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Cover Page Footnote

The authors would like to acknowledge the Florida Department of Agriculture and Consumer Services (FDACS) for maintaining the beetle mass rearing program from 2014-2021. Additionally, Dr. Christopher Kerr for his work in initiating this program with Dr. Lester while working for the FDACS. Contact information: William Lester,* University of Florida Institute of Food and Agricultural Sciences Hernando County Extension 16110 Aviation Loop Dr, Brooksville, FL 34604 Emily Kraus,* UF/IFAS Pesticide Information Office 7922 NW 71st Street, Gainesville, FL 32608 Corresponding Author: William Lester wlester@ufl.edu *Authors contributed equally to this article

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A Citizen Science Approach to Assess Management of an Invasive Species

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Abstract. Citizen science allows for broadening the scope of research by increasing data points and geographical scale. Here, the Florida Department of Agriculture and Consumer Sciences (FDACS) and the University of Florida/IFAS Extension show that citizens utilized various outreach platforms to increase their knowledge of an invasive species the air potato vine, Dioscorea bulbifera, and its biological control agent the air potato beetle, Lilioceris cheni. Citizen scientists also contributed data on the distribution and establishment of the beetle, and reported on behavior change, and attitude toward the project. Valuable lessons were learned in designing surveys and training the citizens in order to increase the quality of their contributions.

INTRODUCTION

The air potato vine, Dioscorea bulbifera, is native to a wide range of locations in Africa, Asia, and Australia (Croxton et al., 2011) but is invasive in the southeastern United States. This climbing invader can outcompete native plants and reduce biodiversity. Management of this invasive species began with chemical and mechanical control (Wheeler et al., 2007). However, these methods were insufficient to stop the vine from spreading. In 2012, the air potato leaf beetle, Lilioceris cheni, was released for biological control in Florida only. Manrique et al. (2017) provide an excellent summary of the biology, discovery, and release of this agent. The air potato vine is now found in Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Texas (Kraus et al., 2021). The Florida Department of Agriculture and Consumer Sciences (FDACS), The University of Florida/IFAS Extension (UF/IFAS Extension), and the U. S. Department of Agriculture developed an online request program in 2014 to distribute beetles to Florida residents and land managers around the state. Subsequently, the online request program was extended to other states in the invaded region: Georgia (2015), Louisiana (2016), Texas (2017), Mississippi (2018), and Alabama (2018). While some reports indicated the establishment of the beetle in Florida (Overholt et al., 2016), there was little information available from outside of the state. Additionally, the beetle apparently had low overwintering success in the winter of 2015 to 2016. FDACS researchers noted a gap in understanding the establishment, distribution, and winter survival rates of the beetles.

A needs assessment performed in 2015 by UF/IFAS Extension (Gioeli, 2015) found that even though 99% of Florida residents felt that invasive air potato was a problem in Florida, only 40% of respondents considered themselves knowledgeable on management of the vine. Florida residents were largely unaware of how to properly identify the plant, apply integrated pest management (IPM) techniques to aid in its control, and assess the efficacy of their efforts. Additionally, this assessment found that people overwhelmingly preferred to get information on air potato management from UF/IFAS Extension, rather than the Florida Department of Agriculture and Consumer Services, social media, or the Internet. This showed an opportunity for educating residents about air potato identification and control, along with creating similar programs for other invasive organisms and their biological controls in the future.

Citizen science programs have been used to locate and monitor invasive species and pest threats in recent years (Aigner et al., 2014; Crall et al., 2006; O'Callaghan & Skelly, 2013). Previous work reports that having trained eyes monitoring the problem can reduce the likelihood of destruction by pests (O'Callaghan & Skelly, 2013). Having additional citizen scientists could increase knowledge about the efficacy of biological control agents and destruction of the invasive plant. This is only one of many benefits to involving the pub-

lic in monitoring invasive species and the presence of introduced biological control agents. Others include scientific and educational outcomes such as expanding the geographical area surveyed, answering research questions, fostering an understanding of the scientific process, and increasing public awareness (Gommerman & Monroe, 2012; Stofer, 2017).

METHODS

CREATION OF THE "AIR POTATO PATROL" CITIZEN SCIENCE GROUP

To better educate Florida residents about this invasive vine and how to manage it, a citizen science project, The Air Potato Patrol, was created. This program was created by Dr. William Lester (UF/IFAS Extension) and Dr. Chris Kerr (FDACS) and was launched in early June of 2017. This builds upon the suggestion by other authors that Extension and state agencies work together to increase public knowledge and to support community decision making (Clyde et al., 2018). Our initial objectives were to educate Florida residents on proper identification of the invasive air potato, use of an IPM strategy to control it, and identification and incorporation of the air potato beetle as a part of that IPM strategy. As the program progressed, it became important to evaluate the impact of the public education component and the public's perspective on the program as a whole.

Even though most citizen science programs do not require any specialized training, it is useful to improve the data collection skills of the volunteers (Bois et al., 2011). Previous research has suggested that standards of data quality and training must be addressed (Callaghan et al., 2019; Stofer, 2017). We sought to address these concerns in this project by encouraging residents to volunteer for the program, to complete video training on understanding the vine and beetle, and to provide survey data at their location from a "test plot." Test plots were self-determined by the volunteers. These were areas where they had previously noted the presence of the vine and were often on their own properties. In this paper, we present an evaluation of that educational approach.

A website (https://airpotatobeetle.com) was created. It included information on the program and a contact form where interested residents could volunteer after viewing five training videos. A 10-question survey used as a pre and posttest was incorporated into this virtual training. The survey was created in Qualtrics. Participants took it before and after they watched the five training videos to measure their knowledge gained. Topics included proper identification of air potato vines, common look-alike plants, and the biology and identification of the air potato leaf beetle. Participants were instructed on the capabilities of biological control agents, including the fact that these would not eradicate invasive pests on their own.

Blog posts (of which there were 18) were written to keep the volunteers updated on the biological control beetles. A Facebook page (https://www.facebook.com/AirPotatoPatrol) and Instagram channel (www.instagram.com/airpotatopatrol/) were also created to further disseminate information and to draw attention to the citizen science program. Using social media platforms for public education and engagement has proven especially valuable in Extension programming (Cornelisse et al., 2011). These media provide an opportunity to reach a broad audience, and they were especially useful during the pandemic when the surveys discussed in the results below and the Florida Department of Agriculture and Consumer Services fieldwork were ongoing.

CITIZEN SCIENTIST SURVEY DESIGNS

An ex post facto research design was implemented by using the citizen scientists' email contact information to send out an online questionnaire. The survey instrument Qualtrics was used to develop the surveys and assess the response. Annual satisfaction surveys were sent to participants to gauge the effectiveness of the training and support provided to volunteers. Our questionnaire consisted of two items on youth participation, five items related to how useful the training materials (YouTube videos, blog posts, and Facebook Group updates) were, one question on adoption of practice changes as a result of participation, and a question on herbicide use in controlling the vines, for a total of nine items. Participants were asked if any youth (their children, a school class, church group, etc.) had assisted with their data collection and, if so, how many. Overall satisfaction with program participation was measured using a 7-point Likert scale, ranging from *extremely useful* to *extremely useless*. For the practice changes adopted, space was included for text entries where participants could share three practices or actions they had adopted as a result of participating in the program. Participants were also asked if they had reduced their herbicide use on their air potato patches, if they had eliminated the plants, and if they had simply achieved a level of control over the plants.

The survey was sent to 566 current members in 2020 and 2021. Results were summarized using basic Qualtrics analysis tools and basic Excel summary statistics. No comparative analyses were performed.

A second set of surveys were generated through Qualtrics for biological assessments. The responses were grouped by zip code to determine where in the state the respondents' test plots were located. These questions included three on specific dates when the plants began growth in the spring or senesced in the fall; six on the presence, absence, or effectiveness of the biological control beetles; and two on the extent of vine coverage on the test plot. The citizen scientists used a 3-point Likert scale regarding their opinion on the production of air potato bulbils. They were also asked to estimate the

area covered by the vine and to indicate if they felt that the vines were crowding out the native vegetation.

These survey questions were generated to mimic data being collected across the state by FDACS employees who were performing field work on this plant-insect biological control system. The volunteers were given several weeks to collect their data and report the findings through Qualtrics. Using a citizen science approach allowed for broad geographical coverage and required less funding. These survey questions had two additional purposes. First, they were meant to address concerns voiced by the scientific community about knowledge gains, behavior changes, and effective changes (Stofer, 2017). Second, they were meant to build on previous work that has shown there can be psychological benefits related to helping the environment (Newberry & Israel, 2018).

RESULTS AND IMPACT

This program has been operating for 5 years, with most of the members having been involved since the beginning. The majority of the members are homeowners in Florida. However, as mentioned above, air potato is also present in other Gulf Coast states. Thus, the program was expanded to include volunteers in Georgia, Alabama, Louisiana, and Texas, as FDACS is permitted to ship the beetles to these states. The 15 volunteers outside of Florida have provided valuable survey data from areas that would otherwise have been out of the geographical scope of the fieldwork. From a public education standpoint, these long-term participants indicate that the information they learned from our program led to several positive impacts.

Between June 2017 and early 2022, 635 volunteers completed the training with a 58.0% mean knowledge gain (based on the pre/posttest survey), and the website has been visited over 20,000 times. The 428 email questions from volunteers were answered. The Facebook page that was created for the program (https://www.facebook.com/AirPotatoPatrol) currently has 476 page followers, and during 2022, page reach increased by 24.6%, indicating continued interest in the topic. Presentations on the program have been given at professional conferences in Texas and Tennessee and at a grower's workshop in Mobile, Alabama. The program has also been referenced in numerous outreach presentations and research presentations to the biological control community through William Lester.

Responses to the satisfaction surveys showed that 72.0% of respondents felt the training videos were useful and 81.0% felt the information helped them with identifying and obtaining air potato leaf beetle biological control; 83.0% indicated that they had decreased or eliminated their use of herbicide to control air potato by adopting IPM techniques demonstrated in the instructional videos. A small number (5.0%) of respondents felt that the program had led to a total eradication of air potato on their properties, and 36.0% indicated they had achieved some level of control as a long-term impact of participation.

This survey also revealed the citizen scientists had adopted behavior changes based on their training to reduce the population of the invasive species. Reported behavior changes included: gathering and disposing of the bulbils, showing patience in waiting for natural beetle populations to arrive, digging up the roots or tubers, using mechanical control in the form of cutting vines, and informing others in the community about both air potato vine and the air potato leaf beetles. When asked "How has being a member of this citizen science project benefited you?", they offered responses including increased utility of land, increased knowledge and resources on the subject, and observed decreases in vine density. Several respondents remarked that participation made them feel like they were making a difference in their communities.

Additionally, there were several responses that referred to a decrease in use of herbicides to manage the invasive plant and a decrease in insecticide use to allow beneficial insects to thrive. This suggests there was an overall decrease in use of pesticides among program participants.

The data request survey sent to participants in June of 2020 showed there were several indications that the air potato leaf beetle was contributing to overall vine management. Respondents (56.0%) noted they had air potato leaf beetle present in their test plots, and 81.5% noted that the number of bulbils produced were fewer than or the same as in the previous year. This reduction in propagule (bulbil) pressure is highly noteworthy, as the vine reproduces in its native range by producing bulbils. Although this is promising, 54.8% of respondents did not feel the beetles were effectively controlling the vine, while 45.2% felt they were. This is somewhat difficult to assess, as what one citizen considers "effectively controlling" may be different from another. Similar results were obtained from asking whether or not the vine was crowding out native species; 57.0% felt the vine was crowding out natives on their property, while 43.0% said it was not. This speaks to the highly variable nature of the vine, which FDACS scientists also noted. Only 2.2% of respondents saw beetles where there were no vines. This may align with the beetles' ability to search long distances for food and with their host-specific nature. They are generally only seen with the plant they were brought in to control.

The same survey enabled scientists at FDACS to compare their field data (from 2020) with that of respondents. Unfortunately, the dates provided by participants were approximate and were not given in a common format, complicating analysis. Most respondents saw vine growth initiation from March to May, and beetles arrived from April to July. Beetles were noted to leave sites from September to November, and

vines senesced from October to December. Additionally, the respondents confirmed that beetles were largely absent from October to January, with only 11.1% seeing beetles during this time. These responses were in line with what the FDACS scientists were finding in their own fieldwork. Collaboration between the agencies involved in this effort allowed the scope of and benefits from the Air Potato Patrol to be maximized. Combining the reach of UF/IFAS Extension, and its ability to harness online media, with the existing biological control program at FDACS created a larger reach and ability to assess outcomes than either organization would have achieved alone. The existing research program at FDACS provided a basis for the information needed, generation of appropriate survey questions, and a source of biological control agents. The wide reach and expertise of UF/IFAS Extension and its Extension agents provided an agency which has the trust of the public. This is vital when extending information on new programs about which citizens may be skeptical. Their resources for building online content facilitated media which could be accessed across the state and beyond.

CONCLUSION

The public was successfully engaged through the website, the training provided, and the social media (Facebook, Instagram, and blog post) components of this program. This project took place in part during the COVID-19 pandemic. The online approach allowed citizens to remain engaged with their community. This was a social benefit that could not have been anticipated. The use of these materials resulted in clear knowledge gain in the community. This was indicated through the large number of individuals who stated that the training was useful and that they had an improved ability to identify the organisms. The 2021 responses indicated in participants' own words that they had learned more on the topic. Additionally, evidence from the reported decreased use of pesticides, both herbicides and insecticides, demonstrated a more well-rounded IPM strategy in the community.

FDACS scientists iput hundreds of man hours into their concurrent field study, the goal of which was to determine the distribution of the invasive plant and the efficacy of the beetle. There are ways this program could be altered to benefit researchers and reduce these man hours. For example, if one goal of a field study were to assess distribution of beetles and efficacy of beetles across as biological control agents across the state, this citizen science approach could cover large areas at essentially no cost. The Air Potato Patrol citizen science program can therefore serve as a model to assess the establishment and efficacy of biological control agents wherever they are released. This could save vast amounts of research funds while educating the public on the impact of invasive species and the importance of native species.

While the responses appeared to correlate with the data collected by the state research group, there was some ambiguity in responses. In the future, the surveys will need to be set up to request more specific data rather than ranges of months or vague time frames. This was a drawback noted by Cohn (2008). Citizen scientists must be "trained to read instruments and provide actual numbers" or in this case be given a specific time frame and told to record presence or absence of beetles, and other data within that specific time frame, providing specific dates. That data could then be overlayed with their geographical data. Overall, this collaborative effort was a highly successful outreach program. The public was able to learn about an invasive species in their community from their homes during the pandemic. They were presented with identification tools and various management strategies with a focus on biological control. Survey responses correlated with the concurrent fieldwork but revealed the need for further structuring and training in detailed reporting. In the future, this model could be used to support research objectives, broadening the scope of field studies.

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