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Small Hive Beetle, *Aethina tumida*, in Africanized Honey Bees in Costa Rica: Sentinel Apiaries, Epidemiological Surveillance and Training Programs as Strategies for Early Detection or to Prevent Its Spread

Rafael A. Calderón-Fallas and Luis A. Sánchez-Chaves

Introduction

The small hive beetle (SHB), *Aethina tumida* Murray (Coleoptera: Nitidulidae), is a parasite and scavenger of honey bee (*Apis mellifera*) colonies endemic to sub-Saharan Africa (Hepburn & Radloff, 1998). It has become an invasive species with well-established populations in North America and Australia (Neumann & Ellis, 2008). In 1996, SHBs were discovered in colonies of European subspecies of honey bees in the southeastern USA (Elzen et al., 1999). SHBs cause considerable economic damage to apiculture in the USA (Hood, 2004; Neumann & Elzen, 2004) and Australia (Spiewok et al., 2007).

The SHB has been found in Africanized honey bee colonies in several countries of North and South America. It was detected in Mexico in October 2007 (Del Valle Molina, 2007; Neumann & Ellis, 2008), in Brazil 2016 (Al Toufailia et al., 2017), in Colombia in October 2020 (OIE, 2020c) and in Paraguay (OIE, 2022a) and Bolivia (OIE, 2022b) in May and June 2022, respectively.

In Central America, SHB was discovered in El Salvador in 2013 (OIE, 2013) and in Nicaragua in March 2014 (Calderón et al., 2015). In Nicaragua, SHB was confirmed in Africanized honey bee colonies located in San Juan del Sur, Department of Rivas (South of the country), about eight kilometers north of the border with Costa Rica, increasing the risk of invasion of this pest into bee hives in Costa Rica (Calderón et al., 2015).

Sentinel Apiaries

After the Bee Pathology Program of the Tropical Beekeeping Research Center (CINAT-UNA), confirmed the presence of the SHB in the Department of Rivas, Nicaragua, in March 2014 (Calderón et al., 2015), the National Animal Health Service (SENASA) of Costa Rica placed a "sentinel apiary" with four Africanized honey bee colonies in Santa Cecilia, La Cruz, province of Guanacaste, close to the border (about 20 kilometers from the border with Nicaragua: straight line distance). Because in La Cruz, Guanacaste the number of colonies is low, SENASA installed and monitored this sentinel apiary. Colonies were monitored visually by examining all individual frames, hive covers, and bottom boards (Neumann et al., 2013; Cornelissen & Neumann, 2018).

Sentinel apiaries are established in different contexts as early warning systems to alert of sanitary problems, in this case, to perform periodical SHB surveillance and maximize the likelihood of detection in an area nearby to a potential entry point, mainly close to international borders. Sentinel apiaries are recommended in risk areas, because early detection is crucial for the success of eradication efforts (Schäfer et al., 2019). Furthermore, the only known efficient attractants for adult SHBs are functional honey bee colonies. To identify the pest early and to investigate a new outbreak in detail, it is recommended to install sentinel apiaries, consist of fully functional queenright honey bee colonies, to attract and trap beetles in zones at risk of new introductions (Mutinelli, 2016). Apiary surveillance in temperate and subtropical zones should be reinforced from spring to autumn and all year long in tropical zones (Neumann et al., 2016).

SHBs were detected and confirmed in the sentinel apiary in August 2015 in Costa Rica, specifically in La Cruz, province of Guanacaste (11°6′0″ N, 85°25′0″ W). Only adult beetles were detected in the Africanized colonies (Calderón & Ramírez, 2018). Those colonies were immediately eliminated (burned), and movement was restricted to and from this region. The SHB most likely entered Costa Rica through natural dispersal from Nicaragua.

Epidemiological Surveillance

Cepero et al. (2014) state that surveillance and reporting are important practices for the early detection of exotic pests and

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diseases in order to maintain effective biosecurity control. In beekeeping, these activities involve adequate collection, analysis, and interpretation of information on the presence or absence of diseases and their effective reporting to competent authorities. Sentinel apiaries provide one of the tools for epidemiological surveillance.

After confirmation of the SHB in the north of the country, and given economic importance and biological significance, a sampling of the main beekeeping areas was conducted during the last years (2015–2022) to monitor the distribution and report the situation of the SHB in Africanized honey bee colonies in Costa Rica (Calderón & Ramírez, 2018; Arguedas et al., 2020). Such information is needed to the best time to act and to keep beekeepers informed.

A nationwide monitoring program carried out between 2015–2018 by the Bee Pathology Program (Laboratory) (CINAT-UNA), with the inspection of 476 colonies in 77 apiaries located in the provinces of Guanacaste, Puntarenas, Alajuela, San José and Heredia (five of the seven provinces of the country), confirmed that SHB, remained restricted to the original detection site (Calderón & Ramírez, 2018). Colonies were monitored visually by examining all individual frames, hive covers, and bottom boards (Neumann et al., 2013; Cornelissen & Neumann, 2018).

Furthermore, two Cutts Beetle Blaster® traps were placed per colony, for eight to 15 days, with 25 ml of vegetable oil as a killing agent. These traps were placed inside the bee hives between two frame top bars in the bottom chambers. The content of the traps was examined for beetles at the Bee Pathology Lab. According to Neumann et al. (2016) specialized laboratories are required to confirm or reject the presence of SHBs. This holds especially true for eggs and larvae, which cannot be assigned to SHB based on morphometrics alone. In addition, 10 colonies (swarms) located in trees or houses in urban areas in the provinces of Heredia and Cartago (Central Valley) captured by beekeepers and transferred to Langstroth hives, were also monitored.

The SHB detection in Nicaragua and then in Costa Rica, as described, allows us to consider two significant points. First, once the SHB spreads within a country (as occurred in Nicaragua), the invasion to border countries becomes a recurrent threat, carefully positioned sentinel apiaries are useful to achieve early detection of the invader. Second, the adoption of timely confinement measures, such as restricting colony movement in areas with low colony densities, as was the case in North-West (La Cruz, province of Guanacaste) Costa Rica, are effective to prevent or slow SHB dispersal (Calderón & Ramírez, 2018). A protection zone should be installed immediately to limit further spread (at least within a 10 km radius), including a strict ban of movements of bees and beekeeping equipment, because migratory beekeeping poses a highest risk of the SHB spreading (Neumann & Elzen, 2004).

In September 2018, adult SHBs were found in a honey bee swarm located in Heredia-Central Valley in the middle of the country (about 265 km south from the first detection site) (Calderón & Ramírez, 2019). Because no intensive beekeeping is practiced at the focal point of detection in the Central Valley, and this place is located nearby an important fruit distribution center that receives fruits from all over Costa Rica, including Guanacaste, Calderón and Ramírez (2019) hypothesized that the SHBs found in the Central Valley could have arrived in fruit transported into the facility from Guanacaste. SHBs are able to reproduce on fruits and other food in the laboratory and in semi-field assays (Ellis et al., 2002; Buchholz et al., 2008). Nevertheless, field surveys were not able to confirm, any association of SHB with alternative food sources outside social bee colonies (Mutinelli et al., 2015).

No other reports of the SHB in central parts of the country have occurred since then. However, in October 2019, the SHB was confirmed in a commercial apiary in Liberia, province of Guanacaste, approximately 25 km south from the initial point of detection in the country (Arguedas et al., 2020).

Nowadays, the SHB has been found in different commercial apiaries, especially in the province of Guanacaste, approximately 100 km southwest from the initial point of detection in the country. Definitely, continuous epidemiological surveillance is necessary to prevent the further spread of adult SHBs. Apicultural trade and migratory beekeeping activities, abandoned or registered apiaries, as well as possible infestations of wild host populations, should be considered (Neumann et al., 2016).

Training Programs

After the confirmation of the SHB in August 2015 in Costa Rica, training programs were directed to technicians and beekeepers focused on SHB recognition and identification, the importance of early detection, the potential impact on beekeeping and methods for colony inspection. These programs included workshops, fieldwork and training materials flyers and brochures with images illustrating different stages of the life cycle to facilitate SHB recognition and identification. Beekeepers should be able to recognize the SHB infestations via adult and larval morphology as well as clinical signs at the colony level (Neumann et al., 2016). Training activities have been conducted at the main beekeeping areas of the country. All stakeholders, in particular beekeepers, should be provided with information on how to access tools and guidelines that enable recognition of new infestations (Schafer et al., 2019). At this time, the SHB has been reported in collaboration with trained beekeepers in different commercial apiaries in the province of Guanacaste.

SHB Threats to Native Stingless Bee Species

In addition to the threats that the SHB represents for honey bee colonies, it is also a potential hazard to native stingless bees (Hymenoptera: Apidae: Tribe Meliponini) (Peña et al., 2014; Pereira et al., 2021) and bumble bees (*Bombus* sp.) (Ambrose et al., 2000), as well as native solitary bees (Gonthier et al., 2019). Stingless bee species account for about half of the pollinators of native tropical plants, and provide pollination to different crops (Camargo, 2013). The SHB has been found to infest commercial colonies of bumble bees *(Bombus impatiens)* (Spiewok & Neumann, 2006; Hoffmann et al., 2008), managed hives of Australian stingless bees (*Austroplebeia australis*) (Halcroft et al., 2011), *Melipona beecheii* (Peña et al., 2014; Hernández-Torres et al., 2021) and *Tetragonula carbonaria* (Greco et al., 2010). In Costa Rica, there are more than 50 species of stingless bees, *Melipona* (jicotes) and *Tetragonisca* (mariolas), the most used by meliponiculturists (stingless bee keepers) (Aguilar et al., 2013). There is now significant concern that the SHB will infest native bees. The SHB has not been found in stingless bee colonies in the country to date, but systematic inspection of such colonies has not been conducted. In a preliminary monitoring, 10 colonies of the stingless bee *M. beecheii* located

near the first point of detection in La Cruz, province of Guanacaste were inspected visually by checking inside the colonies, and no SHBs or signs of infestation were found (Calderón & Sánchez, 2021).

Considering that meliponiculture is an activity that is carried out in different regions of Costa Rica, Aguilar et al. (2013), recommend to establish a SHB surveillance, in order to detect or rule out its presence in native stingless bee colonies. The aim of surveillance must provide evidence of the presence or absence of the SHB in native bees. Furthermore, training programs should be directed to meliponiculturists on SHB identification, and the potential impact on stingless bees. The potential impact of this pest for native stingless bees should be evaluated to know if it represents a real threat or danger for the survival of their populations.

Conclusions

The Costa Rican case with Africanized honey bees strongly supports the notion that by implementing sentinel apiaries for continued surveillance, a degree of containment and deceleration of the invasion could be attained. The fact that, SHB was detected at the established sentinel apiary near the border with Nicaragua provided a better grasp of the dynamics at the early stages of the invasion process. Implemented with measures to restrict the movement of colonies in, and out of the region, may pay off in terms of slowing down SHB spread and allowing for the tracking of the invasion, anticipating SHB movements. Nevertheless, the fact that SHBs were found associated with a honey bee swarm in the Central Valley three years after the first report illustrates that this approach is not devoid of gaps, and that we may be underestimating the potential of the SHB to be transported by alternative means, or associated with other types of incoming freight, originating in or nearby the areas of early detection. In addition, training programs directed to beekeepers, seem to play an invaluable role in the success of early detection or to prevent SHB spread, as illustrated by the case in Africanized bees in Costa Rica.

In conclusion, implementing strategies for the early detection of the SHB as it spreads to new countries or areas requires, as illustrated by the case in Costa Rica, implementing sentinel apiaries, the development of epidemiological surveillance, and the development of training activities for technicians and beekeepers to aid in SHB recognition.

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