ARTICLES

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Adverse Reactions to the Tawny Crazy Ant (*Nylanderia fulva*) by Komodo Dragons (*Varanus komodoensis*) at the Jacksonville Zoo and Gardens

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Abstract-The tawny crazy ant (*Nylanderia fulva*) is an invasive species that has been introduced to the United States and is now most prevalent in the state of Florida. Known for their large colony sizes and the damaging effects they can have on agriculture, electrical equipment and wildlife, *N. fulva* has become a pest for humans and other animals in many different environments including zoological parks. In this article, some interesting interactions between *N. fulva* and Komodo dragons (*Varanus komodoensis*) housed at the Jacksonville Zoo and Gardens are explored, specifically the behavioral response of *V. komodoensis* to the ant's formic acid-spraying mode of defense.

Introduction

Creating complex habitats has become a major focus of zoological parks in the past decade to promote animal welfare and wellness (Nolen, 2002). In the southeastern United States, a milder climate allows zoos to build a variety of outdoor enclosures that promote natural behaviors in tropical and subtropical species. However, open, outdoor habitats also come with their own set of unique challenges. For example, the Southeastern U.S. is home to many native and introduced species that pose potential threats to collection animals in a zoological setting. At the Jacksonville Zoo and Gardens in northeastern Florida, predators such as raccoons, otters, foxes, rats, snapping turtles, snakes, herons, and vultures have been documented wounding, fatally injuring or predating collection animals. Disease transmission from raccoons, feral cats, and rodents is another potential hazard for some collection animals. Additionally, mitigating invertebrate pest species such as cockroaches and ants in and surrounding animals' enclosures is an ongoing and ever-evolving challenge.

The tawny crazy ant (*Nylanderia fulva)* is an introduced, invasive South American species that has persisted in the southeastern United States for several decades (Trager, 1984) and now occurs in 27 counties in the state of Florida (Oi *et al*., 2016). Due to its extremely large colony sizes, usually with multiple queens and a footprint that can span entire neighborhoods, this insect can be very difficult to control (Sharma *et al*., 2014). Although *N. fulva* lacks a stinger, it is a formidable opponent to other insects such as the fire ant (*Solenopsis invicta*) by using its own venom, which is formic acid-based (Touchard *et al*., 2016), to detoxify itself after sustaining a sting from *S. invicta* (LeBrun *et al*., 2014). Instead of being injected through a stinger, the formic acid is sprayed and then spread over its body for defense (LeBrun *et al*., 2014).

The Jacksonville Zoo and Gardens is currently home to a large *N. fulva* population. Although they are

found throughout the zoo's 100+ acres (ca. 40 ha), their highest concentration occurs at the southernmost end of the park, particularly in the Asia section, which includes exhibits for Komodo dragons (*Varanus komodoensis*) and various bird and mammal species including, but not limited to rhinoceros hornbills (*Buceros rhinoceros)*, Babirusa (*Babyrousa celebensis*) and Sumatran tigers (*Panthera tigris sumatrae*).

While physically harmless to humans, *N. fulva* can be a pest to zoo guests and staff; when standing still in areas of high concentration, the ants will begin to crawl up and onto peoples' shoes and legs. *Nylanderia fulva* have also shorted out various types of electrical equipment on zoo grounds including fire alarm beacons and digital photo booths. Modifications have been made to how keepers present food items to certain animals, so that ants do not swarm and cover food before it can be consumed. Although previously just a persistent pest to humans at the zoo, here I describe observations that suggest that *N. fulva* may be causing adverse reactions and behavioral changes in a group of *V. komodoensis*.

Observations and Results

The Komodo dragon exhibit complex at the Jacksonville Zoo and Gardens is comprised of two habitats on public display including an indoor and outdoor exhibit (Fig. 1), and several off-exhibit areas including an outdoor holding yard and three indoor holding stalls. All habitats and holding areas feature a sandy soil substrate, various natural furnishings including dead fall tree trunks and live plants, as well as large plastic corrugated tubing for refuge in off-exhibit areas. The complex currently houses three *V. komodoensis* including a 17-year-old male (M1), a 9-year-old male (M2), and a 7-year-old female (F1). Animals are housed individually and rotated through these areas on a daily basis, with some exceptions that are discussed below.

Nylanderia fulva colonies are known to have explosive population booms, followed by an eventual reduction in numbers and disappearances from areas altogether (Sharma *et al*., 2014). In the summer of 2018, the *N. fulva* colony near the *V. komodoensis* exhibit complex seemed to be more prominent than in years' past. As is routine during scheduled public feedings for the *V. komodoensis*, the dragons are shifted off-exhibit while their food is scattered on the ground throughout their habitat for them to find, providing natural foraging opportunities while also showcasing their acute sense of smell to zoo guests.

In early July 2018, M2 was observed approaching a food item (a chick) that was placed along the edge of the outdoor exhibit's pool closest to the viewing window (Fig. 2), but when opening his mouth to pick up the item, he became hesitant, drew his head back, and held his mouth open in a gagging-like reaction (Fig. 3). After several minutes, he eventually picked up the item and consumed it without issue. As the summer progressed, herpetology staff noticed other adverse and/or distressed behaviors in this male as well as in M1 once feedings had commenced. After walking and tongue-flicking through the narrow strip of land between the interior exhibit viewing window and the edge of the exhibit pool (Fig. 2.), both dragons would suddenly begin to display signs of agitation (tail-curling) followed by a

Fig. 1. View of outdoor *Varanus komodoensis* exhibit at the Jacksonville Zoo and Gardens.

Fig. 2. Location of exhibit where negative interactions were observed.

Fig. 3. Gagging response observed in *V. komodoensis* after tongue-flicking a prey item that had been swarmed with *Nylanderia fulva*.

burst of full-speed sprinting around the exhibit (Fig. 4). Episodes lasted from a few seconds to several minutes in duration. Staff also observed a general avoidance of this area, especially by M1. Although he would initially tongue-flick and approach the area, he would eventually back up and turn around.

Fig. 4. *Varanus komodoensis* sprinting across exhibit in response to negative stimuli.

Herpetology staff noticed that the area in which the *V. komodoensis* were avoiding had substantial clusters and trails of *N. fulva* leading through it (Fig. 5.). This trail also led directly out into the guest area, where ants are regularly observed in large numbers on the ground directly below the exhibit viewing windows.

Following a winter dormancy, we began to see increased activity from *N. fulva* as daily temperatures increased in the spring of 2019, and in early April we observed a minor adverse reaction in M1 during a feeding event. That summer proved to be much milder than the previous year, with ants visibly lower in numbers on both the exhibit and guest sides of the Komodo habitat, although mild ant reactions were still observed during and after feedings. It is unclear what has caused the reduced numbers; however, observations of *N. fulva* in other areas of the zoo have increased.

Discussion

Nylanderia fulva are encountered in all exhibits and holding areas of the *V. komodoensis* building, but adverse reactions have only been observed in the outdoor exhibit. In the presence of a food source, *N. fulva* are naturally attracted to, and swarm the area. It is hypothesized that when a large disturbance such as a *V. komodoensis* walks through an area with a food item that has attracted *N. fulva* or an area where a food item had previously been located, the ants defensively release their formic acid into the air. The formic acid is then picked up by *V. komodoensis* through olfaction, subsequently causing discomfort and adverse reactions.

Fig. 5. Abundance of *N. fulva* near the site of the observed interactions, leading in and out of the *V. komodoensis* exhibit

Since the concentration of ants in this area is greatest, the formic acid released when the ants are disturbed may be more abundant and concentrated.

Historically, our female *V. komodoensis*, who due to her smaller size has only been given limited supervised access to the open-top outdoor exhibit, had not exhibited any adverse reactions. However, with her increase in body size, she has recently been given more frequent access to this area and for longer periods of time. In September 2019 and March 2020, mild ant reactions were observed in F1 in the form of tail curling and slight mouth-gaping after tongue-flicking. In order to confirm that these adverse reactions in *V. komodoensis* are associated with *N. fulva*, we are hoping to increase our observations during non-feeding times and perhaps even initiate a study to determine the potential concentration of formic acid and *N. fulva* in the immediate area.

The Jacksonville Zoo and Gardens' herpetology staff and pest-control specialist have experimented with several chemical and natural management techniques to control *N. fulva.* In guest and non-animal areas we have tried InVict Blitz™ ant granules, Talstar® P professional insecticide, Suspend® SC Insecticide, Eco PCO® D-X Dust, MaxForce® Ant Bait gel, and Advion® Ant Bait Gel, whereas in animal habitats and holding areas, we have tried hot soapy water, cinnamon powder, cinnamon water, lemon juice, vinegar, baby powder and dish soap. Although a decrease of ants is typically seen after administering these treatments, within a few days the ants have usually returned to their normal numbers. Continued integrated pest management will be implemented.

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