The Biology of Rattlesnakes II

Edited by: Michael J. Dreslik • William K. Hayes • Steven J. Beaupre • Stephen P. Mackessy

Published by
ECO Herpetological Publishing and Distribution
4 Rattlesnake Canyon Rd.
Rodeo, NM 88056
Printed in the United States of America

Copies may be ordered from
http://www.williamkhayes.com/rattlesnakes/volume.htm

ISBN 978-1-938850-54-7

Dust jacket illustration
An adult Tiger Rattlesnake (*Crotalus tigris*) set beautifully in its Sonoran desert habitat. Tiger Rattlesnakes occur from south-Central Arizona into southern Sonora, Mexico. The image titled, "Tiger Rattlesnake (*in situ*)," was painted by Tell Hicks and commissioned for the cover of Biology of the Rattlesnakes II. Limited edition prints of this painting are available at http://tellhicksprints.weebly.com/index.html.

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Morris, M. C. 2017. Rattlesnakes in the Classroom: A Research-based Model for Educational Outreach Programs. Pp. 55–65 *in* Dreslik, M. J., W. K. Hayes, S. J. Beaupre, and S. P. Mackessy (eds.), *The Biology of Rattlesnakes II*. ECO Herpetological Publishing and Distribution, Rodeo, New Mexico.

Rattlesnakes in the Classroom: A Research-based Model for Educational Outreach Programs

M. Cale Morris[1,2,3]

[1] Science Department, Heritage Academy, Mesa, Arizona 85205, USA
[2] Department of Venomous Reptiles, Phoenix Herpetological Society, Scottsdale, AZ 85255, USA

ABSTRACT.—Misconceptions about rattlesnake behaviors are widespread and entrenched in many cultures. Accurate rattlesnake behaviors that are witnessed during scientific studies stands in sharp contrast to public opinion. Misunderstandings are perpetuated in large part because scientific research is not easily accessible to the general public. Most wildlife conservation organizations turn to outreach programs to solve this problem. Though many studies have pointed out a need for educational outreach programs they have not produced a successful model to follow. Considering the challenges of changing public opinion and the fact that outreach programs require a lot of work, time and money it is critical to have an effective model for rattlesnake programs. In developing this model the author conducted 116 rattlesnake outreach programs over a ten year period between 2005 and 2014. To have applicable, firsthand data for the outreach model original research was conducted with 46 free-ranging Western Diamond-backed Rattlesnakes (*Crotalus atrox*) showing behavioral responses to human contact. The data from the research was integrated into the outreach model and used in the educational programs. The data showed that rattlesnakes did not behave in a way consistent with public opinion. Two surveys were conducted; one with 98 middle school students and the other with 113 adults to see if opinions changed for the better following the educational programs. The surveys provided evidence that the research-based model was successful at changing negative public attitudes towards rattlesnakes.

INTRODUCTION

Rattlesnakes have a reputation for being nasty, aggressive and dangerous animals. This reputation leads to fear which causes well intending people to kill rattlesnakes. Ironically, it is not uncommon to hear animal conservationists and biologists speak negatively about rattlesnakes. The scientific name of the Western Diamond-backed Rattlesnake (*Crotalus atrox*) even means "cruel" or "horrible" (Campbell and Lamar, 2004). Researchers have known for decades that rattlesnakes do not deserve this reputation since they are observed in the field as being–more often than not–quiet, non-combative, and shy creatures (Duvall et al., 1985). With the truth being the complete opposite of public opinion there is a clear need for education in this area. Laurence Klauber (1972) put it best when he stated one of his objectives in writing his two volume *magnum opus* on rattlesnakes, "I have sought to disentangle rattlesnakes as they are from rattlesnakes as people imagine them to be". Changing irrational negative opinions about rattlesnakes is an important step in suppressing the recently documented global decline in reptiles (Gibbons and Dorcas, 2002).

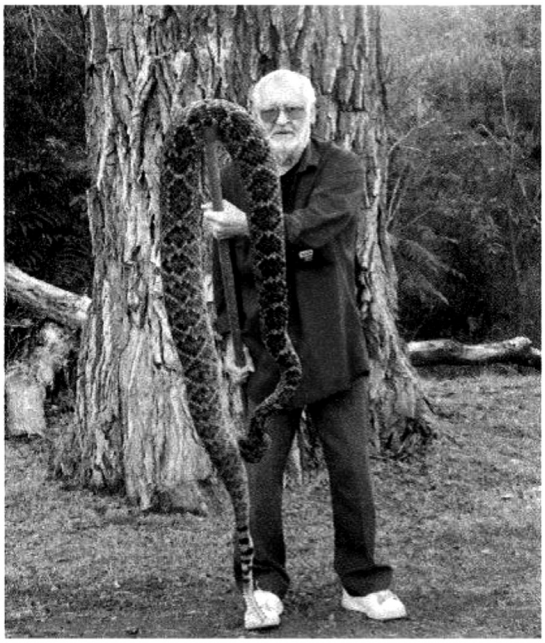
It is believed that rattlesnakes have been studied more frequently than any other snake genus (Beaman and Hayes, 2008). This large amount of rattlesnake research is a powerful tool for educational and conservation-based programs (Greene, 2003). If data showing accurate rattlesnake behaviors where more accessible to the general public then fear and suspicion towards rattlesnakes would be reduced (McCrystal and Ivanyi, 2008). Many wildlife organizations use outreach programs as a conservation

[3] Correspondence e-mail: cale@venomteacher.com

strategy, but sometimes it is difficult to determine the most effective way to organize and present these programs (Gomez et al., 2004). Several studies have pointed out how outreach programs can help change opinions, lower fears, and help in conservation efforts (Kellert, 1985; Greene and Campbell, 1992; Greene 2003; Gomez et al., 2004; Carmichael, 2008; Sasaki et al., 2008; Ballouard et al., 2012).

The main objective for this project was to create an effective educational outreach model for rattlesnake programs. In planning to accomplish this objective I created three specific goals, 1) Create a model that will help change misconceptions, lower fears and help develop communities that contribute towards preservation and conservation of rattlesnakes. 2) Complete a four year behavioral study with free-ranging rattlesnakes and integrate the data into the model. 3) Test the model by conducting outreach programs and find evidence through surveys and questionnaires that public opinion has changed for the better. Education is clearly the answer. Even though rattlesnakes are a highly feared and misunderstood animal, people are often fascinated with them because of their sinister reputations (Klauber, 1972). A positive aspect to the rattlesnakes threatening reputation is that they will always draw a crowd, which is a big advantage when doing educational programs. They might come because of the perceived danger but prejudices will evaporate when people see rattlesnakes as an accumulation of special adaptions to their environment (Greene, 1997). The public needs to be educated and be made aware of the importance of maintaining all species in the natural world especially rattlesnakes (Rubio, 1998).

The actual danger of rattlesnakes as presented in Western movies has always been grossly exaggerated (Babb, 2000). One of the biggest obstacles in teaching accurate rattlesnake behaviors to the public is fighting against the continuous flow of misconceptions that comes through the media. For the purposes of this paper "media" is anything describing agencies of mass communication that are most commonly accessed through the internet (i.e., television, movies, news, emails, books, magazines). Most of the information circulated in the media is not scientific in nature or peer reviewed. The media commonly portrays rattlesnakes exhibiting anti-predator behaviors such as the raised, coiled striking position; which studies have shown are rare in rattlesnakes (Duvall et al., 1985). Since many people learn incorrect ideas about rattlesnake behavior from the media I look at it as a form of education that I call the "media model". Wildlife organizations tend to target school-age children for outreach programs (Gomez et al., 2004, Sasaki et al., 2008), but many of those children have already been influenced with negative ideas from the media on how rattlesnakes behave. Children today have easy access to the internet and online media. Studies have shown that internet use among children has risen drastically in the last two decades and young people are most likely to use the internet for three reasons: social networking, video games, and watching videos (Child Trends, 2012). The videos they watch about rattlesnakes will most likely portray the media model of education.



Arizona Man Kills Record Western Diamondback

By Euben Hadd
THE ARIZONA GAZZETTE

GLOBE - Lowell "Butch" Burns, of Globe, Arizona killed a monster rattlesnake October 26, 2008 during an overnight campout up on Gobbler's Knob near the Sabino Basin. Burns was walking near his camp when he stepped close and the snake buzzed a warning. He said "At first I wasn't sure I wanted to do battle with so formidable a critter but I sure didn't want him to be roaming around my campsite." Burns notified the authorities to report the incident and the snake was measured at a world record 8ft. 10in. The snake was packed in ice, then given, by request, to the Arizona State University Herpetology Department for study and preservation. For further information, see: www.asucentral.com

Figure 1. Viral email showing rattlesnake misconceptions.

Emails and social media are another way that misconceptions are spread about rattlesnakes. In 2008 I received an email that was sent to me from several different people showing the capture of a world record rattlesnake in Arizona (Fig. 1). All the facts in the email turned out to be false including the claim that the rattlesnake was 8 feet 10 inches. The creator of the article wanted everyone to know it was a joke, because it was written by Euben Hadd (you been had). Even though this was openly a joke, it was clear that many people believed it. I had it sent to me by several people that believed it was true and two of them were professional wildlife educators.

In October 2009 I was filming a rattlesnake show with National Geographic in a county park just outside of Phoenix, Arizona. We spent all day hiking up and down the mountain trying to find rattlesnakes. We found two Speckled Rattlesnakes (*Crotalus mitchellii*), a Black-tailed

Rattlesnake (*Crotalus molossus*) and a Gila Monster (*Heloderma suspectum*). None of the rattlesnakes rattled or showed defensive behaviors. Towards the end of the day we filmed a very excitable *C. atrox* that was rattling non-stop. Once we were done filming the host said that it's a shame because the diamondback will most likely be the star of the show and the other rattlesnakes won't even be in it. He thought it was a shame because the blue *C. mitchellii* we found where such beautiful rattlesnakes. He was right; the rattlesnakes that most accurately portrayed common rattlesnake behaviors were cut from the show. It was apparent to me that many wildlife television programs are calculated to invoke fear and danger with the plan to make as much money as possible. This is another example of the media model.

Using live reptiles is a key part of the outreach model; including live rattlesnakes in safe display cages and non-venomous snakes for participants to hold. Children are usually very excited to hold snakes (Fig. 2). Harry W. Greene and Jonathon Campbell (1992) said, "As teachers we can convert ignorance and fear of venomous snakes to knowledge and admiration, by direct contact with students and the public". This is important because there is growing evidence showing how schools are getting farther away from using animals and studying nature in the classroom (Louv, 2008). Louv shows that there is an increased need for what he calls "environment-based education". Another study showed that children who frequently studied animals in school and visited zoos scored surprisingly low on knowledge tests about animals, while students that actively bird watched and belonged to animal related clubs were more appreciative and knowledgeable about animals. This suggests that direct contact with animals is an important tool in learning and attitude formation (Kellert, 1985). Having an effective model that utilizes live reptiles will help rattlesnake relocation organizations including national, state, county, and city parks when they educate the public. The model presented in this paper can be used as a powerful conservation tool in helping change negative perceptions on rattlesnakes.

MATERIALS AND METHODS

Outreach program locations.—The model was tested using three different outreach locations. 1) Maricopa County Parks and Recreation (MCPR) are an excellent place to do educational outreach programs for two reasons: first they are located in the desert but in close proximity to the city and second they have nature centers that can be used for large educational programs (Fig. 3). According to the MCPR website all 10 parks in the county cover approximately 120,000 acres of desert habitat, making it the largest county park system in the United States. The ten parks are located on the edge of the Phoenix metropolitan area of Arizona and all are within a 45 min. drive of downtown Phoenix. 2) The Phoenix Herpetological Society (PHS) is a 501 (c)(3) non-profit, statewide organization in Arizona that includes a two acre reptile sanctuary and surrender facility, educational outreach programs, summer camps, herpetology clubs, rescue and rehabilitation, and rattlesnake relocation services. In 2011 PHS reached 130,000 people through educational outreach programs (D. Gibson, pers. comm.). The PHS outreach trailer is 9.1 m and can display 48 rattlesnakes in separate cages with large popup doors on both sides for easy viewing (Fig. 4). The trailer has an attached generator and can be climate controlled. 3) In public classrooms and at Heritage Academy, a 7–12 grade public charter school in Mesa, AZ (Fig. 5). The administration of Heritage Academy approved to build a venom room for rattlesnakes which is attached to the main science room with a secure door and viewing window. The venom room houses all six species of rattlesnakes found in the Phoenix

Figure 2. A group of excited Cub Scouts holding a Sonoran Gopher Snake (*Pituophis catenifer affinis*) at a rattlesnake outreach program.

Figure 3. A rattlesnake educational program at Usery Mountain Regional Park. The show boxes contain the six species of rattlesnakes found in the Phoenix, AZ area.

Figure 4. The Phoenix Herpetological Society outreach trailer being used at an outdoor educational program.

Figure 5. Participants safely viewing rattlesnakes at an outreach program.

metro area and a variety of other venomous creatures from the region. The venom room is used throughout the school year by the author to educate students about rattlesnake natural history and conservation. There are special labs conducted every other month during the school year called Reptile Day and a herpetology club which gives opportunities for students to hold and care for non-venomous snakes on a daily basis.

Rattlesnake question cards.—Most of this model was originally created through trial and error while using public input and responses, either verbal or what was written on question cards. To help create direction for the construction of the outreach model and get an idea of participant misconceptions I passed out question cards before each presentation. The participants were asked to write down one question they have about rattlesnakes.

Rattlesnake behavior research project.—The research was conducted at three different Maricopa County parks surrounding the Phoenix metropolitan area of Arizona. The locations were Usery Mountain Regional Park (UMRP) to the east which is 3,648 acres, San Tan Mountain Regional Park (SMRP) to the south at 10,000 acres, and White Tank Mountain Regional Park (WMRP) on the west side which is 30,000 acres. The biotic community of all three parks is Sonoran Desertscrub, Arizona Upland Desertscrub Subdivision (Brennan and Holycross, 2006). The county parks were a perfect location for studying human/rattlesnake encounters because they are so close to the city. According to 2010 US Census data, there are nearly 4 million people in Maricopa County, which accounts for 59% of the population of Arizona. From 2000–2010 there was a 24.2% population increase to the Phoenix metropolitan area, resulting in constant construction and urban sprawl. This ongoing population growth into the surrounding Sonoran Desert makes rattlesnake encounters very common. Each year in Maricopa County agencies relocate hundreds of rattlesnakes from the yards of homeowners. The Phoenix Herpetological Society reported relocating 282 rattlesnakes in 2011 with *C. atrox* accounting for the majority (D. Gibson, pers. comm.).

I chose to study *C. atrox* because they are the most common rattlesnake in the Phoenix area and the largest rattlesnake species in Arizona (Brennan and Holycross, 2006). Free-ranging *C. atrox* were captured, PIT tagged and released over a four year period between 2010 and 2013. Data was collected on their behavior relative to human contact. The behavior of each snake was recorded during five separate encounters that I called "events". The events were: first sighting, stepping on the snake with an artificial leg, capture, PIT tagging, and release. Two sets of behaviors were recorded for each of the five events: rattling and motion. The rattling behaviors were then divided into four categories: none, 1–2 sec, off and on, and non-stop. The motion behaviors were divided into three categories: procryptic, crawling and escaping. Along with the three motion behaviors I also recorded each time a rattlesnake struck at me or at any of my tools. The data for each event was recorded using a hard copy spreadsheet with check boxes for each event and category. After each behavior was observed the appropriate box was immediately checked off.

In creating the five events to record rattlesnake behaviors I looked at research that studied rattlesnake defensive behaviors. Klauber (1972) described a three unit defensive behavior model of either procrypsis or flight, and then the fighting pose. Duvall et al. (1985) used a seven sequence model that showed how rattlesnakes pass through a series of behaviors when encountered by humans. The seven behaviors are moving, procrypsis, escaping, coiling, cocking, head hiding and striking. I decided to use an adapted version utilizing aspects of both models. I noticed that when I came upon rattlesnakes crossing the road they always did one of three motion behaviors, namely

procrypsis, crawling or escaping. Procrypsis is when they are not moving or they immediately stop moving, crawling is when they are moving across the road using a slow and steady caterpillar motion, and escaping is when they quickly moved in a serpentine motion.

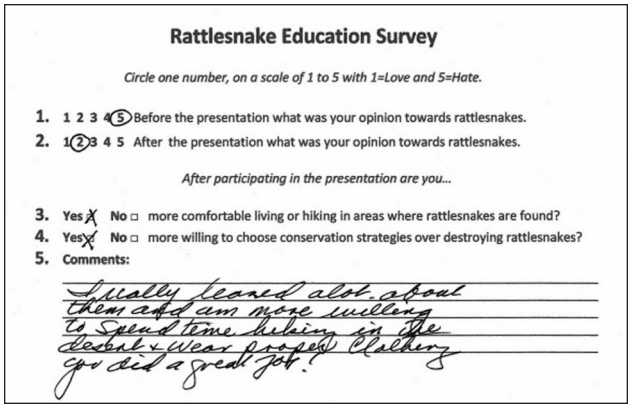
The rattlesnakes in the study were all found at night while crossing the road within the three county parks. I chose to study rattlesnakes crossing the road at night because it was easier and safer for me to find them when I was working by myself. Also the parks closed at sunset so I did not have to worry about cars getting in the way. I would start the research by driving the car until I came upon a rattlesnake crossing the asphalt roads that run through and around the parks. Once I found a rattlesnake I would stop the car between 4.5–6 m of the snake and record the behavioral information for "first sighting". The second event is stepping on the rattlesnake with an artificial leg; because its framework is made out of metal I called it the robo-leg. I came up with the robo-leg by accident while hiking in WMRP. I witnessed someone directly in front of me accidentally step on a *C. mitchellii* that was crossing the trail. In the split second before he jumped off the rattlesnake, it tried to pull itself free from his boot. The rattlesnake did not rattle and never attempted to bite; it was more interested in getting away. I created a hypothesis that this behavior might be common among rattlesnakes. To test this I created the robo-leg to safely step on the rattlesnakes when they were found crossing the road (Fig. 6). I used the same method that Gibbons and Dorcas (2002) used on Cottonmouths (*Agkistrodon piscivorus*) and stepped on the rattlesnakes at mid-body with just enough force to restrain the snakes, but not harm them. I held the pressure on the rattlesnakes for three seconds and then released and pulled the boot back.

Figure 6. Stepping on a Western Diamond-backed Rattlesnake (*Crotalus atrox*) with an artificial leg.

I chose to use an artificial leg opposed to my real leg for safety reasons and convenience in conducting the research. People have asked if the rattlesnake might not bite the boot because it is not hot like a real human leg. A study found evidence that pit vipers like rattlesnakes do not use their thermal pits in predator evaluation even in close terrestrial encounters. Pit vipers have natural predators that are reptiles, birds and mammals and they each have body temperatures that vary widely. Pit viper thermal pits are used primarily for catching food and are only useful at close range, therefore relying on body temperatures to determine if a predator is a threat is ill adapted. (Glaudas and Gibbons, 2005). The third event was capture; this event was done by capturing the rattlesnakes using M1 Midwest snake tongs by gently picking up the snake at mid-body and placing them in a five gallon bucket with a screw lid. For the fourth event which is called PIT tagging the rattlesnakes were usually taken to the Heritage Academy venom room where they were probed to determine their sex and PIT tagged. Motion and rattling behaviors were recorded as the rattlesnakes was put on the ground and put in a plastic restraining tube. The last event is the release; the following night the rattlesnakes are lifted out of the bucket at mid-body and set on the ground where they were originally captured. I then stood and waited a few minutes to see what they would do before I recorded their behaviors.

Rattlesnakes use their rattle primarily as a defensive signaling device (Greene, 1988). I recorded rattling behaviors to see how defensive rattlesnakes were towards humans. A misconception I often hear is that people think rattlesnakes will always rattle and warn you of their presence. Based on previous experience from rattlesnake encounters I hypothesized that the rattlesnakes would not always rattle. Another misconception that I frequently encounter from participants of outreach programs is that rattlesnakes chase people. I hypothesized that I would not see any chasing behaviors in this study. Klauber found examples of people mistaking escaping behaviors as chasing (Klauber, 1972). This could explain what people mean when they claim to be chased by a rattlesnake. Rattlesnakes will often hide in the closest place available even if it means coming in close contact with a person as they move past them.

The control for this study was the "first sighting" event. Once I stopped the car and got out I watched the rattlesnakes from 4.5–6 m away to see what they would do next. Once I could tell whether the rattlesnake was crawling or doing procrypsis by sitting there motionless I moved onto the next event. First sighting is the only event where I did not touch the snake so I hypothesized that this event would produce the least amount of rattlesnake defensive behaviors.



Rattlesnake Education Survey

Circle one number, on a scale of 1 to 5 with 1=Love and 5=Hate.

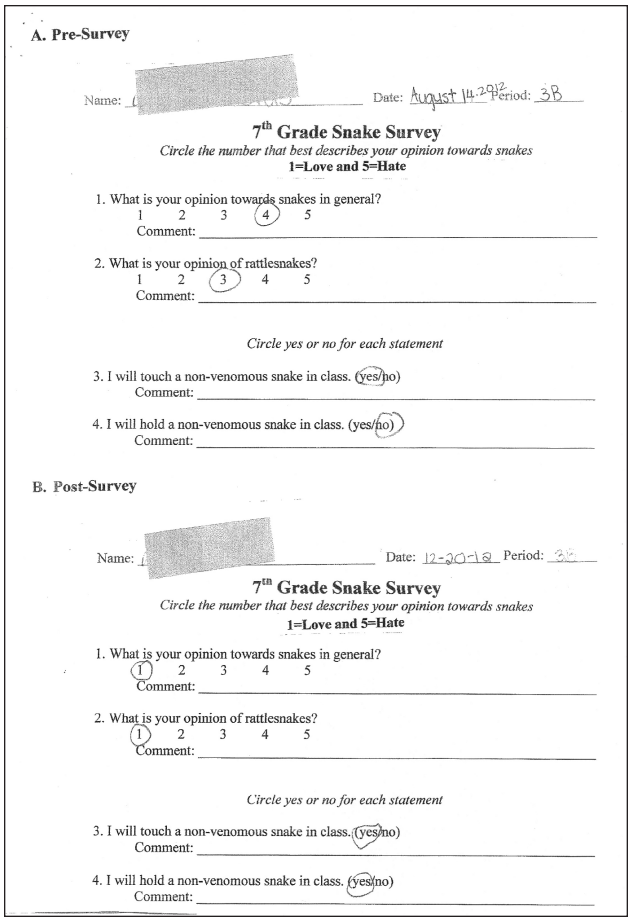
1. 1 2 3 4 (5) Before the presentation what was your opinion towards rattlesnakes.
2. 1 (2) 3 4 5 After the presentation what was your opinion towards rattlesnakes.

After participating in the presentation are you...

3. Yes (X) No ☐ more comfortable living or hiking in areas where rattlesnakes are found?
4. Yes (X) No ☐ more willing to choose conservation strategies over destroying rattlesnakes?
5. Comments:

I really learned alot about them and am more willing to spend time hiking in the desert + wear proper clothing you did a great job!

Figure 7. Example of a survey card used by adult participants at Usery Mountain Regional Park outreach programs.



A. Pre-Survey

Name: [redacted] Date: August 14 2012 Period: 3B

7th Grade Snake Survey

Circle the number that best describes your opinion towards snakes

1=Love and 5=Hate

1. What is your opinion towards snakes in general?
   1 2 3 (4) 5
   Comment: _____
2. What is your opinion of rattlesnakes?
   1 2 (3) 4 5
   Comment: _____

Circle yes or no for each statement

3. I will touch a non-venomous snake in class. (yes/no)
   Comment: _____
4. I will hold a non-venomous snake in class. (yes/no)
   Comment: _____

B. Post-Survey

Name: [redacted] Date: 12-20-12 Period: 3B

7th Grade Snake Survey

Circle the number that best describes your opinion towards snakes

1=Love and 5=Hate

1. What is your opinion towards snakes in general?
   (1) 2 3 4 5
   Comment: _____
2. What is your opinion of rattlesnakes?
   (1) 2 3 4 5
   Comment: _____

Circle yes or no for each statement

3. I will touch a non-venomous snake in class. (yes/no)
   Comment: _____
4. I will hold a non-venomous snake in class. (yes/no)
   Comment: _____

Figure 8. Example of the pre- and post-survey cards used in a seventh grade science classroom over a four-month period.

Opinion surveys.—I decided to use a likert-style questionnaire to determine whether or not the presentations using the outreach model changed public opinion towards rattlesnakes. I did two different surveys, one with adults following presentations done at the UMRP nature center (Fig. 7), and a pre- and post-survey were done with middle school students on the first and last day of the semester in a science classroom (Fig. 8). The adult survey conducted at the nature centers was given at the end of each presentation. The survey asked questions to see whether their opinion towards rattlesnakes changed for the positive or negative after viewing the presentation. The survey asked two additional questions to see if participants feel more comfortable hiking and living around rattlesnakes and whether they will now choose conservation strategies. The classroom survey was given to every seventh grade student at the beginning of class on the first day of school in August. The students had no idea that there were even snakes in the classroom at that point. Then a permission slip was given to parents giving permission to use their survey in the study. Throughout the first semester I did a rattlesnake outreach presentation to the class and let students hold non-venomous snakes nearly every day of class. I also did a live animal lab where student studied detailed aspects of rattlesnakes and other reptiles while observing them in their cages. Students learned about special adaptation of rattlesnakes and studied their role in the ecosystem. On the last day of the semester in December I gave the students the same survey without showing them their original survey or talking about the results of the first survey. The survey asked questions about their opinions towards snakes in general and then specifically towards rattlesnakes.

RESULTS

Rattlesnake question cards.—In 2010 a total of five rattlesnake presentations were conducted at the UMRP nature center with 359 (mean = 72) people attending. Participants turned in 112 questions cards, three cards were removed from the study because responses did not relate to rattlesnakes, which left 109 (22) useable question cards for the survey (N = 109). When categorized into 10 sections they showed that the majority of questions related to rattlesnake behaviors specifically biting, striking, and moving (Table 1).

Rattlesnake behavior research project.—A total of 59 *C. atrox* were encountered with 13 being recaptures making a total of 46 (17 females, 29 males) used in the study (N

= 46). Motion and rattling behaviors were recorded for all 46 rattlesnakes and 35 of the 46 were stepped on with the robo-leg. Body lengths (ST) ranged from 31–117 cm (mean = 70 cm, *N* = 46) with 17 being neonates, 3 sub adults and 26 adults. Crawling was the most common motion behavior; with first sighting being the highest at 41 (89%), and release 38 (83%) (Fig. 9). Escaping was the next most common motion behavior; with capture being 33 (72%), and PIT tagging 16 (35%). The most common rattling behavior was in the "none" category meaning no rattling was document during that event. Rattling behaviors for the "none" category were: first sighting 46 (100%), capture 25 (54%), PIT tagging 30 (65%), and release 38 (83%) (Fig. 10). Striking was observed during two events; capture, 4 (9%) and PIT tagging, 3 (7%). The robo-leg results showed that 26 (74%) did not rattle at all during the entire event, 16 (46%) showed procrypsis, 11 (31%) showed escaping behaviors, and 2 (6%) out of 35 stuck the boot (Fig. 11).

The event with the least amount of defensive behaviors was first sighting. Even though the rattlesnakes did not react defensively during this event they were clearly aware of my presence at 5 m away. This was evident because the snakes would turn their heads slightly in my direction and tongue flick as they continued to crawl across the road.

Opinion surveys.—The adult survey was done following six rattlesnake presentations done in 2011 at the UMRP nature center. Out of the 489 (82) participants from all six presentations 113 (23) completed and turned in the questionnaire (*N* = 113). Results showed that the opinions of 76 (67%) adult participants changed for the positive because of the presentation with 23 (20%) staying the same and 14 (12%) changing for the worse (Fig. 12).

Between August and December of 2012 an identical pre- and post-survey was given to 109 seventh grade students.

Table 1. Summary of data collected from participant question cards given before each presentation at Usery Mountain Regional Park in 2010. Participants were asked to write down one question they had about rattlesnakes (*N* = 109).

Categories of Questions	%
1. **Bites:** Bites to people, dogs, children; the strike; venom types and effects.	41%
2. **Encounters:**What to do in the wild, when they are out, how to avoid.	13%
3. **Range:** How far do they travel, do they come back, dens, distribution.	12%
4. **General:** Random questions that did not fit into a category.	9%
5. **Rattle:** Do the segments tell the age, composition.	8%
6. **Diet:** What do they eat most often.	4%
7. **Offspring:** How many babies, eggs.	3%
8. **Length:** Biggest and longest ones found.	2%
9. **Longevity:** How long do they live.	2%
10. **Shedding:** How often and where.	1%

A total of 109 (17) students from four class periods took the survey and there were 98 (25) that completed both the pre- and post-survey and brought back the permission slip (*N* = 98). The classroom survey results showed that 52 (53 %) of student opinions towards non-venomous snake stayed the same while 65% of opinions towards rattlesnakes changed for the better (Fig. 13). It also showed that 9 (9%) of opinions towards rattlesnakes changed for the worse after the presentations and 25 (26%) stayed the same. There were two yes or no questions at the bottom of the survey cards that asked whether people feel more comfortable living and hiking around rattlesnakes and whether they will be more likely to choose conservation strategies after the presentation. There were 96% of participants that answered yes to both questions. There was also a section where people could leave a comment if they wished. There

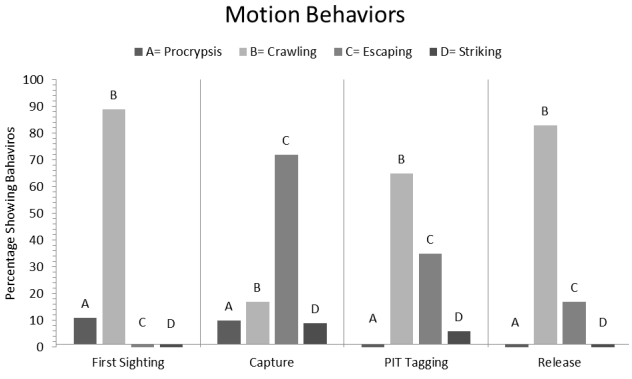


Figure 9. Motion behaviors of wild Western Diamond-backed Rattlesnakes (*Crotalus atrox*). The bars indicate the portion of individuals that responded to each of the four human contact events (*N* = 46).

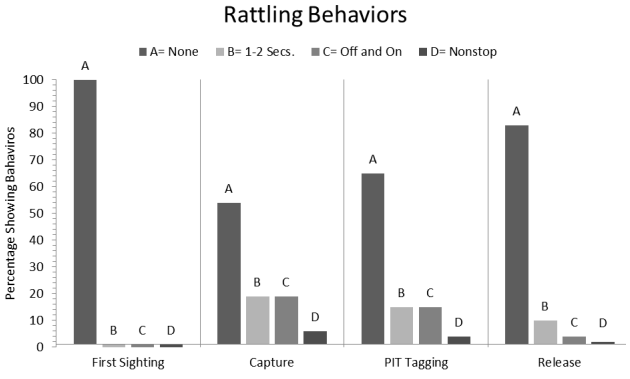


Figure 10. Rattling behaviors of wild Western Diamond-backed Rattlesnakes (*Crotalus atrox*). The bars indicate the portion of individuals that responded to each of the four human contact events (*N* = 46).

were 42 people that left a comment. The majority of the comments were positive with only one out of the 42 having a negative comment towards rattlesnake conservation. The person wrote a note next to the question about choosing conservation strategies over killing snakes that said, "A shotgun is a cheaper solution".

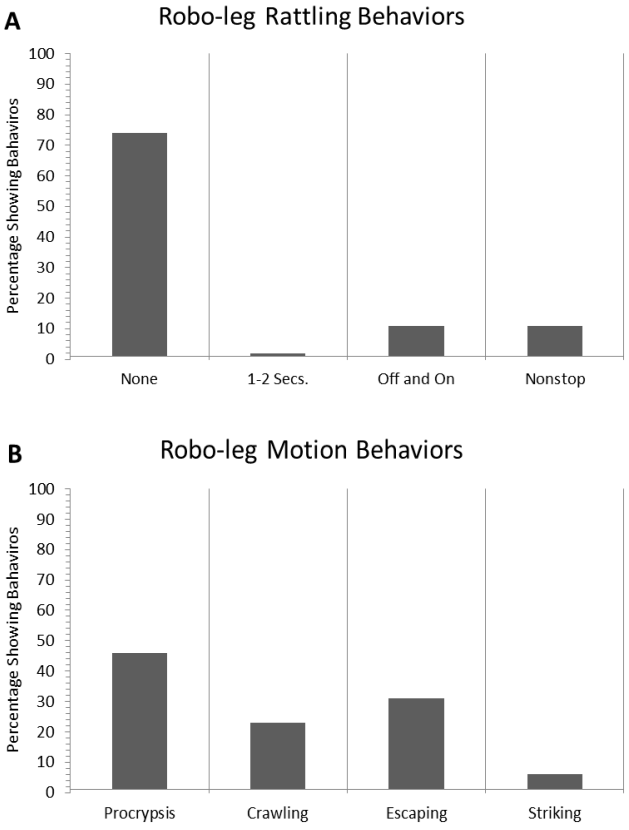


Figure 11. Defensive behaviors of wild Western Diamond-backed Rattlesnakes (*Crotalus atrox*) in response to being stepped on by an artificial leg ($N = 35$).

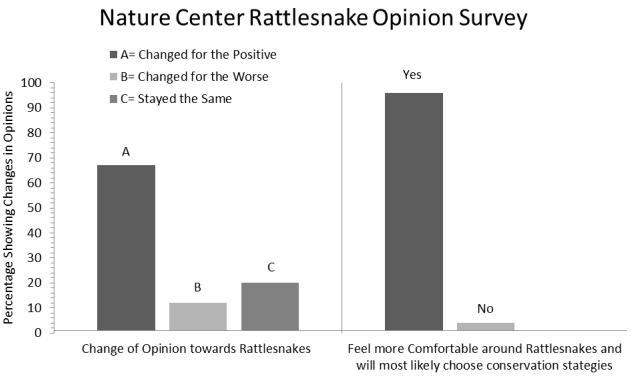


Figure 12. Summary of data collected from survey cards given to adults at the end of rattlesnake outreach presentations taught in the Usery Mountain Regional Park nature center in 2011 ($N = 113$).

Outreach model outline.—This model was designed with the hope that it could be easily followed and duplicated by wildlife organizations that are interested in changed public opinion towards rattlesnakes. In reaching that goal the following is a 10 point outline listing the major components of the research-based educational outreach model.

1. Use facts from research that show accurate rattlesnake behaviors. The literature cited section of this paper has excellent examples.

2. Explicitly point out how media spreads misconceptions and shows an unrealistic portrayal of rattlesnake behaviors. Most people are not surprised when they find out how much of what we see on television and the internet about rattlesnakes is inaccurate.

3. Use PowerPoint presentations with photos of rattlesnakes that are not in defensive postures like the media often portrays them. A photo is worth a thousand words.

4. Answer questions at the end of the presentation as a group and individually. If possible bring an assistant to help people hold the non-venomous snake so the presenter can answer questions. People always have a lot of questions after a presentation.

5. Review safety precautions and snake bite first aid, including what to do if you encounter a rattlesnake or if someone is bitten. It is important to review how it is rare for people to get bitten and extremely rare to die from a rattlesnake bite. Arizona Poison and Drug Information Center has some great information on this subject. http://tonic.pharmacy.arizona.edu/centers/arizona-poison-drug-information-center

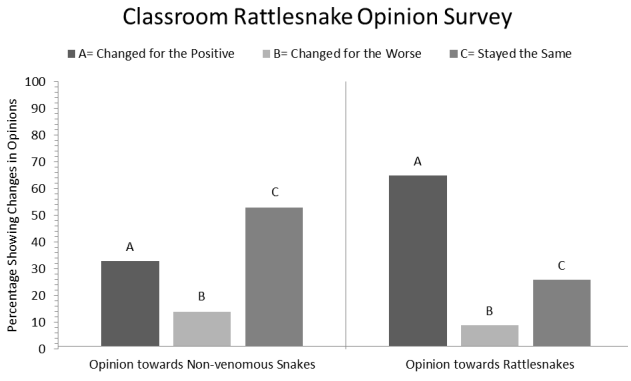


Figure 13. Summary of data collected from survey cards given to Heritage Academy seventh grade students at the beginning and end of the spring semester, 2012 ($N = 98$).

6. Discuss the top ten list of common rattlesnake misconceptions: This list was compiled from recording oral questions from presentations, comment cards and emails: 1) Rattlesnakes are aggressive, 2) they chase people, 3) they always rattle a warning, 4) incorrect length measurements, 5) false bite statistics, 6) inaccurate striking abilities, 7) handling methods, 8) bite treatment methods, 9) baby rattlesnakes cannot control venom and 10) rattle segments equal age of rattlesnake.

7. Teach participants the role of rattlesnakes in our ecosystem. One of the most important aspects of rattlesnake educational programs is to teach conservation strategies by showing people why rattlesnakes are necessary and important to our ecosystem.

8. Use anecdotes to teach rattlesnake conservation principles. Here is an example of an anecdote that can be used to teach how rattlesnakes are an important part of our ecosystem: Debbie Gibson, the Vice President of PHS, told me that she received a call from a female homeowner several years ago. The homeowner lived in a gated community in North Scottsdale that had large, open tracks of desert that ran through the neighborhoods. She was calling to complain about how her home and yard suddenly became overrun with packrats. The packrats were chewing through wiring for outdoor lighting, wiring in cars, and chewing up patio cushions. The homeowner informed Debbie that the security guards were killing the rattlesnakes when they were called to remove snakes from their yard, and they were now seeing the side effects. Debbie received several calls from homeowners in the community stating that the pack rats were a serious problem. Debbie contacted the security guards and tried to convince them that they should not be killing the rattlesnakes. She explained how they can be removed from the yard but their presence is needed in the ecosystem. The security guards claimed that they were killing the rattlesnakes at the request of the homeowners. The security guards and pest exterminators could not control the pack rats. The pack rat problem became so serious in the community that Debbie eventually received a phone call from the security supervisor asking PHS if they could release rattlesnakes back into the community to help solve their problem (D. Gibson, pers. comm.).

9. Use live snakes in each presentation. In my area people often confuse the Sonoran Gopher Snake (*Pituophis catenifer affinis*) for a rattlesnake, so I try to use them in every outreach program. Making cute memorable names for the snakes really helps in getting kids excited about animals. Using live rattlesnakes in educational programs can be dangerous. Proper training and safety precautions are mandatory. It would be beneficial to learn proper techniques and protocols from venomous snake handling professional and read literature on the subject (Smith, 2005; Fry, 2015). Herpetological societies often have snake removal services and usually offer training on how to properly work with rattlesnakes. I always get asked if I have ever been bitten by a rattlesnake. I think it validates your argument that rattlesnake are not aggressive when you can tell a group that you work with rattlesnakes all the time and have never been bitten.

10. I always end my presentations with a quote from Harry W. Greene (2003).

    "'In the end, we will conserve only what we love, we will love only what we understand, and we will understand only what we are taught.' If ever a group of organisms exemplified Senegalese conservationists Baba Dioum's summary of the interplay among nature appreciation, education, and research, it's dangerous snakes." "… Baba Dioum's comments emphasize the extent to which research and education are linchpins for appreciating and thus valuing unpopular organisms. We can all be teachers in some sense or another, whether in classrooms or over backyard fences. If you agree with me that our lives are richer for the existence of dangerous animals, that the Earth is wilder and more wonderful because of their presence, then learn what you can and tell others something good about rattlesnakes."

    This quote is a great way to encourage participants to share the new things they learned about rattlesnakes. As part of this encouraging process I give each child a certificate of completion at the end of each program stating that they have been trained and they now have a correct knowledge of rattlesnake behaviors. I explain how they are officially certified now so it is their responsibility to share what they know with others.

DISCUSSION

The results show that even when rattlesnakes are stretched out crossing a road and clearly more vulnerable to a predator that they still do not exhibit aggressive behaviors. Rattlesnakes are not as aggressive as many people believe and they are reluctant to strike even when they are being stepped on by a perceived predator. I found evidence to support my hypothesis about using the robo-leg to step on rattlesnakes. There were 54% of the rattlesnakes that either tried crawling away or escaping when they were being stepped on, while the other 46% just froze and did not move. There were two out of 35 rattlesnakes that stuck the boot when they were being stepped on. There was also evidence to support my hypothesis that rattlesnakes will not always

rattle a defensive warning to humans, nonetheless I was surprised that 74% of the rattlesnakes did not rattle at all when they were being stepped on. There are other studies that showed similar findings. Behavioral studies done with the Prairie Rattlesnake (*Crotalus viridis*) have shown that striking in defense of a human predator occur in fewer than 2% (Duvall et al., 1985). Glaudas et al. (2005) found that Pygmy Rattlesnakes (*Sistrurus miliaraius*) bit a gloved hand only 8% of the time after they tapped the nose of the snake. Gibbons and Dorcas (2002) reported that only one *A. piscivorus* bit their boot out of the 22 they stepped on. My hypothesis on rattlesnakes not chasing people seemed accurate as well since I found no evidence to suggest they do and ironically it was quite the opposite—most of the rattlesnakes showed escaping behaviors, 33 (72%). I witnessed one rattlesnake that came directly at me once I released him. I immediately stepped aside and watched him quickly move past me and take refuge in the bush that was initially behind me.

The first sighting event which was used as the control for the study showed interesting results because it is the only event where no rattlesnakes showed rattling or escaping behaviors. In my hypothesis I thought I would see the least amount of defensive behaviors in this event, but I was surprised when I found out that they displayed no defensive behaviors at all. Based on these results I believe if I would have stayed at a distance of five meters and just watched the rattlesnakes, without interacting with them, they would have most likely continued slowly crawling across the road without rattling. This gives credibility to the phrase, "if you leave them alone, they will leave you alone". Generally speaking rattlesnakes and humans seem to both want the same thing from each other and that is to be left alone. Both parties have a lot to lose from an aggressive encounter with not much to gain on either side. Randy Babb (2000) put it well when he said, "Many bites occur when people are harassing rattlesnakes or attempting to kill them. We can make it easier on both them and us by appreciating them for what they are—marvelously adapted creatures that are important to the ecological health of our wildlands—and by giving them a little 'wiggle room' if we are fortunate enough to encounter them in THEIR home."

The adult nature center and science classroom surveys both showed evidence to support my hypothesis that the educational outreach model changes opinions towards rattlesnakes. It is not easy changing misconceptions on such a notorious animal, but it is possible. It should also be noted that Gomez et al. (2004) discovered that in children the changes made from interpretive programs appear to decline somewhere between one and seven days after the program, so we cannot assume that a permanent change has occurred. They recommended with children to revisit the subject, which goes to show how much of a need there is for continued outreach programs on rattlesnakes. Based on the positive comments on the survey cards and verbal responses from all the participants of the study, I believe people leave the presentations happier and they are more respectful towards rattlesnakes and animals in general. I like to think that rattlesnake outreach programs are doing more than just changing negative opinions about one species. If people learn to appreciate rattlesnakes then other animals like turkey vultures and badgers should be easy (Greene, 2003). One of my favorite aspects of outreach programs is seeing people leave the presentations empowered with newfound knowledge and hope which gives them courage to venture out and enjoy the beauties of nature; even when they are in rattlesnake country.

ACKNOWLEDGMENTS

Special thanks in helping with the research go to John Caretto, Clint Guadiana, Marco Sassoe, Nate Deason, Larry Zirkelbach, Bill and Kathy Love, Manny Rubio, Gordon Schuett, Scott Tucker, Robert Balogh, Michael Grove, Charlie and Judy Vacha, Scott Dike, Peter Malinka, Jon Duke and family, Ed and Diana Morris, Misty and Robert Scott, Gloria and Howard Scott, Bob and Ethan Wright, Brady Barr, Bryan Fry, David Presley, Matt Player, Robert Lewis, Jon Brophy, Bernd Skubowius, Philipp Zimmermann, Roger Jensen, Kailee Keagan Silas and Ammon Morris, Drew Foster and David Kandiyeli. This project would not have happened if not for the help of everyone at Maricopa County Parks and Recreation. Special thanks go to all those at Usery Mountain, White Tank Mountain and San Tan Mountain Regional Parks for their help and support in the educational programs and research, especially Brennan Basler, Jennifer Johnston, Dan Wilson, Bill Talboys, Steve Barkasy, Raymond Schell, Sarah Steele, Adam Martell and Tishia Stewart. Thanks to Bill Love for supplying photos and Dr. Todd Driggers for giving me training and veterinary advice. I would specifically like to acknowledge Earl Taylor, principal of Heritage Academy, for making the venom room possible and Pete Roberts for its design, construction, and all his help with PIT tagging the rattlesnakes. Thank you to Misty Scott and Myrna Sheppard for editing the manuscript. I am indebted to Russ and Rosie Johnson, Debbie Gibson and Daniel Marchand, the founders of PHS for making their original vision of bringing rattlesnakes into classrooms a reality, without their initial efforts this article would not have been possible. Thanks to Harry W. Greene for pointing me in the right direction with my literature review and research. I would like to recognize Randy Babb of the Arizona Game and Fish Department for his constant guidance and for supporting my ideas from the beginning. I would like to dedicate this article to my wife Shelly Morris for all she has put up with and for her constant support. The research aspect of this

project was approved by the PHS Animal Care and Use Committee and Wildlife Collecting Permits were obtained from the Arizona Game and Fish Department issued to M. Cale Morris (LIC# SP798899).

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