Preliminary Notes on the Use of the Predatory Soil Mite *Stratiolaelaps scimitus* (Acari: Laelapidae) as a Biological Control Agent for Acariasis in Lizards

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Abstract: While commonly employed by the agricultural and horticultural industries, biological control has rarely been utilized in herpetological husbandry to treat infectious or parasitic diseases. This case study describes the use of the predatory soil mite *Stratiolaelaps scimitus* to treat parasitic mite infestations in two adult inland bearded dragons (*Pogona vitticeps*). *Stratiolaelaps scimitus* applied directly to the existing terrarium substrate appeared to have eliminated all traces of parasitic mite infestation in both lizards within 5 days. These results, although preliminary, highlight the potential utility of predatory mites and other biological control agents in the husbandry and veterinary management of reptiles in captivity.

Key Words: Acariasis, biological control, *Hypoaspis miles*, lizards, predatory mites, *Stratiolaelaps scimitus*.

Introduction

Hematophagic and lymphophagic mites are common parasites of reptiles in captivity, where they can spread rapidly through a collection and be difficult to eradicate completely (DeNardo and Wozniak, 1997; Wozniak and DeNardo, 2000; Fitzgerald and Vera, 2006; Schilliger *et al.*, 2013). Current treatments for acariasis in reptiles typically rely on the use of chemotherapeutics, the safety of which may be questionable or poorly understood (DeNardo and Wozniak, 1997; Wozniak and DeNardo, 2000; Fitzgerald and Vera, 2006; Schilliger *et al.*, 2013). Mader (1996) remarked that a completely safe and effective treatment for reptile mites was lacking, illustrating the importance and need for novel and innovative strategies for managing this disease.

Biological control, the use of living organisms to combat pest species, has widely been used by the agricultural and horticultural industries for several decades as an alternative to chemical pesticides (Tjamos *et al.*, 1992; Vincent *et al.*, 2007). Although Rotter (1963) first described using the predatory mite *Cheyletus eruditus* to successfully treat snake mite *Ophionyssus natricis* infestations in captive monitor lizards (*Varanus* sp.) more than 50 yr ago, the potential for biological control in herpetological husbandry has only recently received attention (Fitzgerald and Vera, 2006; Morel *et al.*, 2013; Schilliger *et al.*, 2013). The following case study presents preliminary data and observations on the use of the predatory soil mite *Stratiolaelaps scimitus* in treating parasitic mite infestations in a private lizard collection. Also discussed are the potential advantages that predatory soil mites may have over conventional chemotherapeutic treatments as well as the role that biological control can serve in the husbandry and veterinary management of reptiles in captivity.

Case Report

A sexual pair of adult inland bearded dragons (*Pogona vitticeps*) was acquired by a private keeper in 2007. The female (18.3 cm snout–vent length [SVL]; 265 g) was received in August 2007 while the male (15.2 cm SVL; 168 g) was purchased at a reptile exposition in early December 2007. No quarantine period was implemented for the newly acquired male, which was immediately introduced into the female's glass terrarium (51 cm × 51 cm × 36 cm [L × W × H]). The terrarium was furnished with oak limbs, driftwood, virgin cork bark, and rinsed play-sand as substrate.

In late December 2007, approximately 30 days after the pair's introduction, the male became lethargic, lost its appetite, and exhibited noticeable weight loss. Upon closer physical examination, it was discovered that the male had a total of 67 red, parasitic mites (presumptively belonging to the family Trombiculidae, although proper taxonomic identification was not made) embedded beneath the scales on his abdomen, upper forelimbs, and gular region as well as around the tympanic recesses, eyes, and nostrils. The female was also afflicted but had far fewer mites than did the male ($n = 8$) and her appetite, weight, and activity levels remained unchanged.

Choosing not to employ conventional permethrin-based acaricides, a 1-L culture of approximately 15,000 predatory soil mites (*Stratiolaelaps scimitus* [advertised as *Hypoaspis miles*; see discussion]) was purchased from an online biological control supplier on 11 January 2008. In preparation of their delivery, all terrarium furnishings, except for the substrate, were discarded. The sand substrate was slightly dampened and the basking light was turned off, reducing the ambient temperature within the terrarium to 22°C (71.6°F) to prevent the *S. scimitus* from possibly overheating, as temperatures of 32°C (89.6°F) and above have been shown to disrupt its lifecycle (Wright and Chambers, 1994). The *S. scimitus* arrived packaged within a substrate of moist peat and vermiculite, which was then evenly distributed atop the sand substrate in the terrarium, forming a layer 0.6–1.3 cm deep. The substrate was gently misted twice daily to maintain its moisture. Both *P. vitticeps* were maintained atop this substrate for the duration of their treatment and were inspected daily for progress and changes in physical condition.

Immediately after the culture's introduction to the terrarium, *S. scimitus* could be seen active on the surface of the substrate. After 24 h, there was an 18% reduction in the number of parasitic mites on the male *P. vitticeps* and the female no longer showed signs of infestation. After 48 h, only five mites remained on the male, which were completely eradicated by the fifth day. By this time, both animals were feeding normally on mixed greens and crickets, even in the absence of a basking lamp.

On 22 January 2008, only six live *S. scimitus* were seen active on the substrate; by 24 January 2008, no live *S. scimitus* could be detected and were presumed to have died off in the absence of available prey. No signs of bodily injury or irritation from the *S. scimitus* were found on either lizard and, after nearly a month free of infestation, both *P. vitticeps* were transferred to a larger terrarium with new substrate and furnishings on 22 February 2008. Feeding patterns, activity, and general behavior in both animals continued to remain normal, and no recurrences of acariasis have occurred.

Discussion

Given its polyphagus predatory diet and widespread availability, *S. scimitus* makes an ideal candidate for testing the utility of biological control agents in herpetological husbandry. While the small sample size (n = 2) and lack of a control in the present study are limiting, and further testing involving a targeted parasite species, larger sample sizes, and multiple lizard species are needed, it appears that *S. scimitus* can safely be used as a treatment for parasitic mite infestations in captive lizards. When compared to current treatments for acariasis in reptiles, predatory soil mites such as *S. scimitus* may offer many advantages over chemotherapeutics and deserve further exploration.

Stratiolaelaps scimitus is widely cultured within the agricultural industries of North America, South America, Europe, and Australia for controlling a myriad of invertebrate plant and fungal pests including sciarid fly larvae (Lind and Chambers, 1993; Wright and Chambers, 1994; Ali *et al.*, 1999; Cabrera *et al.*, 2005; Freire *et al.*, 2007; Castilho *et al.*, 2009), enchytraeid oligochaetes (Cabrera *et al.*, 2005), acarid mites (Wright and Chambers, 1994; Cabrera *et al.*, 2005), phytoseiid mites (Messelink and van Holstein-Saj, 2011), and dermanyssid mites (Lesna *et al.*, 2012; Tuovinen, 2013). Cultures of *S. scimitus* are available year-round through many biological control suppliers, although they are commonly advertised under the junior synonym *Hypoaspis miles*. Cultures of *S. scimitus* are comparably priced to commercially available chemotherapeutics such as aerosolized permethrin sprays; smaller cultures, which are probably more appropriate for single applications than the size chosen for this study, are also available. Alternatively, *S. scimitus* can also be cultured in the laboratory (Wright and Chambers, 1994; Steiner *et al.*, 1999; Freire and de Moraes, 2007), making it possible for veterinary clinics, zoos, and possibly even reptile dealers and large-scale breeders to maintain their own colonies for episodic treatment of infected individuals; the practicality of doing so, however, remains to be seen.

Safety and toxicity are important factors to consider when developing and selecting treatments for any clinical disease. Because several acaricides have shown some levels of toxicity in reptiles (Boyer, 1992, 1995; Mader, 1996; DeNardo and Wozniak, 1997; Wozniak and DeNardo, 2000; Burridge *et al.*, 2002; Fitzgerald and Vera, 2006), and the safety and long-term health effects of others have yet to be studied (Fitzgerald and Vera, 2006), one of the most appealing aspects of *S. scimitus* is its apparent lack of toxicity or danger to the patient. Neither lizard in this study exhibited signs of discomfort, irritation, or physical damage caused by the predatory mites, and it seems that once their food supply disappeared, the *S. scimitus* simply died off.

With allegedly 15,000 adult *S. scimitus* in the culture, a perplexing question raised is why did it take several days for only 70 parasitic mites to be consumed? Several factors may have been responsible. First, shipping live mites to the mid-Atlantic United States (Baltimore, Maryland) in a non-insulated cardboard box during subfreezing weather in January might have killed off a large number of the *S. scimitus*, resulting in a dramatically reduced final count. Although Wright and Chambers (1994) noted that adult *S. scimitus* can survive exposure to temperatures of 10°C (50°F) in the laboratory, it is unknown how low a threshold they can withstand and whether subfreezing temperatures are lethal. Given that newly emerged adult *S. scimitus* can survive an average of 24 days without ever feeding (Wright and Chambers, 1994), and the fact that all *S. scimitus* in the present study appeared to have died off within 2 wk of their receipt, the author speculates that the culture received was not healthy or the predatory mites' environmental needs (i.e., temperature, humidity) were not properly met. It is also plausible that most of the remaining *S. scimitus* took advantage of the food source that came premixed in with the peat and vermiculite substrate rather than the mites on the lizards. This food source, unidentified by the supplier but probably the flour mite (*Acarus siro*) given its common usage in *S. scimitus* culturing (Wright and Chambers, 1994), may have been more abundant, accessible, and of a more-appropriate size for the *S. scimitus* than were the parasitic mites living on the lizards, up off of the substrate.

In their discussion of treatments for acariasis in reptiles, Fitzgerald and Vera (2006) stressed that "any treatment plan that only deals with mites on the host and not the surrounding environment is doomed to failure." At less than 1 mm in length as adults, another benefit of *S. scimitus* is that they are capable of penetrating narrow cracks, holes, and fissures in wood and rock that may harbor parasitic mite eggs, larvae, nymphs, or adults. Therefore, even though terrarium furnishings were removed during treatment in the present study, such removal and subsequent disinfection may not be necessary with *S. scimitus* applications. Although it was not tested in the present study, care should be taken not to introduce *S. scimitus* to reptile enclosures that have been treated in the past with acaricides or insecticides, such as permethrin sprays, as residues from chemical agents may prove lethal to *S. scimitus* or reduce their efficacy (Cabrera *et al.*, 2004).

Unlike many chemotherapeutic treatments that require multiple applications spaced out over several weeks or months due to their inability to target all mite life stages (DeNardo and Wozniak, 1997), it is possible, given their very catholic predatory diets which include the eggs, larvae, and adults of many invertebrate species including mites (Wright and Chambers, 1994; Enkegaard *et al.*, 1997; Cabrera *et al.*, 2005), that *S. scimitus* is capable of feeding on all life stages of mites. Moreover, the 142 day longevity of adult *S. scimitus* when in the presence of food (Wright and Chambers, 1994) would eliminate the need for repeated applications.

Given the devastating effects that exotic species can have on natural environments, the potential invasibility of a species must be heavily scrutinized whenever considering biological control as a treatment option. Concerns about the invasibility of *S. scimitus* can be dismissed, as the species has a Pan-Holarctic distribution (Walter and Campbell, 2003) and has been extensively used by the agricultural industry throughout this region for decades.

In addition to feeding on parasitic lizard mites, *S. scimitus* may also show similar effectiveness against other pest species known to affect captive reptiles, particularly the snake mite (*Ophionyssus natricis*). Many private reptile keepers have already experimented with *S. scimitus* in this capacity and have reported favorable results (Moser, personal communication), and some online biological control suppliers now market *S. scimitus* specifically for this purpose (Fitzgerald and Vera, 2006). Additionally, given its ability to feed on dipteran larvae of several species (Lind and Chambers, 1993; Wright and Chambers, 1994; Ali *et al.*, 1999; Cabrera *et al.*, 2005; Castilho *et al.*, 2009; Freire *et al.*, 2007), *S. scimitus* might also prove effective in controlling humpback (or 'drain' fly [Phoridae]) infestations in reptile collections, particularly those featuring enclosures with natural substrates.

A few authors have recently commented on some possible shortcomings of *S. scimitus* when used for treating acariasis in herpetological collections, selecting instead another predatory mite species, *C. eruditus*, as a more-appropriate candidate due to its tolerance of more reptile-appropriate thermal conditions (Morel *et al.*, 2013; Schilliger *et al.*, 2013). Nevertheless, the preliminary results of the present case report and those of Schilliger *et al.* (2013) are encouraging and necessitate further experimentation with predatory mites as an alternative to chemotherapeutic acaricides. Moreover, they highlight the potential role that biological control can play in the husbandry and veterinary management of reptiles in captivity.

Acknowledgments: I would like to thank Scott Moser for sharing personal data and observations and for assistance with this research; Megan Baumer, Robert Olley, and Ben Aller for providing literature; and James B. Murphy for his support. Three reviewers provided useful comments on an earlier draft of this manuscript.

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