REPTILES & AMPHIBIANS

Aberrant Coloration in Three Species of Mud Turtles (*Kinosternon*) from Western Mexico

Nadin E. López-González[1,5], Carlos Santiago Rosales-Martínez[2], José R. Garrido[3], Carlos Daniel Bello-Sánchez[4], Armando H. Escobedo-Galván[5], and Fabio G. Cupul-Magaña[5]

[1]Turtle Island, Am Katzelbach 98, 8054 Graz, Austria
[2]Justo Sierra 2807, Colonia Vallarta Norte, Guadalajara 44690, Jalisco, México
[3]Amphibian and Reptile Conservancy, 6844 Bardstown Road STE 677, Louisville 40291, Kentucky, USA
[4]Cocoteros 116-A, Fracc. Paseos Universidad II, Puerto Vallarta 48280, Jalisco, México.
[5]Centro Universitario de la Costa, Universidad de Guadalajara, Av. Universidad 203, Delegación Ixtapa, Puerto Vallarta 48280, Jalisco, México (fabiocupul@gmail.com)

In herpetology, aberrant coloration is defined as a conspicuous deviation from typical or expected coloration of the skin, scales, shells, and/or eyes (e.g., Bechtel 1995; McCardle 2012; Borteiro et al. 2021). Aberrant coloration, seemingly rare within populations, has been recorded in numerous species of reptiles, including snakes (e.g., Kolenda et al. 2017; Rivas et al. 2022; Sahu et al. 2022; Vyas 2023), lizards (e.g., Kolenda et al. 2017), alligators (e.g., Rainwater et al. 2020), and turtles (e.g., Marion et al. 1984; Devkota et al. 2020; Vittapu et al. 2022).

Recessive alleles affect the enzymes involved in the syntheses of various integumentary pigments, leading to inherited abnormal or aberrant color variation (Bechtel 1995; Mahabal and Thakur 2014). Recorded aberrant colorations in reptiles include albinism, amelanism, hypomelanism, leucism, xanthism, axanthism, piebaldism, and melanism (e.g., Bechtel 1995; Turner 2011; de Vosjoli et al. 2003; Borteiro et al. 2021). Each of these describes a specific, departure from typical coloration, as well as the underlying genes (Bechtel 1995).

Most common chromatic aberrancies are those related to the production and distribution of melanin (a black-brown pigment), mainly in the form of amelanism, hypomelanism, and melanism (Borteiro et al. 2021; van Grouw 2021). Amelanism is caused by a lack of melanin in all or parts of the skin, including the eyes, whereas in hypomelanism, melanin expression is diminished while maintaining pigmented eyes (Borteiro et al. 2021). Amelanistic individuals typically exhibit shades of yellow or gold, which are produced by xanthophores, cells containing an abundance of yellow pteridine pigments. In typically pigmented individuals, melanin creates darker pigments that interact with xanthophores to create other darker colors. In contrast, melanism is an unusual darkening of normal pigmentation due to increased melanin (Bechtel 1995; Borteiro et al. 2021; van Grouw 2021).

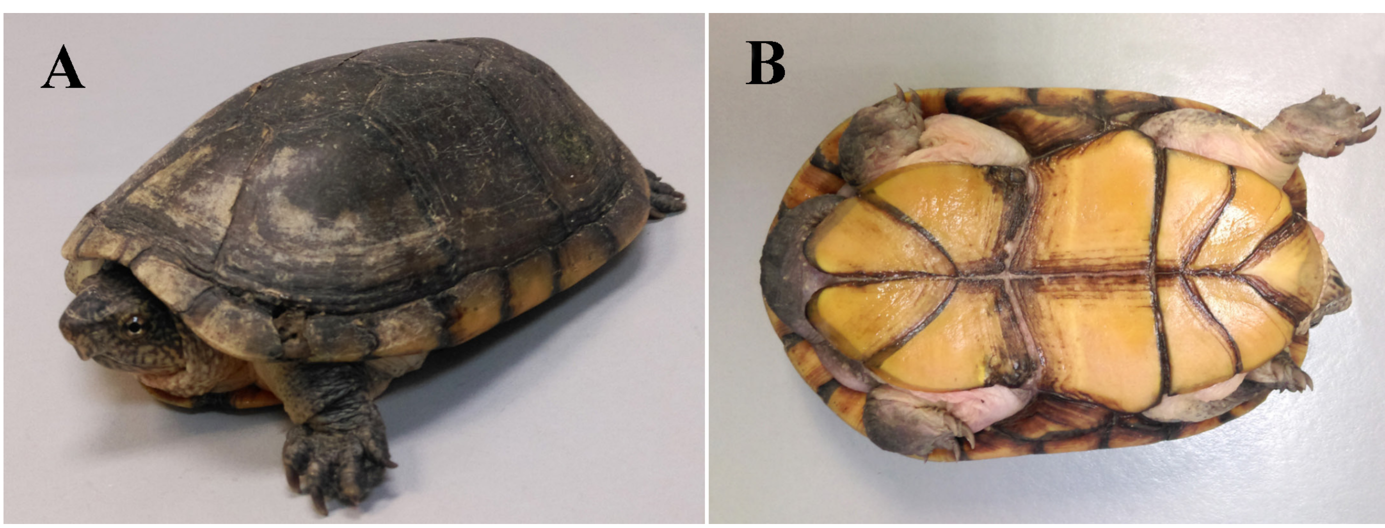

Figure 1. A typically pigmented Jalisco Mud Turtle (*Kinosternon chimalhuaca*) from Puerto Vallarta, Jalisco, Mexico: Anterodorsal view (A) and plastron (B). Photographs by Fabio G. Cupul Magaña.

Copyright is held by the authors. Articles in R&A are made available under a Creative Commons Attribution-NonCommercial 4.0 International license.

Reptiles & Amphibians ISSN 2332-4961
https://doi.org/10.17161/randa.v32i1.22785

Coloration and patterns serve several functions in animals, including camouflage and disruptive coloration, mimicry, deliberate conspicuousness such as warning coloration, effective visual signals to conspecifics, usually for reproduction, sometimes to attract prey for feeding (e.g., Bechtel 1991; Kuriyama et al. 2020). Turtles typically exhibit cryptic coloration, and some authors (e.g., Devkota et al. 2020) have suggested that aberrant coloration is likely to represent a disadvantage for affected individuals.

In mud turtles (Kinosternidae) (the name is an allusion to the aquatic habitats and bottom-dwelling behavior in these turtles; Iverson 1992), as in many other chelonians, habitat characteristics likely influence typical pigmentation (McGaugh 2008). In most kinosternids, coloration is quite cryptic in typical habitat. The carapace usually is pale gray, brown, olive, gray, orange or yellow, to almost black; skin is yellow, cream, or pale gray ventrally to gray, brown, or black dorsally; sides of the neck, head, and nasal scutes are frequently mottled, spotted, vermiculated, or reticulated; and bodies are sometimes marked with spots, circles, or lines. Although typical coloration is consistent in most species, coloration can vary widely between populations of some species (Legler and Vogt 2013).

One well-documented case of abnormal coloration in kinosternids was a xanthic juvenile Flattened Musk turtle (*Sternotherus depressus*), an Alabama (USA) endemic (Marion et al. 1984). Xanthism is typically expressed as a largely yellow-orange individual with normally pigmented eyes. Herein, we present three cases of aberrant coloration in kinosternids from the central Pacific Coast of Mexico. All descriptions of coloration follow Köhler's (2012) guidelines.

The Jalisco Mud Turtle (*Kinosternon chimalhuaca* Berry, Seidel, and Iverson 1997) occurs in the lowlands of Jalisco and Colima, Mexico (Berry et al. 1997). This species typically has a brown, olive, or tan carapace (Leger and Vogt 2013; Fig. 1A). The head is dark green to brown, with mottled bright yellow to orange-yellow or pale brown markings. Limbs and tail are brown dorsally and yellow ventrally, whereas the plastron is yellow-brown with darker seams (Legler and Vogt 2013; Fig. 1B). We encountered and photographed two individuals from the same population on 19 December 2019 (Fig. 2A–C) and 13 July 2021 (Fig. 2D–E) in a semi-urban canal

Figure 2. A hypomelanistic juvenile Jalisco Mud Turtle (*Kinosternon chimalhuaca*) (A–C) and a hypomelanistic subadult (D–E), both from the southern coast of Jalisco, Mexico. Photographs by José R. Garrido.

on the southern coast of Jalisco (exact locations are withheld due to the risk of illegal collection; Garrido et al. 2021). The first was an unsexed juvenile with a carapace length (CL) of 77.84 mm; the second was a subadult male (CL = 90.94 mm). Both differed dramatically in coloration and pattern when compared to a typical individual (Fig. 1). Central areas of the carapacial scutes of the juvenile were a light buff and surrounded by dark, fuzzy lines, marginals were substantially darker, and the ground color of the head and forelimbs was a pale sulphur yellow. The plastron bore the dark contact zones on annuli typical of kinosternids. Skin and nails were largely unpigmented, and a deep yellow on the top of the head faded to a more muted, smoky white on the underside of the neck, limbs, and anterior body. The subadult waw a golden color (dark-spectrum yellow), with radially striated patterns on the central and lateral scutes, dark contact zones, and mottled marginal scutes. The plastron also bore this radial striation, with pigment distributed smoothly across annuli, except for the innermost natal rings. As in the juvenile, skin and nails were largely unpigmented and were a pale smoky white on the head, limbs, and body. Both individuals lacked the mottling that is characteristic of this species and had dark eyes and bright white irises. The color variations, skin tones, and bright irises aligned with hypomelanism (Turner 2011).

The Mexican Mud Turtle (*Kinosternon integrum* Le Conte 1854) is widely distributed across the central and southern portions of the Mexican Plateau from Sonora to Oaxaca (Iverson et al. 1998; Legler and Vogt 2013). This species usually exhibits a carapace color ranging from olive-green to dark brown, whereas the plastron is yellow to yellow-orange. The limbs, tail, and head are typically dark brown (Legler and Vogt 2013; Loc-Barragán 2017; Fig. 3A). On 28 August 2020, we examined and photographed a captive male *K. integrum* (CL = 78.87 mm) that had been collected in Compostela, Nayarit. It had dark eyes, whitish lime-green coloration on the central, lateral, and marginal scutes of the carapace, drab-gray margins on the central and lateral scutes, and dark neutral gray margins on the lateral scutes. The head and neck bore a mottled whitish lime-green pattern, and the limbs and anterior body was a light venetian blue hue. This aberrant coloration observed likely represents hypomelanism (Fig. 3B). Both diet and substrate can influence turtle coloration in captivity, which could have triggered the observed color pattern (Rowe et al. 2006; McGaugh 2008; Steffen et al. 2021). However, this specimen had been in captivity for 15 years and, although environmental conditions can affect color patterns, the keepers noted that the yellow coloration was present when the turtle was first collected.

The Vallarta Mud Turtle (*Kinosternon vogti* López-Luna et al. 2018) has been recorded in the Ameca River Valley between Nayarit and Jalisco (López-Luna et al. 2018; Cupul-Magaña et al. 2022). This species exhibits sexual color dimorphism, with males possessing a yellow rostral shield. Typical coloration consists of a brown-olive carapace, yellow-orange plastron, brown head, and limbs and tail that are brown above and a light reddish-brown below (López-Luna et al. 2018; Fig. 4A). On 23 March 2021, we observed and photographed a female (CL = 83.00 mm; only 5 mm below minimal reproductive size reported for the species; Rosales-Martínez et al. 2022) in a natural habitat dominated by tropical subdeciduous forest in a suburban area of Puerto Vallarta. The eyes were dark, the carapace grayish-olive with the external margins of marginal scutes chamois, and the body a medium green to strong yellowish-green (Fig. 4B). This hyperpigmentation was congruent with melanism.

Our observations represent the first documented cases of hypomelanism in *K. chimalhuaca* and *K. integrum* and melanism in *K. vogti*. Melanism is a low-frequency condition in other kinosternids. For example, 18.9% of male and 11.1% of female Sonoran Mud Turtles (*K. sonoriense*) in popula-

Figure 3. A typically pigmented Mexican Mud Turtle (*Kinosternon integrum*) (A) and a hypomenalistic individual from Compostela, Nayarit, Mexico (B). Photographs by Andrés Alexander Gutiérrez Amaral (A) and Nadin E. López-González (B).

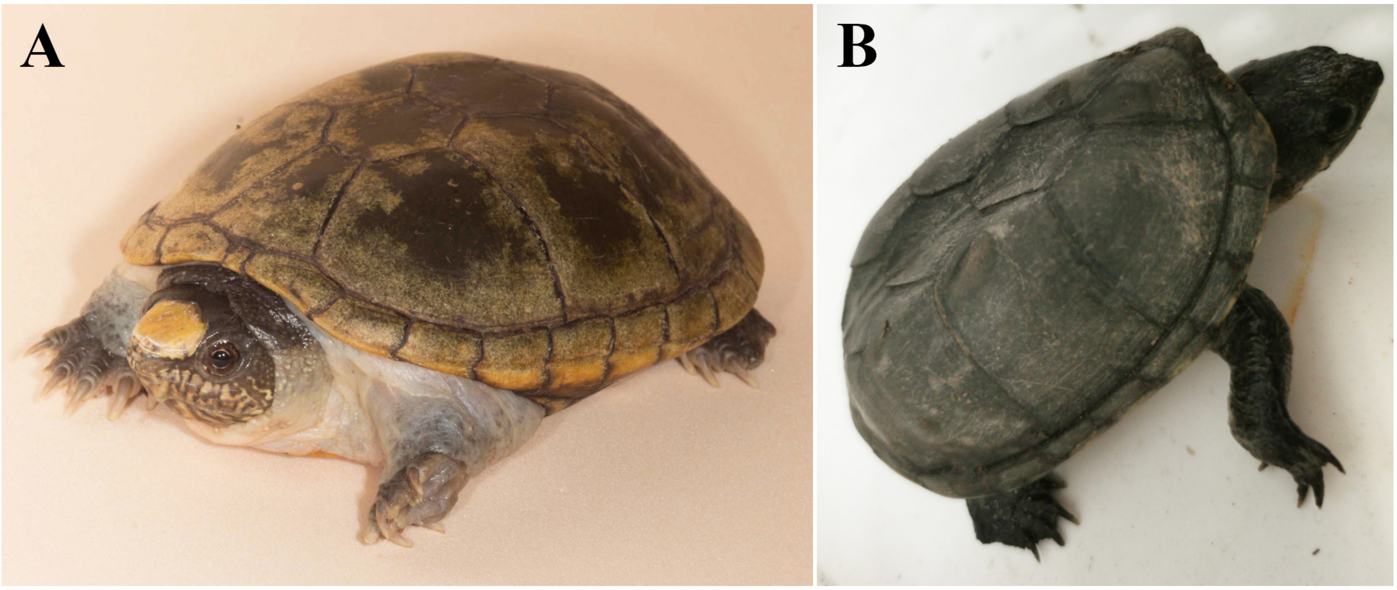

Figure 4. A typically pigmented Vallarta Mud Turtle (*Kinosternon vogti*) (A) and a melanistic individual (B) from Puerto Vallarta, Jalisco, Mexico. Photographs by Marco Antonio López-Luna (A) and Fabio G. Cupul-Magaña (B).

tions of central and southern Arizona streams exhibited some degree of plastral melanism (Hulse 1976). In Red-eared Sliders (*Trachemys scripta elegans*), the frequency and extent of melanism varies between populations, but the onset of this condition is coincident with population-specific female size at maturity (as observed in *K. vogti*) and maximum claw-length development (an androgen-dependent phenomenon), suggesting that those two factors are interlinked and indicative of a hormonal basis for melanism (Lovich et al. 1990).

Hypomelanism might be more widespread in the affected species than has been reported; however, such individuals likely experience higher predation rates (accentuated by the contrast of colors between turtles and their natural environment) or increased susceptibility to ultraviolet radiation (and increasing susceptibility to diseases) than normally pigmented individuals (Adkins et al. 2003; Virens et al. 2017; Devkota et al. 2021; Mora et al. 2022), resulting in reduced survival, which would decrease the prevalence of these phenotypes (Virens et al. 2017). However, we cannot rule out the possibility that hypomelanism does not affect the species, because turtles of all sizes have an algal and silt coating on the shell and skin that tends to conceal paler colors, and the benthic habit could afford some protection from terrestrial predators that rely primarily on vision to detect prey (Turner 2011). More field observations are needed to obtain conclusive results.

Acknowledgements

The Programa PROSNI-2023 of the Universidad de Guadalajara provided partial support to NEL-G. This research was conducted under SEMARNAT permits SGPA/DGVS/03088/22 and SGPA/DGVS/01156/19. We thank Taggert Butterfield, Misael Sánchez, and Enya Córdoba for their assistance in sampling, and Marco Antonio López-Luna and Andrés Alexander Gutiérrez Amaral for their photos. Finally, we thank the editor and anonymous reviewers for their valuable comments and suggestions to improve this manuscript.

Literature Cited

Adkins, E., T. Driggers, G. Ferguson, W. Gehrmann, Z. Gyimesi, E. May, M. Ogle, T. Owens, and E. Klaphake. 2003. Ultraviolet light and reptiles, amphibians. *Journal of Herpetological Medicine and Surgery* 13: 27–37. https://doi.org/10.5818/1529-9651.13.4.27.

Bechtel, H.B. 1991. Inherited color defects: Comparison between humans and snakes. *International Journal of Dermatology* 30: 243–246. https://doi.org/10.1111/j.1365-4362.1991.tb04628.x.

Bechtel, H.B. 1995. *Reptile and Amphibian Variants: Colors, Patterns, and Scales*. Krieger Publishing Company, Malabar, Florida, USA.

Berry, J.F., M.F. Seidel, and J.B. Iverson. 1997. A new species of mud turtle (genus *Kinosternon*) from Jalisco and Colima, Mexico, with notes on its natural history. *Chelonian Conservation and Biology* 2: 329–337. https://doi.org/10.11646/zootaxa.4885.4.3

Borteiro, C., A.D. Abegg, F.H. Oda, D.E. Cardozo, F. Kolenc, I. Etchandy, I. Bisaiz, C. Prigioni, and D. Baldo. 2021. Aberrant colourations in wild snakes: case study in Neotropical taxa and a review of terminology. *Salamandra* 57: 124–138.

Cupul-Magaña, F.G., T. Butterfield, T. Gregory, J.B. Iverson, R. Macip-Ríos, and M.A. López Luna. 2022. *Kinosternon vogti*. *The IUCN Red List of Threatened Species* 2022: e.T215164369A215164374. https://dx.doi.org/10.2305/IUCN.UK.2022-1.RLTS.T215164369A215164374.en.

de Vosjoli, P., R. Klingenberg, T. Barker, D. Barker, and A. Bosch. 2003. *The Ball Python Manual*. Companion House Books, Mount Joy, Pennsylvania, USA.

Devkota, K., D.N. Mandal, and H. Kaiser. 2020. A golden turtle in Nepal: First country record of chromatic leucism in the Spotted Northern Indian Flapshell Turtle, *Lissemys punctata andersoni*. *Herpetology Notes* 13: 671–674.

Garrido, J.R., T.G. Butterfield, A.G. Scoville, R. Macip-Ríos, and D.D. Beck. 2021. Comparing semi-urban and forest populations of the Jalisco Mud Turtle (*Kinosternon chimalhuaca*) in Mexico. *Herpetological Review* 52: 725–729.

Hulse, A.C. 1976. Growth and morphometrics of *Kinosternon sonoriense* (Reptilia, Testudine, Kinosternidae). *Journal of Herpetology* 10: 341–348. https://doi.org/10.2307/1563072.

Iverson, J.B. 1992. *A Revised Checklist with Distribution Maps of the Turtles of the World*. Privately published, Richmond, Indiana, USA.

Iverson, J.B., C.A. Young, and J.F. Berry. 1998. *Kinosternon integrum* LeConte (Mexican Mud Turtle). *Catalogue of American Amphibians and Reptiles* 652: 1–6.

Köhler, G. 2012. *Color Catalogue for Field Biologists*. Herpeton-Verlag, Offenbach, Germany.

Kolenda, K., B. Najbar, A. Najbar, P. Kaczmarek, M. Kaczmarski, and T. Skawiński. 2017. Rare colour aberrations and anomalies of amphibians and reptiles recorded in Poland. *Herpetology Notes* 10: 103–109.

Kuriyama, T., A. Murakami, M. Brandley, and M. Hasegawa. 2020. Blue, black, and stripes: Evolution and development of color production and pattern formation in lizards and snakes. *Frontiers in Ecology and Evolution* 8: 232. https://doi.org/10.3389/fevo.2020.00232.

Legler, J.M. and R.C. Vogt. 2013. *The Turtles of Mexico: Land and Freshwater Forms*. University of California Press, Berkeley, California, USA.

Loc-Barragán, J.A. 2017. *Kinosternon integrum*. Carapace and plastron coloration. *Mesoamerican Herpetology* 4: 492–493.

López-Luna, M.A., F.G. Cupul-Magaña, A.H. Escobedo-Galván, A.J. González-Hernández, E. Centenero-Alcalá, J.A. Rangel-Mendoza, M.M. Ramírez-Ramírez, and E. Cazarez-Hernández. 2018. A distinctive new species of mud turtle from Western Mexico. *Chelonian Conservation and Biology* 17: 2–13. https://doi.org/10.2744/CCB-1292.1.

Lovich, J.E., C.J. McCoy, and W.R. Garstka. 1990. The development and significance of melanism in the slider turtle, pp. 233–254. In: J. Whitfield Gibbons (ed.), *Life History and Ecology of the Slider Turtle*. Smithsonian Institution Press, Washington, D.C., USA.

Mahabal, A. and S. Thakur. 2014. Instances of aberrant colors and patterns among the Indian herpetofauna: a review. *Russian Journal of Herpetology* 21: 80–88. https://doi.org/10.30906/1026-2296-2014-21-2-80-88.

Marion, K.R., W.A. Cox, and C.H. Ernst. 1984. A xanthic flattened musk turtle, *Sternotherus depressus*. *Herpetological Review* 15: 51.

McCardle, H. 2012. Albinism in wild vertebrates. Unpublished M.S. thesis, Texas State University-San Marcos, San Marcos, Texas, USA.

McGaugh, S.E. 2008. Color variation among habitat types in the Spiny Softshell Turtles (Trionychidae: *Apalone*) of Cuatrociénegas, Coahuila, Mexico. *Journal of Herpetology* 42: 347–353. https://doi.org/10.1670/07-176.1.

Mora, J.M., L.I. López, G. Chávez, and J.M. Mora. 2022. Amelanism in the Nicaraguan slider turtle *Trachemys grayi* in Costa Rica. *The Herpetological Bulletin* 162: 19–20. https://doi.org/10.33256/hb162.1920.

Rainwater, T.R., J. Griess, T.M. Murphy, S.M. Boylan, B.B. Parrott, S. Kohno, K.A.E. Rainwater, S.M. Richards, M. Guillette, T. Mills, S.G. Platt, P.M. Wilkinson, and L.J. Guillette. 2020. Leucistic American alligator hatchlings in coastal South Carolina. *Southeastern Naturalist* 19: 62–72. https://doi.org/10.1656/058.019.0405.

Rivas, L.R., C.B. Eversole, A.V. Crocker, and R.L. Powell. 2022. Two records of xanthism in *Corallus hortulana* (Serpentes: Boidae) in Bolivia with comments on the yellow, patternless morphotype. *Acta Amazonica* 53: 61–64. https://doi.org/10.1590/1809-4392202201612.

Rosales-Martínez, C.S., C.D. Bello-Sánchez, M.A. López-Luna, A.H. Escobedo-Galván, and F.G. Cupul-Magaña. 2022. First observations on courtship and nesting behavior of *Kinosternon vogti* (Testudines: Kinosternidae). *Cuadernos de Herpetología* 36: 95–99. https://doi.org/10.31017/CdH.2022.(2021-055).

Rowe, J.W., D.L. Clark, C. Ryan, and J.K. Tucker. 2006. Effect of substrate color on pigmentation in Midland Painted Turtles (*Chrysemys picta marginata*) and Red-Eared Slider Turtles (*Trachemys scripta elegans*). *Journal of Herpetology* 40: 358–364. https://doi.org/10.1670/0022-1511(2006)40[358:EOSCOP]2.0.CO;2.

Sahu, J.S., B.B. Nahak, A. Samal, S. Maharana, and S. Pandey. 2022. Aberrant head coloration in a Barred Wolf snake, *Lycodon striatus* (Shaw 1802), from Odisha, India. *Entomology, Ornithology & Herpetology* 11: 293. https://doi.org/10.35248/2161-0983.22.11.293.

Steffen, J.E., R. Quigley, I. Whibley, and K.J. McGraw. 2021. Carotenoid deprivation and beta-carotene's effects on male and female turtle color. *Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology* 253: 110546. https://doi.org/10.1016/j.cbpb.2020.110546.

Turner, G.S. 2011. Hypomelanism in Irwin's Turtle, *Elseya irwini*, from the Johnstone River, North Queensland, Australia. *Chelonian Conservation and Biology* 10: 275–281. https://doi.org/10.2744/CCB-0851.1.

van Grouw, H. 2021. What's in a name? Nomenclature for colour aberrations in birds reviewed. *Bulletin of the British Ornithologists' Club* 141: 276–299. https://doi.org/10.25226/bboc.v141i3.2021.a5.

Virens, J., R.A. Davis, and T.S. Doherty. 2017. Two records of amelanism in the Australian skink *Ctenotus fallens* (Storr, 1974). *Herpetology Notes* 10: 453–455.

Vittapu, M.K., S.K. Poshetty, G. Sailu, and B.L. Narayan. 2022. An albino Indian Flap-shelled turtle, *Lissemys punctata* (Bonnaterre 1789), from Telangana, India. *Reptiles & Amphibians* 29: 225–226. https://doi.org/10.17161/randa.v29i1.16588.

Vyas, R. 2023. Merolepid Common Trinket Snake (*Coelognathus helena helena*). *Reptiles & Amphibians* 30: e18569. https://doi.org/10.17161/randa.v30i1.18569.