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CONCEPTS

Mohave Rattlesnake (*Crotalus scutulatus*) Identification Revisited

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Crotalus scutulatus (Mohave rattlesnake) is a clinically significant pit viper broadly distributed across much of the arid southwestern United States and mainland Mexico. Identification of *C scutulatus* is a concern among emergency medical service and emergency department personnel owing to its reputation for severe envenomations and difficulty in visually differentiating between *C scutulatus* and other species, primarily *Crotalus atrox* (western diamond-backed rattlesnake). We contrast distinctive characteristics of *C scutulatus*, *C atrox*, and 3 other sympatric species: *Crotalus molossus*, *Crotalus ornatus*, and *Crotalus viridis* (western and eastern black-tailed rattlesnakes and prairie rattlesnake, respectively). Greenish coloration eliminates *C atrox* but does not confirm *C scutulatus.* Obvious coarse and fine speckling of the dorsal pattern and a pale postocular stripe intersecting the mouth characterize *C atrox.* Dorsal speckling is insignificant or absent in the other species, whereas the pale postocular stripe passes above the mouth in *C scutulatus* and *C viridis* and is absent in *C molossus* and *C ornatus*. Tails boldly ringed with alternating black and white or contrasting shades of gray are shared by *C atrox* and *C scutulatus*, respectively, but a lack of boldly ringed tails characterizes the other species. The proximal rattle segment is yellow and black, or entirely yellow, in *C scutulatus* but black in the others. The most reliable visual identifications are based on evaluations of multiple traits, all of which are variable to some extent. Traits such as tail ring width and the size and number of crown scales have frequently been overemphasized in the past.

Keywords: Mojave rattlesnake, Mojave green, snakebite, rattlesnake identification

Introduction

Over the 2 decades since one of us coauthored "Mojave rattlesnake (*Crotalus scutulatus scutulatus*) identification,"[1] it has become apparent that distinguishing *C scutulatus* (Mohave rattlesnake[2]), particularly from sympatric *Crotalus atrox* (western diamond-backed rattlesnake), is more complex than originally thought. After little initial interest in the original paper, it has attracted considerable recent attention, accumulating >900 reads on researchgate.net since 2014 and recently adding approximately 12 reads per week. Two additional decades of research combined with the aforementioned interest argue for an updated and expanded treatment of the subject. Herein, we explain that there is no single observable trait that will reliably identify *C scutulatus* or differentiate the species from others. Consequently, the most reliable visual identifications are based on evaluation of multiple traits, all of which are variable to some extent.

C scutulatus is distributed across much of the arid southwestern United States and deep into mainland Mexico, and its range overlaps largely with *C atrox* (Figure 1). *C scutulatus* is well known for venom that contains a presynaptic PLA_2 neurotoxin named Mojave toxin.[3] Yet in a large area of south-central Arizona (as well as some parts of Mexico), *C scutulatus* produces venom that lacks Mojave toxin but contains tissue-

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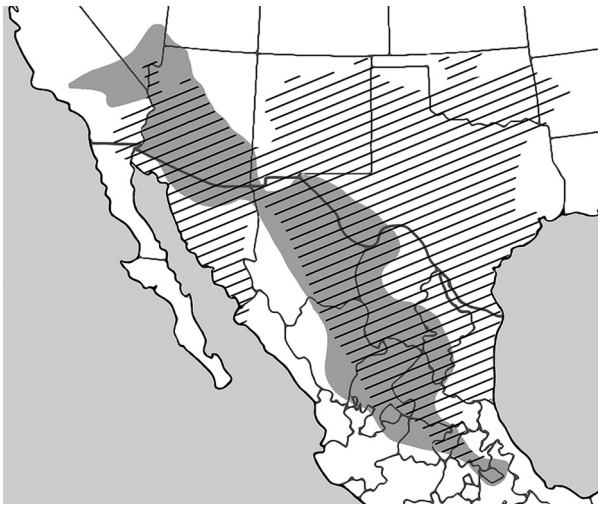

Figure 1. Distribution of *Crotalus scutulatus* (shaded area) and of *Crotalus atrox* (cross-hatched area).

destroying and hemorrhagic snake venom metalloproteinases (SVMPs) and other biologically active proteins and peptides, like *C atrox* and many other pitvipers.[4-7]

Extensive gene flow has been demonstrated between adjacent Arizona populations of *C scutulatus* with neurotoxic venom (venom-A[4] and type II[8]) and those without neurotoxin but rich in SVMPs (venom-B[4] and type I[8]), yet neither venom type appears to be spreading into the other population.[7] The poorly defined intergrade zone contains some animals that express both Mojave toxin and SVMPs, termed venom-A+B.[6,7,9]

Venomous snakes produce an average of about 6 annual fatalities in the United States, many of which occur outside the range of *C scutulatus*,[10] yet the species has a widespread but undeserved reputation for being especially deadly despite dozens of annual bites that rarely produce fatalities.[11] Anecdotal, misquoted, and sometimes fabricated accounts of *C scutulatus* hybrids are common in social media, on the Internet, and occasionally in the mainstream news media.[11] Yet despite decades of searching for wild hybrid rattlesnakes by multiple investigators, some looking for genetic evidence, only 1 small population of wild hybrids involving *C scutulatus* has been found: a well-established population of *C scutulatus* x *viridis* (Mohave x prairie rattlesnake) hybrids in Hidalgo County, New Mexico.[12] Like the intermediate venom-A+B animals in Arizona, most Hidalgo County hybrids express both Mojave toxin and SVMPs in their venom. Yet many of the traits previously suspected of indicating hybrids elsewhere have been shown by repeated investigations to be variations in unhybridized animals.[12-14]

We provide an updated assessment of how various traits compare between *C scutulatus* and *C atrox*. Additionally, we include distinguishing features of 3 other species that are occasionally, but less frequently, misidentified as *C scutulatus*: *Crotalus molossus* (western black-tailed rattlesnake) and *Crotalus ornatus* (eastern black-tailed rattlesnake), which are broadly sympatric with *C scutulatus* in Arizona, New Mexico, and Texas; and *Crotalus viridis* (prairie rattlesnake), which is sympatric with *C scutulatus* in New Mexico and Texas (summarized in Table 1). Note, however, that our identification guidelines are confined to United States populations. Some Mexican populations, especially of *C scutulatus* and *C molossus*, differ substantially from their US conspecifics, especially in color and pattern.

Safety Concerns

Live rattlesnakes can strike nearly their entire length. Dead rattlesnakes and even severed heads may reflexively bite and envenomate if handled even several hours after death.[15-17] Some snakebite patients or their companions occasionally bring the snake that delivered the bite to the emergency department. Live rattlesnakes should generally not be allowed into ambulances or clinics. Opening a container holding a live rattlesnake is extraordinarily dangerous. Apparently dead rattlesnakes should be manipulated with tools longer than the snake, and severed heads should never be manipulated by hand, even with gloves.

Countless references, both popular and scholarly, describe identifying characteristics that often include fine-scale traits that cannot be examined safely on a live rattlesnake. We have divided our comments into gross traits that can be observed and photographed from a safe distance (≥2× the length of the snake) and fine-scale traits that can be used when examining a dead snake, a high-quality photograph, or occasionally a live animal secured in a transparent glass or plastic container. In the latter case, care must be taken to avoid allowing fingers or other body parts to touch air holes and other places where a fang might protrude if the snake inside strikes. Attempting to put a live rattlesnake into a transparent container to facilitate close examination should never be considered.

Gross Identifying Characteristics

The tail of nearly all rattlesnakes terminates in a hard keratinous “rattle.” Baby rattlesnakes have a single hard button, like the eraser on a pencil. Older rattlesnakes have segmented rattles of varying lengths. Rattlesnakes with

Table 1. Comparison of most significant distinguishing traits with (corresponding figures noted)

Trait	*Crotalus scutulatus*	*Crotalus atrox*	*Crotalus molossus/Crotalus ornatus*	*Crotalus viridis*
Greenish color	Sometimes	No	Sometimes	Often
Pattern speckling	Little or none (2A)	Obvious, coarse and fine (2B)	Little or none	Little or none
Tail color and caudal rings	Dark gray, black, or brown rings on pale gray or white background (3)	High-contrast black rings on white background (4)	Tail uniformly black, gray, or dark brown, with occasional faint pale rings (5A)	Narrow dark and pale rings, same colors as dorsum, with little or no whitish color (6A)
Proximal rattle segment	Yellow or bicolor (yellow and black) (3,8A)	Black with occasional brush of white (4,8B)	Black (5A)	Black (6A)
Pale postocular stripe	Passes above the mouth (7A)	Intersects the mouth (7B)	Absent (5B)	Passes above the mouth (6B)
Crown scales	Large and irregular, spilling out onto parietal area (10)	Small and granular, indistinct from parietal area (11)	Large and square anteriorly, others small and uniform	Small and granular, indistinct from parietal area

deformed or missing rattles, caused by either genetic deformity or trauma, are encountered on rare occasions. Invariably, such deformed rattlesnakes have a blunt stub for a tail, with or without a deformed rattle. Even the so-called "rattleless" rattlesnake, *Crotalus catalinensis*, has a single rattle segment on a blunt tail. Thus, regardless of potentially atypical color or markings, no sympatric rattlesnake has a tapered pointed tail.

C scutulatus is a heavy-bodied snake, with typical adults averaging about 60 to 90 cm in length with a single row of large, roughly diamond-shaped blotches along the dorsal midline, an unmarked white or pale-yellow ventral surface, and alternating dark and pale rings on the tail. The greatest verified length is 124 cm. Neonates are perfect miniatures of the adults, averaging about 29 cm long.[11,14] *C atrox* looks broadly similar, and most adults are similar in size to *C scutulatus*, although *C atrox* can be much larger (largest recorded=226 cm).[18] *C molossus* and *C ornatus* are similar to *C scutulatus* in size and body shape, but with high-contrast dark dorsal blotches that are less diamond-shaped compared to *C scutulatus* and *C atrox*.[19] *C viridis* is similar in appearance but with more rounded dorsal blotches that are more widely spaced.[20]

DORSAL COLOR AND MARKINGS

The dorsal color of *C scutulatus* sometimes features a greenish tinge, although some animals are shades of brown, tan, gray, or even yellowish, with little or no green. The dorsal blotches typically consist of dark centers, surrounded by a single row of darker scales, with an outer margin of pale scales, all on a medium-toned background. Significantly, there is little speckling within the dorsal blotches and the colored margins are well defined, resulting in a crisp, clean pattern. The monochrome light and dark scales of the blotch edges usually give the blotches a characteristically serrated outline (Figure 2A).

The dorsal color of *C atrox* is typically a mixture of brown, tan, or gray, often blending into an orange or salmon tint near the tail. In some animals, the entire body has an orange/pink tint. Significantly, however, the authors know of no *C atrox* with a greenish dorsal color. The shape of the dorsal blotches is less well defined than in *C scutulatus*. Dark scales occur within the blotches, making the inner dark margins poorly demarcated. Some scales of the posterior portion of the pale outer margins are usually partially or entirely white (Figure 2B), unlike *C scutulatus*. Overall, the impression is often of a rather faded, washed-out pattern.

C molossus and *C ornatus* are highly variable, with background colors ranging from gray to greenish, brown, or bright yellow, with darker dorsal blotches that seldom

Figure 2. Typical dorsal colors and markings of most *Crotalus scutulatus* (A) and *Crotalus atrox* (B). Top is cranial. Although colors of individuals of both species may be darker or paler and some *C scutulatus* are not greenish, *C atrox* may be many shades of gray, brown, and pink, but not greenish, posterior margins of diamonds are edged in white, and the pattern is notably more speckled with poorly defined margins.

touch or overlap and tend to be elongated laterally. The blotches consist of a dark outline with a center of the same color as the background, and at least those on the caudal two-thirds of the body extend laterally toward the ventral surface via narrow dark zigzag bars. The blotches may have light outer edges, but these are often

Figure 3. Selection of typical caudal markings of *Crotalus scutulatus.*

Figure 4. Selection of typical caudal markings of *Crotalus atrox.*

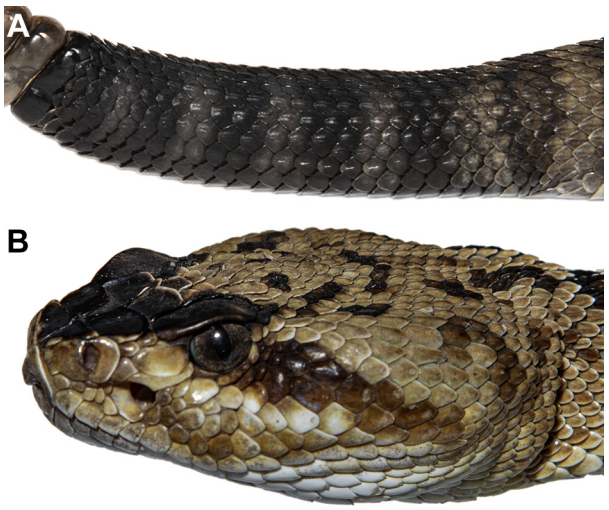

Figure 5. *Crotalus molossus*, showing faint pale caudal rings found on some animals (A) and lack of a pale postocular stripe (B). Both traits also apply to *Crotalus ornatus.*

poorly defined. Individual scales are usually monochrome, giving a serrated or pixelated outline to all pattern elements. The dorsal color of *C viridis* is usually dominated by olive green and/or brown, with rather oval or hexagonal dark dorsal blotches, usually with a thin pale outline. Greenish specimens of all 3 species are sometimes confused with *C scutulatus* owing to the mistaken belief that any greenish rattlesnake must be *C scutulatus*, stemming from the common moniker "Mohave green rattlesnake."

Figure 6. *Crotalus viridis*, showing narrow caudal rings of the same colors as the body (A) and the distinct pale postocular stripe (B) passing above the corner of the mouth.

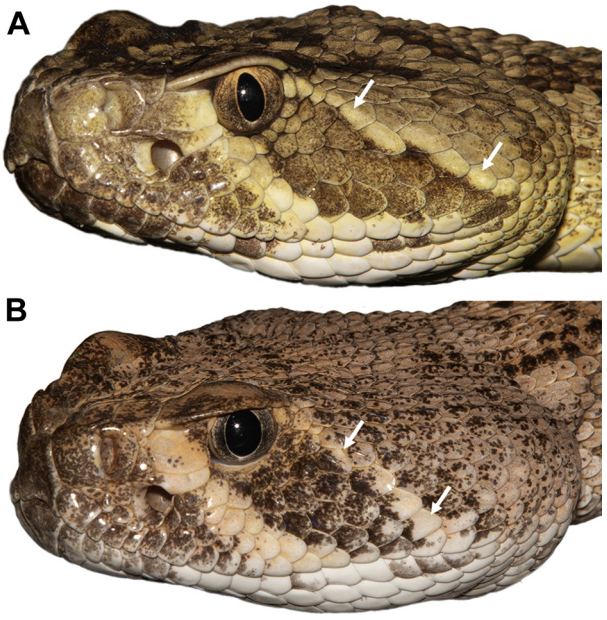

Figure 7. Facial markings of *Crotalus scutulatus* (A) and *Crotalus atrox* (B). Note that the postocular pale stripe (arrows) passes above the corner of the mouth in *C scutulatus* but intersects the mouth in *C atrox.*

Nonetheless, variations in pattern can complicate identification. Distorted, merged, and fragmented dorsal blotches are common in the nuchal area of all 5 species and, occasionally, elsewhere on the animals. Some of these variations occur regionally but are outside the scope of this account. On extraordinarily rare occasions, striped, patternless, and leucistic individuals have been encountered.

CAUDAL COLOR AND MARKINGS

The width of alternating dark and pale caudal rings is commonly suggested to distinguish between *C scutulatus* and *C atrox*, yet this trait is quite variable. Although popularly described as "rings," these markings frequently do not extend across the ventral surface of the tail in both species. Furthermore, the dark rings are often fragmented, incomplete, and sometimes offset at the dorsal midline. In *C scutulatus*, the pale color on the tail may be various shades of gray but is occasionally nearly white or even tan. The dark rings may be black, dark gray, or brownish and are usually considerably narrower than the pale spaces between them, but their number, spacing, and width are highly variable (Figure 3).

Caudal rings in *C atrox* usually consist of a bright white background and pure black rings, often about as wide as the white spaces between them. However, the

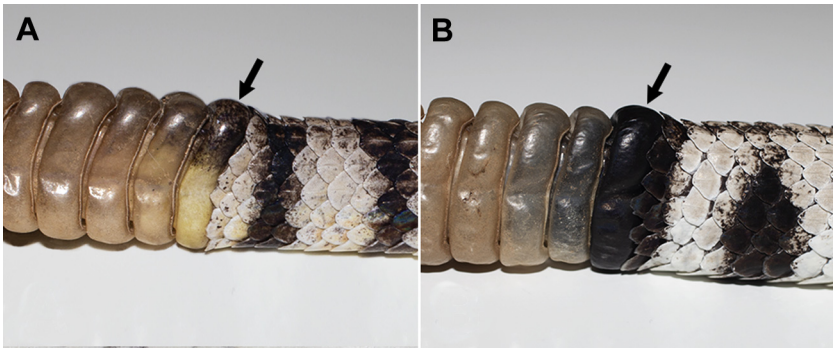

Figure 8. Live tissue is visible within the proximal rattle segment (arrows). Proximal rattle segment is light yellow or bicolor (yellow and black) in *Crotalus scutulatus* (A) but usually entirely black in *Crotalus atrox* (B).

shape and spacing of the black markings are inconsistent (Figure 4).

As their common names suggest, *C molossus* and *C ornatus* have uniformly black, brown, or dark smokey gray tails, sometimes with faint narrow pale rings (Figure 5A), especially in juveniles. The overall impression is invariably of a dark, relatively uniform tail. The dark tail alone separates them unmistakably from *C atrox* and *C scutulatus*. The tail of *C viridis* bears narrow alternating rings of the same colors as the dorsal body, with the dark body blotches morphing into dark caudal rings separated by background body color (Figure 6A).

FACIAL MARKINGS

Both *C scutulatus* and *C atrox* bear 2 pale facial stripes bilaterally, one originating just anterior to the eye and the other just posterior, termed preocular and postocular stripes, respectively. Both stripes sweep down and extend caudally. The postocular stripe passes above the corner of the mouth and sometimes extends horizontally beyond the mandibles in *C scutulatus* (Figure 7A) but drops down and intersects the mouth in *C atrox* (Figure 7B). However, it is not uncommon in both species for the postocular stripe to pass very close to or contact the corner of the mouth, which is complicated by the exact extent of the closed mouth being difficult to discern from a safe distance.

An indistinct pale preocular stripe may be visible on *C molossus* and *C ornatus,* but these species lack the pale postocular stripe (Figure 5B). *C viridis* bears a pale postocular stripe (Figure 6B) similar to that of *C scutulatus*, rendering the trait useless in differentiating between them.

COLOR OF PROXIMAL RATTLE SEGMENT

The newest rattle segment is found at the base of the rattle and contains live tissue. The color of the live tissue in the proximal segment is visible and usually bicolor (pale yellow and black) or entirely pale yellow in *C scutulatus* (Figures 3 and 8A). In adult or sub-adult *C atrox*, the proximal segment is entirely black, sometimes with a faint superficial brush of white (Figures 4 and 8B). However, the proximal segment of neonates and juveniles of *C atrox* (1–3 rattle segments) are pale, sometimes

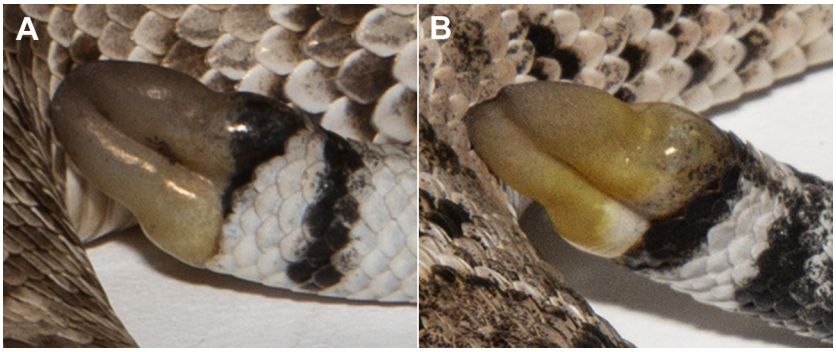

Figure 9. First rattle segments of neonate *Crotalus scutulatus* (A) and *Crotalus atrox* (B).

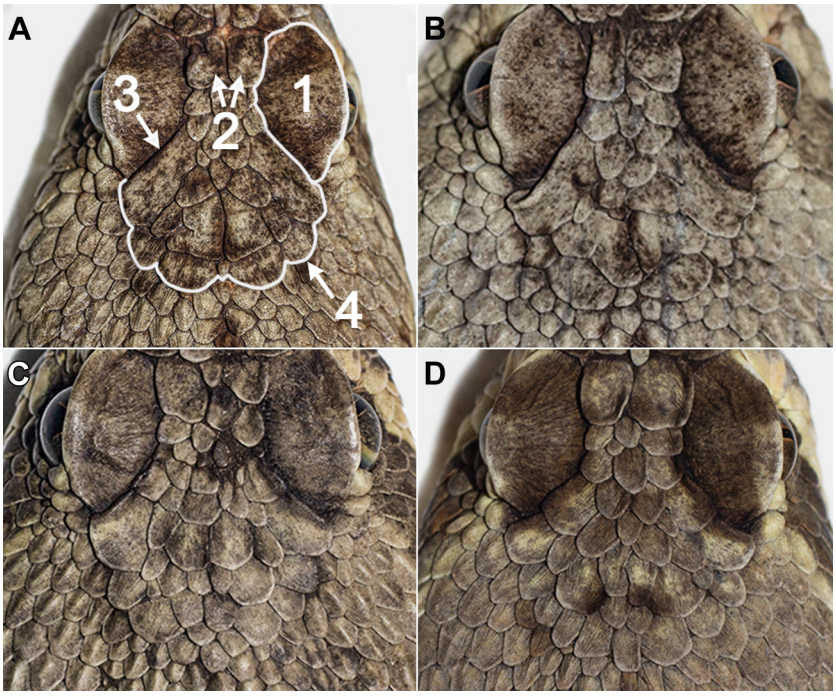

Figure 10. Crown scales on *Crotalus scutulatus* are highly variable in size, shape, number, and arrangement. Terminology (A): right supraocular scale (1), fewest crown scales separating supraoculars (2), deep furrow where enlarged crown scales overlay the supraocular (3), and posterior margin of enlarged crown scales (4). Two scales separating supraoculars (B). Three scales separating supraoculars (C). Enlarged crown scales more evenly shaped, sized, and blended than usual (D).

yellowish or reddish (Figure 9B). *C molossus*, *C ornatus*, and *C viridis* have black proximal rattle segments (Figures 5A and 6A).

Figure 11. Typical crown scales of *Crotalus atrox*. Although there are often a few irregularly sized and shaped scales, especially anteriorly, most crown scales are small and similar in size and shape to scales on the parietal region. Note the distinct dark speckling on the scales compared to *Crotalus scutulatus* (Fig. 10).

Fine-Scale Identifying Characteristics

Do not attempt examination on a live rattlesnake.

CROWN SCUTELLATION

Two large crown scales separating the supraocular scales are commonly listed as diagnostic for *C scutulatus*, yet the supraoculars are separated by 3 and occasionally 4 scales in about 14% of individuals[14] (Figure 10). The crown scales of *C atrox* and *C viridis* are more granular, with at least 4 and usually many more scales separating the supraoculars (Figure 11).

Although the small scales between the supraoculars of *C atrox* and *C viridis* merge relatively seamlessly with similar scales in the parietal region, the enlarged crown scales of *C scutulatus* are irregular in shape and size and fan out onto the parietal region of the head. Additionally, in *C scutulatus*, the medial edges of the supraoculars tuck under the enlarged crown scales, forming a deep, dark furrow (Figure 10) that is missing in most or all *C atrox* (Figure 11) and *C viridis*.

C molossus and *C ornatus* have a series of large, squarish scales on the crown forward of the eyes and the supraoculars are separated by 2 large scales

nearest the rostrum, but they lack the "fan" of enlarged crown scales extending onto the parietal region.

FINE SPECKLING ON SCALES

Many dorsal scales on *C atrox* are multicolored, with most bearing many dark speckles of varying sizes. Dorsal scales on *C scutulatus*, as well as *C molossus* and *C ornatus*, are generally monochromatic with little or no speckling. In *C viridis*, some features like the pale outlines of dorsal blotches cut across individual scales.

Conclusions

Determining whether a particular rattlesnake is *C scutulatus* or *C atrox* can be challenging, with distinction from *C molossus*, *C ornatus*, and *C viridis* being somewhat less so. All identifying traits are variable, and some highly so. Despite ample rumors, wild hybrid rattlesnakes are very rare, with variation in identifying characters being common in genetically pure animals of all species. On extraordinarily rare occasions, aberrant individuals of each species have been encountered, including striped, patternless, and leucistic animals,[11,14] but no sympatric rattlesnake has a tapered pointed tail.

In general, *C scutulatus* sometimes displays a greenish tinge, its dorsal pattern is well defined with little or no speckling, the pale postocular facial stripe sweeps rearward and usually does not intersect the mouth, caudal rings tend to be alternating shades of pale gray with narrower dark gray, and the proximal rattle segment is partially or entirely pale yellow.

C atrox is not greenish in color, margins in the dorsal pattern appear ragged or washed out with heavy speckling, the pale postocular facial stripe intersects the mouth, caudal rings are usually high-contrast black and white, and the proximal rattle segment is usually entirely black (in all but very small animals) with an occasional faint brush of white.

C molossus and *C ornatus* have uniformly dark tails, sometimes with faint narrow pale rings, and black proximal rattle segments. *C viridis* has widely separated ovoid dorsal blotches, tails ringed in the same colors as the dorsum, and black proximal rattle segments.

Although determining which species is involved can be helpful in evaluating the potential clinical course of an envenomation, specific identification is not necessary for antivenom selection, and clinicians must remain alert and prepared for unexpected sequelae. Attempting to identify a live rattlesnake is potentially dangerous, and the risk almost always outweighs any perceived benefit. Well-focused digital photographs taken by the patient or bystanders and transmitted to a poison control center can often be quickly identified by a consulting herpetologist.

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