers outside the target areas were not incorporated into the analysis, as our interest was specific to perceptions of the agricultural landscape of South Georgia. Both paper surveys and online responses were anonymous and coded with sequential number identifiers as they were received.

Data analysis primarily focused on the rankings affecting bee health. In order to display the highest ranked factors for visual comparison on a bar graph, rankings were reversed from the maximum rank of 14 and averaged for each factor. For example, raw rankings of 1 became 14, 2 became 13, and so on. The reversal facilitated the graphic interpretation of factors that were ranked highly by beekeepers. The reversed rank will be referred to simply as "rank" hereafter. Rank data were analyzed using one-way ANOVA (unequal variance option) in JMP Pro 15. Means were compared using Tukey Kramer HSD option using alpha = 0.05. Other situations, such as whether they had experienced a bee kill due to pesticide applications or which efforts they took to limit pesticide exposure, were evaluated on a percentage basis.

RESULTS

There were 61 total surveys initiated, with 32 from the target areas in South Georgia. Of those, 29 were filled out to completion. Incomplete survey data are included in the figures, with total number of responses noted.

Beekeepers ranked *Varroa* as the most influential factor affecting bee health, with an average ranking of 13.07 out of 14; pesticides alone were the second-most influential, with a score of 11.77 out of 14 (Figure 2). A majority of South Georgia beekeepers indicated that they experienced slight or major bee health decline due to pesticide applications made by others (72.7%, n = 33) or experienced a minor or major bee kill due to pesticide applications made by others (75.8%, n = 33) (Figure 3). A majority reported moving hives prior to application to avoid such an event. Beekeepers often did not take other efforts to limit pesticide exposure (Table 1). Results showed that 32.3% of beekeepers either did not discuss pesticides and bee health with landowners or discussed it very little. Lastly, respondents self-reported the number of colonies for which they are responsible (Figure 4).

DISCUSSION

Results from the survey confirm that sideliner and commercial beekeepers in South Georgia perceive *Varroa* as a lead-

Table 1. Percent of Beekeepers (n=31) Taking Specific Actions to Prevent the Exposure of Honey Bees to Pesticides

Action	Moved hives prior to application	Made application in early morning or late evening	Specifically selected pesticides that are deemed safer for bees than others	Made efforts to prevent drift from sprays or dust from planting treated seeds
Count	26	7	5	5
Percent	83.9%	22.6%	16.1%	16.1%

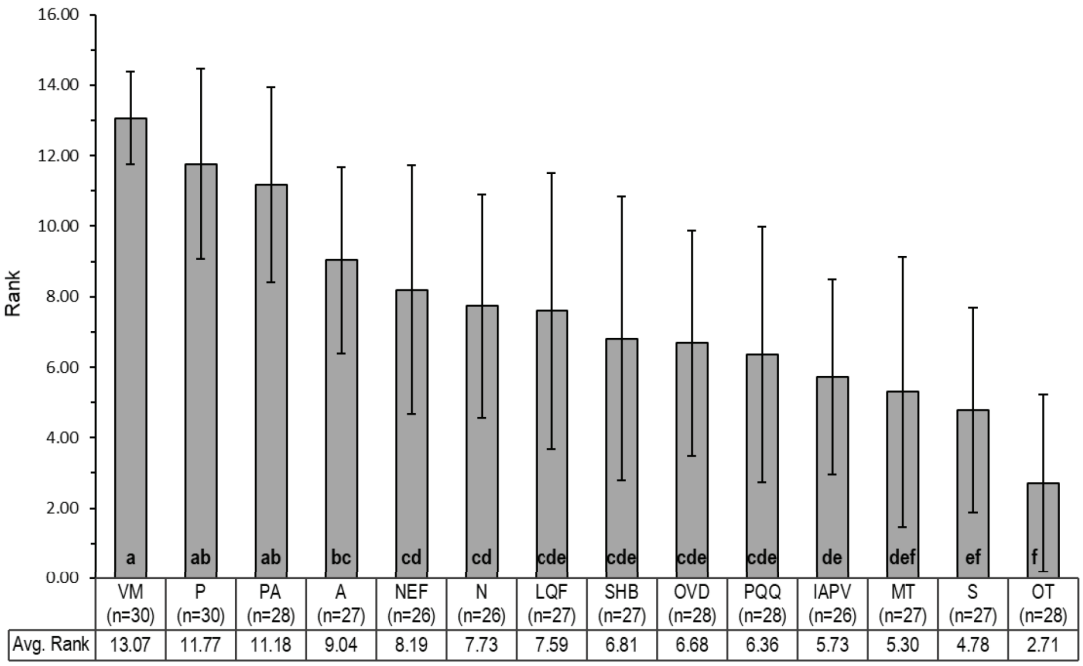

Figure 2. Average ranking (± SD) of the perceived impact of factors affecting bee health (higher rank signifies a greater perceived impact). VM = Varroa mites, P = pesticides alone, PA = pesticides and adjuvants acting together, A = adjuvants alone, NEF = not enough forage/habitat, N = nosema, LQF = low quality forage/habitat, SHB = small hive beetle, OVD = other viruses and diseases, PQQ = poor queen quality, IAPV = Israeli Acute Paralysis Virus, MT = mite treatments, S = stress from hauling/relocation, OT = Other bee medications/treatments.

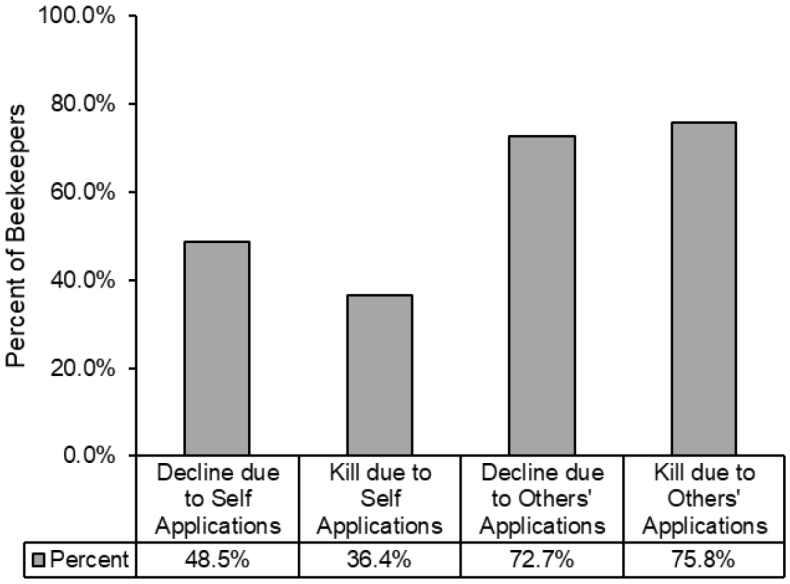

Figure 3. Percent of beekeepers reporting perceived health decline or bee kill due to pesticide applications by self or others.

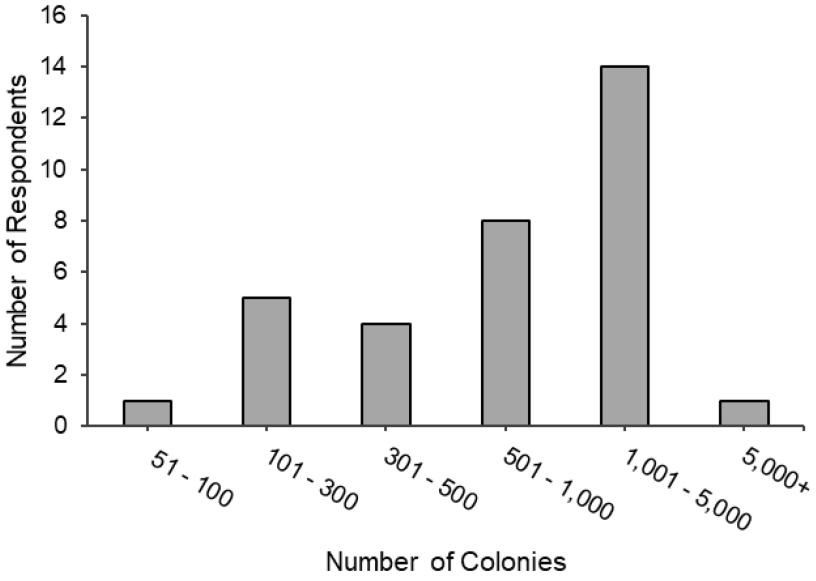

Figure 4. Number of colonies in South Georgia operated by survey respondents.

ing and major cause of bee health issues. Beekeepers also experience bee kills due to pesticides, likely due to the heavy agricultural presence in the counties from which responses were accepted. Increased communication between landowners and beekeepers may mitigate some pesticide exposure risk to honey bee colonies. This idea presents a much larger issue that may be limiting progress: even in situations where beekeepers may discuss honey bees and pesticide interactions with the landowner or crop grower, it may not be the same individual ultimately applying pesticides to the field or orchard. For example, an employee may be unaware of the potential risks of pesticides or the proper notification protocol prior to pesticide application. Additionally, growers' application schedules are variable—often based on weather—and short-notice pesticide applications do not always allow adequate time for beekeepers to act. Regardless of cause, these communication breakdowns can lead to unintended bee loss or health decline.

Distribution of the survey via social media allowed non-Georgia residents to respond. Although these respondents were not the target audience, researchers can use their data for future comparisons to South Georgia beekeepers. In the future, collecting survey responses from a larger sample may help solidify these results, further identify opportunities for improving communication between beekeepers and landowners, aid in recognizing the challenges unique to South Georgia beekeepers, and refine Extension programming efforts to better suit the needs of sideliner and commercial beekeepers. Finally, the authors would like to note that this level of response would not have been possible without the connections between county Extension agents and agricultural producers.

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