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A review of chromatic anomalies in *Blanus* (Amphisbaenia: Blanidae) through citizen science records

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Abstract: Hypopigmentation is characterized by the lack of melanin in part or the whole body. For nocturnal or fossorial reptiles, hypopigmentation may be less disadvantageous, as they are less exposed to visually oriented predators. But chromatic anomalies are challenging to observe in fossorial species, such as worm lizards (Amphisbaenia), because they are difficult to detect in the wild. We assessed information on hypopigmentation in the worm lizard genus *Blanus* based on two citizen science platforms and found the first record of piebaldism in *B. aporus*, new records of piebaldism in *B. vandellii* and *B. strauchi*, and the first record of amelanism in *B. cinereus*. This underscores the relevance of citizen science for obtaining new data on chromatic anomalies in fossorial animals. Hypopigmentation occurs more frequently in *Blanus* than previously known and most, if not all new records were observed in adults, supporting the hypothesis that this chromatic anomaly is less disadvantageous to fossorial reptiles.

Key words: Amelanism, hypopigmentation, iNaturalist, natural history, observation.org, piebaldism

Skin color arises due to the presence of pigments in chromatophores. In reptiles, a range of colors can be expressed by different kinds of chromatophores, such as melanophores, xanthophores, and erythrophores, each one bearing a set of pigments, and when the production of a pigment is excessive or reduced (sometimes absent), there is a color anomaly (Betchel, 1978; Borteiro et al., 2021). Among a series of possible deviations from the typical coloration pattern, hypopigmentation (amelanism, leucism, and albinism, *sensu* Borteiro et al., 2021) is characterized by the lack of melanin in different degrees, affecting part or the whole body (Burns et al., 2008). Although hypopigmentation is a phenomenon probably occurring in all vertebrate species, a survey conducted a decade ago found that this anomaly had been recorded in only 620 wild species, primarily among birds (McCardle, 2012). In reptiles, hypopigmentation has been reported in lizards, snakes, turtles, and crocodilians (e.g., Rocha and Rebelo, 2010; Erickson and Kaefer, 2015; Grigg and Kirshner, 2015; Borteiro et al., 2021; Paiva et al., 2022), through mutations in different genes such as *oca2*, *Mc1r*, and *TYR* (Rosemblum et al., 2004; Borteiro et al., 2021).

Hypopigmented individuals may be more conspicuous to predators, less attractive for reproduction, and may have poor vision in the case of albino and amelanic individuals (McCardle, 2012). However, in some cave populations, albinism appears to be a selected trait, due to beneficial pleiotropic effects (Culver et al., 2023). For instance, research has demonstrated that mutations in the *oca2* gene of the cave-dwelling fish species *Astianax mexicanus* are responsible not only for the albino phenotype, but also for higher resistance to anesthesia (potentially resulting in heightened alertness), and a decrease in sleep duration (potentially leading to extended feeding periods); these two behavioral traits would confer advantages in a dark environment (Bilandžija et al., 2018; Culver et al., 2023).

For nocturnal or fossorial reptiles, hypopigmentation may be more common and less disadvantageous, as these species are less exposed to visually oriented predators (Sazima and Di-Bernardo, 1991). In worm lizards (Amphisbaenia), for example, some species that dig deeper galleries in the soil have unpigmented skin, while those living in shallower depths or that occasionally forage on the surface have a dorsum varying from faintly to densely pigmented (Gans, 1968). Nevertheless, chromatic anomalies are challenging to observe in Amphisbaenia since they are difficult to detect in the wild. To date, 10 published reports of color anomalies in worm lizards

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have been documented, consisting of one case of albinism (total absence of pigments), one case of amelanism (lack of melanin), one case of hypomelanism (diminished melanin expression), and seven cases of piebaldism (body patchily or mostly white with pigmented eyes) (Schleich et al. 1996; García-Roa and Martín, 2016; Atance and Meijide Fuentes, 2020; Paiva et al., 2022)—although Atance and Meijide Fuentes (2020) recorded 20 piebald specimens of the same species.

Most recorded instances of hypopigmentation in Amphisbaenia have been documented in the genus *Blanus*, the only member of Blanidae, whose species occur in the Iberian Peninsula, Morocco, and from Türkiye to Iraq (Costa and Garcia, 2019). Currently, seven species are identified in *Blanus*, namely *Blanus alexandri* Sindaco, Kornilios, Sacchi, & Lymberakis, 2014, *B. aporus* Werner, 1898, *B. cinereus* Vandelli, 1797, *B. mettetali* Bons, 1963, *B. strauchi* (Bedriaga, 1884), *B. tingitanus* Busack, 1988, and *B. vandellii* Ceríaco & Bauer, 2018 (Uetz et al., 2022).[1] They are densely pigmented (Gans, 1968) and usually bask under rocks (López et al., 1998). Piebaldism has been observed in B. *mettetali*, B. *strauchi*, and B. *vandellii* (sometimes identified as *B. cinereus*), while albinism has been recorded in *B. strauchii* (Schleich et al., 1996; Atance and Meijide Fuentes, 2020; Paiva et al., 2022, and references therein). In a population of B. vandelli, piebaldism affect up to 50% of individuals (Atance and Meijide Fuentes, 2020).

In November 2022, we searched two citizen science platforms for photographic records of hypopigmented specimens of *Blanus*: observation.org (https://tinyurl.com/2tm3jfwz) and iNaturalist (https://tinyurl.com/vhapmmvk). We did not consider as piebald the specimens with only small whitish marks resembling scars (e.g., https://tinyurl.com/2uau57sv). As species of *Blanus* are not sympatric across most of their range (Sindaco et al., 2014; Ceríaco and Bauer, 2018; Şahin et al., 2021), we determined the taxonomic identity of photographed specimens based on the geographic location of each record.

We found 14 records of hypopigmentation, four (0.95%) on observation.org and 10 (1.98%) on iNaturalist, out of 419 and 503 photographic records, respectively (Table 1; Figure 1). Our findings represent the first records

1 Uetz P, Hošek J (2022). The Reptile Database. Available at http://www.reptile-database.org

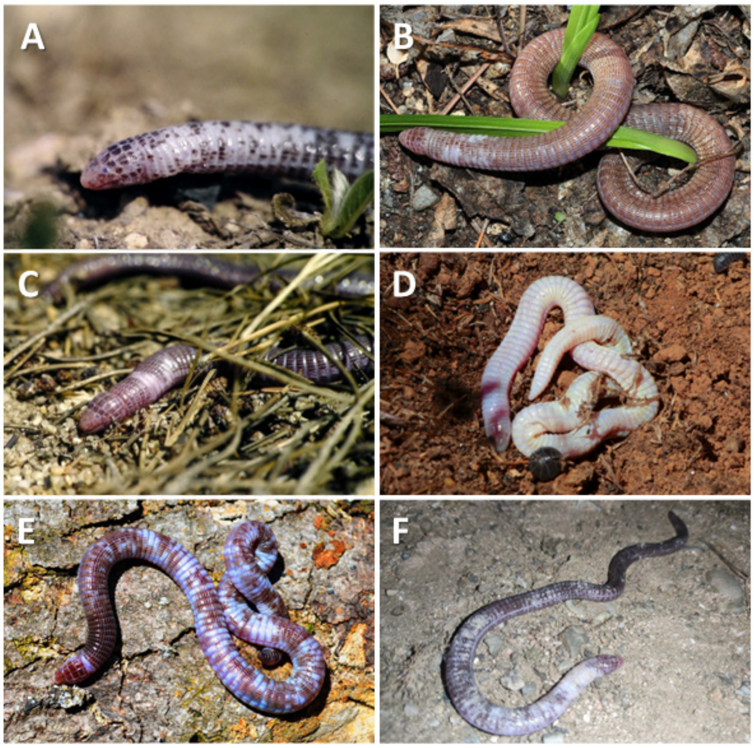

Figure 1. Six of the 14 new records of hypopigmentation in *Blanus* spp.: A) *Blanus aporus* with piebaldism; B) *Blanus vandelli* with piebaldism; C) *Blanus cinereus* with piebaldism; D) *Blanus cinereus* with amelanism; E-F) *Blanus vandelli* with piebaldism. Credits: A) Jan van der Winden, CC BY-NC 4.0; B) Francisco Rodriguez, CC BY-NC 4.0; C) Jan van der Winden, CC BY-NC 4.0; D) José Sousa, reproduced with permission; E) Ernesto Raya, CC BY-NC 4.0; F) Toño García, CC BY-NC 4.0.

Table 1. Records of chromatic anomalies in *Blanus* based on data from citizen science platforms.

Species	Anomaly	Date	Country	Latitude	Longitude	Link
Blanus aporus	Piebaldism	12/IV/1991	Türkiye	36°19′17.3″ N	33°52′11.0″ E	https://tinyurl.com/52jufc3s
Blanus cinereus	Piebaldism	24/IV/1995	Portugal	37°01′56.3″ N	7°59′35.2″ W	https://tinyurl.com/kh8xzvfe
Blanus cf. *vandellii*	Piebaldism	25/XI/2011	Spain	36°46′53.8″ N	3°06′37.5″ W	https://tinyurl.com/y5k95mw2
Blanus vandellii	Piebaldism	19/IV/2015	Spain	40°44′26.3″ N	4°03′24.7″ W	https://tinyurl.com/bdds7vfw
Blanus strauchi bedriagae	Piebaldism	04/V/2017	Türkiye	36°08′45.1″ N	29°35′23.3″ E	https://tinyurl.com/28dhmycf
Blanus cinereus	Piebaldism	10/IX/2017	Spain	36°22′18.5″ N	33°54′11.2″ E	https://tinyurl.com/yc7m6nsr
Blanus cinereus	Piebaldism	24/VI/2018	Spain	37°16′22.4″ N	6°56′13.1″ W	https://tinyurl.com/3dp3bxz9
Blanus cinereus	Amelanism	12/VI/2019	Portugal	38°19′47.1″ N	8°09′15.9″ W	https://tinyurl.com/ynznbtau
Blanus vandellii	Piebaldism	13/VII/2019	Portugal	41°04′20.7″ N	7°11′57.9″ W	https://tinyurl.com/4snzvz9j
Blanus strauchi	Piebaldism	07/II/2020	Türkiye	Details hidden	Details hidden	https://tinyurl.com/y6b3k2aj
Blanus aporus	Piebaldism	12/IV/2021	Türkiye	36°22′18.5″ N	33°54′11.2″ E	https://tinyurl.com/2ddmm4ca
Blanus cinereus	Piebaldism	IV/2022	Spain	37°30′29.3″ N	6°00′57.6″ W	https://tinyurl.com/mt46bw5n
Blanus vandellii	Piebaldism	X/2022	Spain	40°31′53.8″ N	4°10′39.2″ W	https://tinyurl.com/43babnjm
Blanus cinereus	Piebaldism	13/XI/2022	Portugal	37°01′55.6″ N	7°59′36.7″ W	https://tinyurl.com/6pd7hjnx

of amelanism in *B. cinereus* and piebaldism in *B. aporus*, as well as new records of piebaldism in *B. strauchi* and *B. vandellii* (Table 1). The observed anomalies varied from minor hypopigmentation, such as a small white patch on the anterior part of the dorsum (e.g., https://tinyurl.com/y5k95mw2) to more extensive depigmented areas along the body (e.g., https://tinyurl.com/bdds7vfw). Notably, one of the records available on iNaturalist had already been published in a scientific journal: a piebald *B. strauchi* from Kastellorizo Island, Greece (https://tinyurl.com/28dhmycf; Kazilas et al., 2018).

The internet and technologies such as cell phones, cameras, and GPS have made citizen science an invaluable tool by sharing a large number of digital media useful for scientific research (Miller-Rushing et al. 2012; Silvertown, 2009), despite shortcomings such as the lack of voucher specimens, that could offer data, for example, on genetics and histology of recorded animals. Nonetheless, the records presented here underscore the relevance of citizen science for obtaining new data on chromatic anomalies in fossorial animals like worm lizards. Our findings demonstrate that chromatic anomalies occur more frequently in *Blanus* than previously known. The body proportions of individuals photographed suggest that most, if not all new records of hypopigmentation in *Blanus* were found in adults. This supports the hypothesis that hypopigmentation is less disadvantageous to fossorial reptiles (Sazima and Di-Bernardo, 1991), such as worm lizards, even those species living at shallower depths or those that occasionally forage on the surface.

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