Although ticks are common parasites on wild lizards, snakes, and tortoises in the United States,1–6 previously they were seldom brought to the attention of veterinarians. However, with the dramatic growth of international trade in live reptiles (many of which are infested with exotic ticks7–8) during the past decade, the tick problem in reptiles became a concern for veterinarians. In 1997, an estimated 1,700,000 reptiles were imported into the United States and 9,300,000 reptiles were exported.9 In 2000, an estimated 8,600,000 reptiles and amphibians were kept as pets in the United States. Despite the large numbers of pet reptiles and the frequency with which they are infested with ticks, there are few published reports of direct pathogenic effects of ticks on reptiles. Heavy infestations with the exotic tick *Amblyomma* (Aponomma) exornatum in the nasal passages of monitor lizards can cause suffocation and death,10–11 and the iguana tick *Amblyomma dissimile* has reportedly caused ulcers at the site of attachment on rainbow boas (*Epicrates cenchria*).12 Another report13 suggested that heavy tick infestations could significantly limit the aerobic capacity and behavior of lizard hosts. In addition, ticks are known vectors of hemogregarine infections in boa constrictors (*Boa constrictor*), shingleback skinks (*Trachydosaurus rugosus*), rough-tailed agamas (*Laudakia stellio*), and Greek tortoises (*Testudo graeca*).8

It was not until events that occurred in Florida in the late 1990s that the need for developing safe and efficacious protocols for controlling and eradicating tick infestations on reptiles became apparent. Following identification of an established population of exotic African tortoise ticks (*Amblyomma marmoreum*; Figure 1) on a reptile-breeding operation in central Florida in 1997,14 subsequent investigations found that at least eight exotic tick species were being imported into Florida on reptiles.15 Two of these exotic species, *Amblyomma sparsum* and *A. marmoreum*, were a particular concern because both are proven experimental vectors of *Ehrlichia* (*Cowdria*) *ruminantium*, the rickettsia that causes heartwater, an acute tick-borne disease of domestic and wild ruminants.16,17 One shipment of leopard tortoises (*Geochelone pardalis*) imported into Florida from Zambia in 1999 was found to be infested with *A. sparsum*, some of which tested positive for *E. ruminantium* infection.18 This illustrated that continued international dissemination of *A. sparsum* on tortoises exported from Africa posed a real risk for the spread of heartwater to the United States and elsewhere.

**ABSTRACT:**

This article describes practical protocols for controlling and eradicating tick infestations on reptiles and their premises. Protocols for eradicating ticks involve administering permethrin (i.e., Provent-a-mite, Pro Products, Mahopac, NY) directly on tortoises and indirectly on snakes and lizards as well as concurrently treating tortoise facilities with cyfluthrin and snake and lizard facilities with permethrin.

**Controlling and Eradicating Tick Infestations on Reptiles**

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These findings stimulated an interest in a safe and efficacious method of controlling tick infestations on reptiles. A search of the veterinary literature found little useful information on the safety and efficacy of acaricides for controlling ticks on reptiles, apparently because the demand had been too small to interest manufacturers and testing of reptiles was not a requirement for pesticide registration. Consequently, a research program was initiated at the University of Florida to develop practical protocols for controlling ticks on infested premises, and the results are summarized in this article.

CONTROLLING Ticks ON REPTILES

There have been very few reports of acaricide administration to treat tick infestations on reptiles. Two reports from South Africa discussed using acaricides to treat tortoises infested with *A. marmoreum*. The first was a retrospective report of an owner treating a pet tortoise with carbaryl solution, and the second report summarized an experiment using amitraz to induce detachment of *A. marmoreum* to facilitate a tick survey. Neither report scientifically evaluated either the efficacy or safety of administering acaricides to treat tick-infested tortoises. Two other short reports from England and India found that the endectocide ivermectin controlled ticks on snakes when given subcutaneously, but ivermectin has been shown to be toxic in tortoises. A recent publication suggested using 0.25% fipronil to control ticks on reptiles with the caveat that further evaluation is needed.

Subsequent research at the University of Florida has defined the optimal acaricide for use on reptiles. The goal of the first phase of the study was to determine the safety and efficacy of acaricides using *A. marmoreum* ticks and leopard tortoises as hosts. Because no acaricide was registered for use on reptiles in the United States, acaricides registered for use on other domestic animals were investigated, including amitraz, carbaryl, chlorpyrifos, cyfluthrin, fipronil, lindane, permethrin, and pyrethrins. Only four of the acaricides (i.e., chlorpyrifos, cyfluthrin, lindane, permethrin) produced 100% tick mortality within 24 hours of application, and only two (i.e., cyfluthrin, permethrin) continued to cause 100% mortality when diluted as much as 1:10,000. Five of the acaricides (i.e., amitraz, carbaryl, chlorpyrifos, cyfluthrin, permethrin) were studied further for toxicity to leopard tortoises.

The results indicated that cyfluthrin and permethrin, the two most effective acaricides, were also the safest. The goal of the second phase of the study was to identify an optimal acaricide formulation for controlling ticks on reptiles. Previous reports had shown that several acaricides were toxic to reptiles when applied dermally or as aerosols. Toxic reactions to cyfluthrin, deltamethrin, flumethrin, propoxur, and pyrethrins had been seen in snakes; to chlorpyrifos, cyfluthrin, deltamethrin, diazinon, flumethrin, lindane, malathion, and pyrethrins in lizards; and to ivermectin in tortoises. Furthermore, carbaryl and chlorpyrifos produced the unwanted side effect of eye irritation in tortoises. In contrast, permethrin had been used safely on reptiles, snakes, and lizards. Consequently, permethrin became the acaricide of choice for tick control in reptiles. However, it was realized that different acaricide formulations contain different ingredients in addition to the active compound, some of which might be toxic to reptiles. For example, piperonyl butoxide, which is added to some formulations as a synergist, has been associated with snake mortality. Therefore, commercially available permethrin formulations were examined. Only one (i.e., Provent-a-mite [Pro Products, Mahopac, NY], a patented formulation containing 0.5% permethrin) had been prepared specifically for use on reptiles, had received Section 18 Exempt registration from the US Environmental Protection Agency (registration No. 50404-7-73617), and had been marketed in the United States for several years as an acaricide to control mites and ticks that feed on reptiles. The clinical effects of applying...
Provent-a-mite were studied on three species of reptiles by direct application to African spurred tortoises (Geochelone sulcata) and application to the bedding of rosy boas (Lichanura trivirgata) and green iguanas (Iguana iguana), using 10 times the recommended dose every fifth day for a total of six applications. Despite the excessive doses of acaricides, no evidence of toxic reactions related to the permethrin formulation was found in any of the three species of reptiles treated, suggesting that Provent-a-mite is a safe acaricide for controlling ticks on tortoises, snakes, and lizards (see box on this page).

ERADICATING TICK INFESTATIONS FROM REPTILE PREMISES

Controlling tick infestations on reptiles is an ongoing activity on premises where ticks have developed breeding colonies. In these situations, tick eradication is the preferable goal, especially when dealing with exotic tick infestations. Three species of exotic ticks recently established breeding colonies on at least five reptile premises in Florida. They were A. marmoreum at three tortoise-breeding facilities, A. sparsum at another tortoise-breeding facility, and Amblyomma (Aponomma) komodoense in a lizard exhibit at a zoo. The Florida climate will likely be suitable to maintain other exotic tick species imported from tropical and subtropical regions of the world, with unknown consequences for native fauna in the absence of adequate control measures. Consequently, there was an urgent need to eradicate established exotic tick infestations to minimize the risk that they would spread to native fauna.

Protocols for eradicating exotic tick infestations were developed at the University of Florida to minimize the risk that exotic ticks would spread to native fauna and thus become established in the United States as had happened in past years in Florida with the iguana tick infestations.

Protocols for Controlling Ticks

In the recommended protocol for controlling ticks on reptiles, the permethrin product Provent-a-mite is used directly with tortoises and indirectly with snakes and lizards.

**Large tortoises (>2 lb [0.91 kg])**
- Spray two 1-sec bursts of Provent-a-mite directly into each leg opening from a distance of 12–15 inches (30–38 cm).
- When spraying foreleg openings, protect the tortoise’s eyes with a barrier such as a piece of cardboard.

**Small tortoises (<2 lb [0.91 kg])**
- Spray one 1-sec burst of Provent-a-mite directly into each leg opening from a distance of 12–15 inches (30–38 cm; A).
- When spraying foreleg openings, protect the tortoise’s eyes with a barrier such as a piece of cardboard.

**Snakes and lizards**
- Remove snakes or lizards and their water from the container.
- When the container is empty, spray the substrate with Provent-a-mite from a distance of 12–15 inches (30–38 cm) at a rate of 1 sec of spray per 1 sq ft (930 cm²; B).
- Allow the acaricide to dry, and confirm that all vapors have disappeared before returning snakes or lizards and their water to the container.

Provent-a-mite were studied on three species of reptiles by direct application to African spurred tortoises (Geochelone sulcata) and application to the bedding of rosy boas (Lichanura trivirgata) and green iguanas (Iguana iguana), using 10 times the recommended dose every fifth day for a total of six applications. Despite the excessive doses of acaricides, no evidence of toxic reactions related to the permethrin formulation was found in any of the three species of reptiles treated, suggesting that Provent-a-mite is a safe acaricide for controlling ticks on tortoises, snakes, and lizards (see box on this page).
Protocols for Eradicating Ticks

The recommended protocols for eradicating tick infestations from reptile facilities depend on the type of reptile involved.

**Tortoise facilities**
- Treat all tortoises with Provent-a-mite.
- Move treated tortoises to a tick-free area.
- Have the premises sprayed with a cyfluthrin product (e.g., Tempo, Bayer Corporation, Kansas City, MO) by a licensed pest-control company, ensuring that all surface areas, including housing and burrows, are treated.
- Have the premises sprayed again 2 weeks later.
- One week after the second premises treatment, place sentinel tortoises on the treated premises, and allow them to roam freely for 10 days.
- If the sentinels remain free of ticks, eradication of the infestation can be considered successful.
- If the sentinels become infested with ticks, repeat the protocol until they remain free of ticks.

**Snake or lizard facilities**
- Secure snakes or lizards in their indoor enclosure.
- Spray the outdoor enclosure with Provent-a-mite at a rate of one can (i.e., 170 g) per 25 m² from a distance of 12 inches (30 cm). Pay special attention to suspected tick-molting areas such as the base of walls, between boards, under ledges and rocks, around the base of basking spots, and cracks or holes.
- Allow the acaricide to dry.
- Release snakes or lizards in their outdoor enclosure.
- Spray the indoor enclosure, including hide boxes, with Provent-a-mite, following the same guidelines as for the outdoor enclosure.
- If the treated test area fails to kill sentinel insects within 15 minutes, retreat the area with Provent-a-mite as already described.
- If no ticks are found after two consecutive treatments, eradication of the infestation can be considered successful.

A. dissimile and the rotund toad tick *Amblyomma rotundatum*. The protocol adopted for tortoises required all tortoises on infested premises be sprayed with the permethrin product Provent-a-mite followed by spraying of the premises by a licensed pest-control company with a cyfluthrin product specifically formulated for premises treatment. Successful eradication was determined by placing tick-free sentinel tortoises on the treated premises (the infestation was considered eradicated when the sentinels remained free of ticks). With this protocol (see box on this page), an exotic tick infestation was eradicated from the Komodo dragon (*Varanus komodoensis*) exhibit at a zoo in Florida over a 6-month period; in the 18 months since the eradication program was terminated, not a single tick has been detected in the exhibit.

REFERENCES


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| 1. **The primary reason for the increased prevalence of ticks on reptiles in the United States is**  
  a. the increased numbers of ticks on native reptiles.  
  b. the dramatic growth of international trade in live reptiles.  
  c. global warming.  
  d. the lack of effective acaricides for use on reptiles.  
  
  **2. How many reptiles and amphibians were estimated to be kept as pets in the United States in 2000?**  
  a. 600,000  
  b. 2,600,000  
  c. 5,600,000  
  d. 8,600,000  
  
  **3. Heavy tick infestations can cause suffocation and death in**  
  a. leopard tortoises.  
  b. monitor lizards.  
  c. ball pythons.  
  d. green iguanas.  
  
  **4. Ticks are known vectors of hemogregarine infections in**  
  a. boa constrictors.  
  b. rough-tailed agamas.  
  c. Greek tortoises.  
  d. all of the above |
5. The endectocide ivermectin is reportedly toxic in
   a. snakes.       c. tortoises.
   b. lizards.      d. none of the above
6. The acaricide of choice for controlling ticks on
tortoises, snakes, and lizards is
   a. permethrin.   c. fipronil.
   b. amitraz.      d. pyrethrins.
7. Direct application of acaricide is recommended only for
   a. lizards.      c. turtles.
   b. snakes.       d. tortoises.
8. The acaricide _______ can be used as a safe and effective premises spray to eradicate ticks from a tortoise facility.
   a. amitraz      c. carbaryl
   b. cyfluthrin   d. fipronil
9. Reptilian ticks carrying exotic pathogens have been found on imported
   a. lizards.      c. tortoises.
   b. snakes.       d. turtles.
10. Reptilian ticks carrying exotic pathogens have been found on reptiles imported from
   a. Africa.       c. Australia.