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Rediscovery and redescription of the holotype of *Crotalus concolor* (Midget-faded Rattlesnake)

Angus Woodbury (1886–1964), a prolific zoologist and naturalist, formally described a new rattlesnake species, *Crotalus concolor*, in 1929 in the Bulletin of the University of Utah (Woodbury 1929). A female specimen, which became the holotype designating the species, was collected at the Henry Mountains, a remote region of southeastern Utah. While no common name was attached to the specimen in the original publication, Woodbury claimed that the species was often called the "Yellow Rattlesnake" by local cowboys. Both its size and muted coloration suggest its contemporary common name: Midget-faded Rattlesnake (Crother 2017).

The Midget-faded Rattlesnake is relatively small, with its total length (TL) ranging from 650 mm to 760 mm (Travsky and Beauvis 2004; Powell et al. 2019); rarely, larger individuals are reported. The record size is a TL of 910 mm (McGinnis and Stebbins 2018). Its venom is more lethal than closely related species and is neurotoxic (Glenn and Straight 1977; Mackessy et al. 2003). The coloration is variable throughout the species' distribution, as individuals may be pale brown, yellow, straw, cream, gray, and sometimes pink or orange. Individuals may have a pale postocular stripe greater than or equal to two scales wide. Still, it is not uncommon to find some individuals, particularly older ones, where the stripe is poorly defined or absent (Powell et al. 2019). The body blotches may not be distinct or present in all specimens, either. When present, the blotches are usually "diamond-shaped or elliptical, [and] if rectangular, edges rough or serrated without narrow light borders" (Powell et al. 2019). The scale row count is 23–25 at mid-body (Travsky and Beauvis 2004; McGinnis and Stebbins 2018). The distribution of this species is primarily restricted to the Colorado Plateau of eastern to southeastern Utah, western Colorado, southwestern Wyoming, and perhaps even northern Arizona (Feldner et al. 2016).

Taxonomically, there has been much back-and-forth debate on the species' designation (Feldner et al. 2016). As previously noted, Woodbury (1929) originally described the species as *Crotalus concolor*. Klauber (1930) described it as *Crotalus confluentus decolor* because he believed the trivial name *concolor* was already taken. This dispute is documented in a series of letters, where Woodbury and Smith (1951) suggested *concolor* as the proper trivial name. In response, Klauber (1951) pointed out that the trivial name *concolor* may have been used previously by Notestein (1905), where he used *cincolor* rather than *concolor*, which Klauber thought was a misspelling; in his notes, he humorously indicated that there were numerous other typographical errors in that document. Consequently, Woodbury and Smith (1951) agreed that *decolor* should be used.

In light of changing taxonomy, Klauber (1956, 1972) renamed the species as *Crotalus viridis decolor*, a subspecies of the Western Rattlesnake (*Crotalus v. viridis*). Decades later, genetic analyses (mtDNA sequence data) were performed, and these results suggested that the Prairie Rattlesnake (C. *viridis*) and its subspecies be split into two distinct lineages: a western group (*C. oreganus* and subspecies) and the Prairie Rattlesnake (*C. viridis* and one subspecies; Pook et al. 2000; Ashton and de Queiroz 2001); consequently, the Midget-faded Rattlesnake

Fig. 1. *Crotalus concolor* holotype within (A) and outside (B) its jar.

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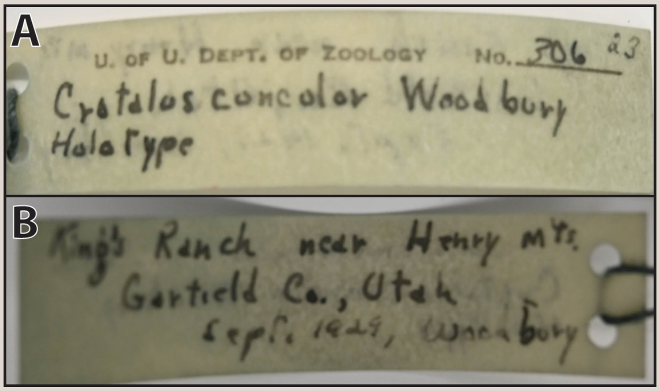

Fig. 2. The front (A) and reverse (B) sides of the *Crotalus concolor* holotype tag.

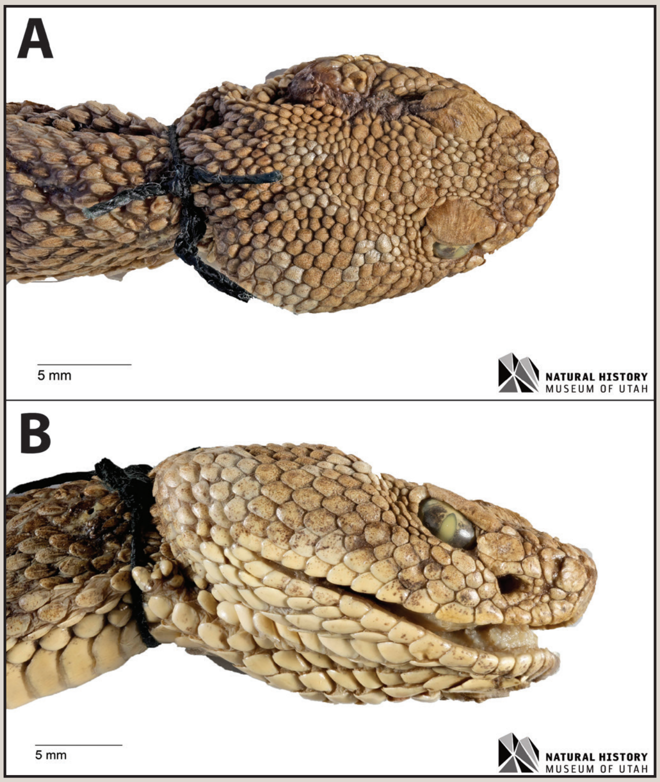

Fig. 3. Dorsal (A) and lateral (B) views of the *Crotalus concolor* holotype. Note the yellow coloration, lack of a distinct postocular stripe, and the conspicuous mark posterior to the left eye.

was redesignated as *C. oreganus concolor* by Ashton and de Queiroz (2001). Subsequent mtDNA analysis by Douglas et al. (2002) was in agreement with the split but suggested that all subspecies of the western group, which included *C. concolor*, be elevated to full species, hence returning Woodbury's original binomial name of *Crotalus concolor* (Douglas et al. 2002, see table 3, p. 38). The most recent analysis of this group of snakes using mtDNA and geometric morphological analysis supports Douglas et al. (2002) in using full species designations for nearly all taxa previously designated as subspecies (Davis et al. 2016; see Uetz et al. 2022). Whether the taxon should be recognized as a full species or subspecies is beyond the scope of this paper. We follow the naming recommendations by Powell et al. (2019) and Uetz et al. (2022) but remain agnostic, as further analysis of molecular, morphological, and ecological data are needed to delimit species (Davis 2016).

This complex history of taxonomic treatment foregrounds the work that led to finding the lost *C. concolor* holotype. Holotypes are essential voucher specimens used to describe and designate new species. Voucher specimens serve as the physical evidence of an organism that occurred at a specific place and time and are essential for verifying and repeating organismal research (Turney et al. 2015). Moreover, preserving voucher specimens is critical for describing new species so that future researchers may re-examine the original holotype in the context of new findings (e.g., molecular and morphological). Natural history collections are the primary repositories responsible for storing and protecting these specimens and their associated data for future study. As natural history collections grow, facilities and storage containers require upgrading, and occasionally specimens are misplaced or lost (Holycross et al. 2008).

In March of 2021, we began re-curating and digitizing rattlesnake specimens to aid ongoing conservation planning through the Utah Division of Wildlife Resources (UDWR). Nearly all of the *C. concolor*, *C. lutosus*, *C. oreganus*, and *C. viridis* specimens at the Natural History Museum of Utah (UMNH) were examined to ensure they were properly identified and that their information (e.g., locality data) was accurate and available through the Arctos Database (www.arctos.database.museum/) and the biodiversity data aggregators VertNet (www.vertnet.org/) and GBIF (www.gbif.org/). Maintaining accurate and detailed specimen records that are accessible online extends the use of the specimens across different disciplines and institutions (Hedrick et al. 2020).

At this same time, we became aware that the Reptile Database's species account for *C. concolor* noted that the holotype was believed lost. We were aware that the specimen should be at UMNH, and we managed to locate it in early 2021. It was stored separately from the rest of the rattlesnake collection, preserved in ethanol in a jar along with its original holotype label and a faded reddish-orange ribbon attached to the jar (Figs. 1, 2). After locating the lost holotype, we shared this information with Peter Uetz of the Reptile Database; the Reptile Database is updated periodically and no longer lists the specimen as lost.

Here, we redescribe the *C. concolor* holotype (UMNH:Herp:306; https://arctos.database.museum/guid/UMNH:Herp:306; Fig. 2) following the description in Woodbury (1929) as a guide (new photographs of the specimen and Woodbury's original publication are available on Arctos via this link). We measured the specimen's TL and found it to be 71.57 cm, slightly longer than Woodbury's original 70 cm description. The tail length was 5.02 cm. We counted the mid-body scale rows as 25, which agrees with the original description. The ventral scales, which Woodbury describes as "abdominal plates," were 175, and the caudal scales were 25; both match the description in Woodbury (1929). Because fluid-preserved specimens may change color over time from light exposure or other factors, we could not confidently evaluate the original description of dark rhombs on the specimen.

One interesting observation from our work is how the natural history drawing of *C. concolor* in Woodbury (1929) is not an exact representation of the holotype. The specimen has a conspicuous marking or injury on its head, evident in Woodbury's original specimen photographs (https://arctos.database.museum/publication/10010639). Other asymmetrical features of the specimen are noted in the drawing, but not this mark (see Fig.

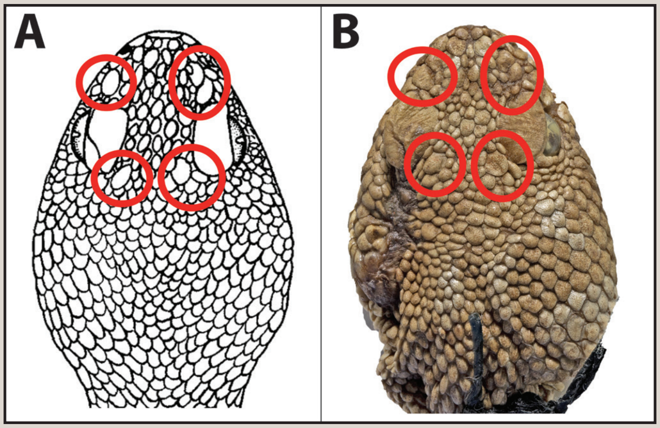

Fig. 4. Original illustration from Woodbury (1929) (A) and the *Crotalus concolor* holotype (B). The illustration does not indicate the mark on the holotype behind the left eye. However, the illustration features several unique scale patterns circled for comparison.

4). We speculate that Woodbury may have drawn the specimen to maintain some degree of symmetry, which may have been the natural history illustration standard at the time. Drawings, paintings, and photographs are sometimes valuable sources of information for species descriptions (Deepak et al. 2021; Mirza et al. 2021). We highlight this discrepancy to show that while representations or drawings can be useful, they may not accurately represent the specimen.

Another observation from our work with the UMNH *C. concolor* specimens is that the holotype does not match some diagnostic criteria used in identification manuals. For example, Powell et al. (2019) utilize two main couplets to identify the species, which are in many ways similar to what was reported in Klauber (1956). In the first, the main criteria for the description are a light postocular stripe greater than or equal to two scales wide and dorsal blotches; both may be indistinct or absent (Powell et al. 2019). In the second, body-color straw, cream, or yellowish, small size (<650 mm TL), and locality ("Colorado and Green river drainages in southwestern Wyoming, eastern Utah, and western Colorado") are used (Powell et al. 2019). The holotype matches the coloration, the lack of blotches, the locality, and color, but it lacks a distinct postocular stripe (Fig. 3) and is longer than 650 mm.

Although the holotype lacks some of the diagnosed characters used by Powell et al. (2019), this is not necessarily a problem, as holotypes need not be typical of the taxa in question, particularly if geographic variation exists. Furthermore, Powell et al. (2019) mention the locality as a diagnostic criterion for this and related taxa. We draw attention to the specimen to show how it may be useful for designing future keys that highlight other criteria. Depending on the specimen or photograph needing identification, the locality may be the most important criterion for discriminating whether the organism is a *C. concolor* or some other species.

We hope that the rediscovery of this holotype draws attention to an interesting rattlesnake species and the role museums provide in storing biological information. Natural history collections serve as essential infrastructure supporting organismal research and providing the information necessary for robust taxonomic assessment, which is crucial for guiding conservation and species management decisions made by wildlife stakeholders (Drew 2011). Insofar as this specimen was thought lost and other specimens were properly identified during our work on the rattlesnake collection, we believe there is substantial value in continued attention to previously collected specimens.

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Literature Cited

Ashton, K. G., and A. de Queiroz. 2001. Molecular systematics of the western rattlesnake, *Crotalus viridis* (Viperidae), with comments on the utility of the D-loop in phylogenetic studies of snakes. Mol. Phylogenet. Evol. 21:176–189.

Crother, B. I. (ed.). 2017. Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, with Comments Regarding Confidence in Our Understanding. Eighth edition. Society for the Study of Amphibians and Reptiles Herpetological Circular 43. 102 pp.

Davis, M. A. 2016. The western rattlesnake complex: 200 years of intrigue and change. *In* Schuett, G. W., M. J. Feldner, C. F. Smith, and R. S. Reiserer (eds.), Rattlesnakes of Arizona: Species Accounts and Natural History, Volume 1, pp. 39–43. ECO Publishing, Rodeo, New Mexico.

———, M. R. Douglas, M. L. Collyer, and M. E. Douglas. 2016. Deconstructing a species-complex: geometric morphometric and molecular analyses define species in the western rattlesnake (*Crotalus viridis*). PLoS ONE 14:e0146166.

Deepak, V., S. Narayanan, P. P. Mohapatra, S. K. Dutta, G. Melvinselvan, A. Khan, K. Mahlow, and F. Tillack. 2012. Revealing two centuries of confusion: new insights on nomenclature and systematic position of *Argyrogena fasciolata* (Shaw, 1802)(auctt.), with description of a new species from India (Reptilia: Squamata: Colubridae). Vertebr. Zool. 71:253–316.

Drew, J. 2011. The role of natural history institutions and bioinformatics in conservation biology. Conserv. Biol. 25:1250–1252.

Douglas, M. E., M. R. Douglas, G. W. Schuett, L. W. Porras, and A. T. Holycross. 2002. Phylogeography of the western rattlesnake (*Crotalus viridis*) complex, with emphasis on the Colorado Plateau. *In* Schuett, G. W., M. Hoggren, M. E. Douglas, and H. W. Greene (eds.), Biology of the Vipers, pp. 11–50. Eagle Mountain Publishing, Eagle Mountain, Utah.

Glenn, J. L. and R. Straight. 1977. The midget faded rattlesnake (*Crotalus viridis concolor*) venom: lethal toxicity and individual variability. Toxicon 15:129–132.

Hedrick, B. P., J. M. Heberling, E. K. Meineke, K. G. Turner, C. J. Grassa, D. S. Park, J. Kennedy, J. A. Clarke, J. A. Cook, D. C. Blackburn, S. V. Edwards, and C. C. Davis. 2020. Digitization and the future of natural history collections. BioScience 70:243–251.

Holycross, A. T., T. G. Anton, M. E. Douglas, and D. R. Frost. 2008. The type localities of *Sistrurus catenatus* and *Crotalus viridis* (Serpentes: Viperidae), with the unraveling of a most unfortunate tangle of names. Copeia 2008:421–424.

Feldner M. J., G. W. Schuett, and J. M. Slone. 2016. Midget faded rattlesnake *Crotalus concolor* (Woodbury 1929). *In* Schuett, G. W., M. J. Feldner, C. F. Smith, and R. S. Reiserer (eds.), Rattlesnakes of Arizona: Species Accounts and Natural History, Volume 1, pp. 179–238. ECO Publishing, Rodeo, New Mexico.

Klauber, L. M. 1930. New and renamed subspecies of *Crotalus confluentus* Say, with remarks on related species. Trans. San Diego Soc. Nat. Hist. 6(3):95–144.

———. 1951. On the question of the correct trivial name for the yellow or midget rattlesnake of the Colorado River Basin. Bull. Zool.

Nomencl. 6(4):101.
———. 1956. Rattlesnakes: Their Habits, Life Histories, and Influence on Mankind, Volumes 1 and 2. University of California Press, Berkeley, California. xxix + xvii + 1476 pp.
———. 1972. Rattlesnakes: Their Habits, Life Histories, and Influence on Mankind, Volumes 1 and 2. Second edition. University of California Press, Berkeley, California. xxix + xvii + 1476 pp.
Mackessy, S.P., K. Williams, and K. G. Ashton. 2003. Ontogenetic variation in venom composition and diet of *Crotalus oreganus concolor*: a case of venom paedomorphosis? Copeia 2003:769–782.
McGinnis, S. M., and R. C. Stebbins. 2018. Peterson Field Guide to Western Reptiles and Amphibians. Fourth edition. Houghton Mifflin Harcourt Publishing Company, New York, New York and Boston, Massachusetts. xi + 560 pp.
Mirza, Z. A., V. K. Bhardwaj, and H. Patel. 2021. A new species of snake of the genus *Oligodon* Boie in Fitzinger, 1826 (Reptilia, Serpentes) from the Western Himalayas. Evol. Syst. 5:335–345.
Notestein, F. N. 1905. The ophidia of Michigan with an analytical key. Ann. Rep. Michigan Acad. Sci., 7th Rep.:111–125.
Pook, C. E., W. Wüster, and R. S. Thorpe. 2000. Historical biogeography of the western rattlesnake (Serpentes: Viperidae: *Crotalus viridis*), inferred from mitochondrial DNA sequence information. Mol. Phylogenet. Evol. 15:269–282.
Powell, R., J. T. Collins, and E. D. Hooper, Jr. 2019. Key to the Herpetofauna of the Continental United States and Canada. Third edition, revised and updated. University Press of Kansas, Lawrence, Kansas. viii + 172 pp.
Travsky, A., and G. P. Beauvais. 2004. Species assessment for the midget faded rattlesnake (*Crotalus viridis concolor*) in Wyoming. U.S. Department of the Interior Bureau of Land Management, Wyoming State Office.
Turney, S., E. R. Cameron, C. A. Cloutier, and C. M. Buddle. 2015. Non-repeatable science: assessing the frequency of voucher specimen deposition reveals that most arthropod research cannot be verified. PeerJ 3:e1168.
Uetz, P., Freed, P., and Hošek, J. 2022. The Reptile Database. www.reptile-database.org. Accessed 21 March 2022.
Woodbury, A. M. 1929. A new rattlesnake from Utah. Bulletin of the University of Utah 20(6): 2–4.
———. 1951. On the correct name for the yellow rattle-snake from the Colorado River Basin. Bull. Zool. Nomencl. 6(4):99–100.
———, and H. M. Smith. 1951. On the correct trivial name of the yellow rattlesnake of the Colorado River Basin: Supplementary Note. Bull. Zool. Nomencl. 6(4):101–102.

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Atlas of the Frogs of Libya

Continental Africa contains more than 800 species of amphibians that correspond to the distinct and largely non-overlapping faunas of North Africa and sub-Saharan Africa (Channing and Rödel 2019; Escoriza and Ben Hassine 2019). The amphibian fauna of North Africa is dominated by salamander and frog species that colonized this region from western Europe in the Late Miocene (e.g., Carranza and Arnold 2004; Escoriza et al. 2006; Busack and Lawson 2008), possibly during the Messinian Salinity Crisis when there was contiguous land between these two regions (Krijgsman et al. 1999; Roveri et al. 2014). In comparison to other countries in North Africa, the amphibian fauna of Libya has received little attention, especially during the past forty years. The meager Libyan amphibian fauna is particularly interesting because the distinct North African and sub-Saharan faunas interdigitate and possibly overlap in Libya. There are many documented populations of frogs in small, isolated water bodies scattered across the large arid regions of the country. Taken together, these indicate that Libyan amphibians provide a unique opportunity to understand the impact of dramatic climatic changes over the past 10,000 years on the water-dependent faunas in what were once extensive paleolake and paleodrainage systems (Drake and Bristow 2006; Drake et al. 2008, 2011).

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With just five species, Libya has the most species-poor amphibian fauna of the 49 countries of continental Africa (Channing and Rödel 2019). Because its reptile fauna is also among the poorest in Africa (only 63 terrestrial species), Libya has received little attention from those interested in the herpetology of North Africa (Bauer et al. 2017; Escoriza and Ben Hassine 2019). Obviously, the lack of amphibian species diversity is not surprising given that the vast majority of Libya's landscape is dominated by the Sahara Desert with few perennial inland water bodies across most of the country. Of the five anuran species recorded in Libya, most records are of two widespread species distributed across northern Africa: *Pelophylax saharicus* and *Bufotes boulengeri*. *Pelophylax saharicus* likely represents a colonization event of North Africa via the western Mediterranean (Beerli et al. 1996), but the direction from which *Bufotes* colonized this region is more ambiguous (Stöck et al. 2006). The other three species are restricted to southwestern Libya (*Hoplobatrachus occipitalis*, *Ptychadena* sp., *Sclerophrys xeros*) and represent isolated northern extensions of the fauna found in the Sahel along the southern fringes of the Sahara (Channing and Rödel 2019). While salamanders are known from neighboring Tunisia and Algeria, there are no records of salamanders from Libya (Schleich et al. 1996; Escoriza and Ben Hassine 2019).