Short Note

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New records of hypopigmentation in two neotropical phyllostomid bat species with different roosting habits (*Uroderma bilobatum*, *Glossophaga soricina*)

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Abstract: Hypopigmentation disorders were reported in several bat species roosting in dark and sheltered roosts, but comparable records from open foliage roosts are rare. Here, we present three observations of non-albinistic hypopigmentation in two neotropical bat species. One extensively hypopigmented individual of *Uroderma bilobatum* was observed roosting among regular pigmented conspecifics in an open foliage roost in Panamá. Two individuals of *Glossophaga soricina* with a patchy hypopigmentation were incidentally mistnetted during studies in Panamá and Costa Rica. Considering the species-specific roosting habits, we briefly discuss potential implications of pigmentation disorders and aberrant visual appearance for the affected individuals.

Keywords: Chiroptera; hypopigmentation; leucism; piebaldism; pigmentation disorder.

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Hypopigmentation disorders are rare, but widespread among vertebrates and are observed in numerous mammal taxa (e.g. McCardle 2012, Abreu et al. 2013). They might derive from a congenital failed biosynthesis and complete absence of the dark pigment melanin leading to eyes appearing reddish, pale skin and white fur, a phenomenon described as albinism (Kinnear et al. 1985). Disorders with an only partial lack of pigments in skin and fur might derive from failures in pigment differentiation or deposition (Bolognia and Pawelek 1988, Lin and Fisher 2007) or can even be acquired (e.g. Vitiligo: Muller 2016; infectious diseases: Bolognia and Pawelek 1988). Affected individuals vary in their optical appearance, exhibiting partially pale, whitish fur, albeit with normally pigmented eyes. Irrespective of the actual origin and extent, observations of non-albinistic hypopigmentation disorders in mammals are often summarized under the terms leucism (e.g. Hofmeyr et al. 2005, Rocha et al. 2013, Muñoz-Romo et al. 2014), partial albinism (e.g. Bowman and Curran 2000, Boada and Tirira 2010), or piebaldism (e.g. Acevedo et al. 2009, Treitler et al. 2013). In general, mammals with hypopigmentation disorders might suffer from reduced protection against ultraviolet radiation of sunlight (Kollias et al. 1991) or in case of albinism also from reduced visual abilities (Abadi et al. 1990). Due to the change in their optical appearance, affected individuals might show an increased visibility to visually hunting predators. In the case of using fur color pattern for intraspecific communication, they might be further negatively affected in their social interactions (Ortolani 1999, Caro 2005, McCardle 2012).

Hypopigmentation is reported in several bat species (albinism: e.g. reviewed in Uieda 2000, Oliveira and Aguiar 2008, Zortéa and Silva in Press; non-albinistic hypopigmentation: e.g. Sánchez-Hernández et al. 2012, Tello et al. 2014, Muñoz-Romo et al. 2014). Records are based on examination of voucher specimens

(e.g. Mantilla-Meluk and Jiménez-Ortega 2011), incidental netting events (e.g. Treitler et al. 2013), or on the mere observation of affected individuals in their day roosts (e.g. Buys et al. 2002, Muñoz-Romo et al. 2014, Romano et al. 2015). The latter observations might be of great interest, as they could allow conclusions to be drawn about how a pigmentation disorder, and with that an altered visual appearance, could impair individuals in intraspecific social behavior, for instance in their acceptance by conspecifics (discussed in McCardle 2012).

There are several reports documenting hypopigmented bats in dark, sheltered roosts such as caves, where the negative consequences of an altered visual appearance might be relatively low (e.g. Uieda 2000, Buys et al. 2002, Rocha et al. 2013, Muñoz-Romo et al. 2014). In contrast, such observations are very rare for illuminated day-roosts like open foliage roosts, where pigmentation disorders lead to increased visibility to predators, present a different appearance to conspecifics, and where affected bats may suffer from harmful ultraviolet radiation (Uieda 2000).

In this note, we present three new records of hypopigmented bats from Panamá and Costa Rica, one for Peters' tent-making bat *Uroderma bilobatum* (observation in roost) and two for Pallas' long-tongued bat *Glossophaga soricina* (incidental netting events).

Uroderma bilobatum (Phyllostomidae: Stenodermatinae) is a frugivorous bat distributed in tropical habitats from Mexico to Brazil (Baker and Clark 1987). During the day, these bats roost under modified leafs (leaf-tents: Timm 1987). Regular pigmented individuals exhibit two prominent white facial stripes and one dorsal stripe on brown fur. This coloration is discussed to serve as a camouflage for visually hunting predators by diminishing outline contours of roosting individuals (Foster and Timm 1976, Fenton 1992). Mantilla-Meluk and Jiménez-Ortega (2011) reported three cases of hypopgimentation in *U. bilobatum* from voucher specimens that were caught in 1971 in Colombia.

We observed one irregularly pigmented *Uroderma bilobatum* during the day on November 13, 2013, in a leaf-tent roost at the botanical garden Summit Municipal Park, Colon Province, Panamá. The bat was visually identified, based on photographs using Reid (2009), and on netting data from the area (Hiller, unpublished data), suggesting *U. bilobatum* to be the only frequently occurring out of several similar species. The irregularly pigmented individual was roosting within a group of 17 conspecifics in an open foliage roost (Figure 1). The bats were hanging in physical contact, close to each other. The foliage roost consisted of a leaf-tent in a talipot palm (*Corypha umbraculifera*) and was located approximately 6 m above ground. The entire palm housed multiple groups of *U. bilobatum* in several leaf-tents. Although leaf-tents were overlapping and poorly visible, we were able to photograph at least 47 individuals of *U. bilobatum* roosting in this palm. Among these bats, the observed individual was the only one exhibiting a visible pigmentation disorder. The entire bat showed a pale, whitish fur, strongly contrasting with the surrounding conspecifics. The eyes appeared regularly colored (not red) and the fur pattern with white facial stripes was still slightly visible. Due to its roosting position, we were not able to see its wings nor were we able to determine sex or age. Based on the photographs, the irregularly pigmented individual had approximately the same size as its surrounding conspecifics. We revisited the open foliage roost in May 2016 but were not able to rediscover the particular or any other irregularly pigmented individual. Further, during an unrelated project TH and SDB captured 386 *U. bilobatum* in the region between 2013 and 2015 but no other similarly colored individual was encountered.

Figure 1: One hypopigmented individual of *Uroderma bilobatum* was observed roosting within a group of regular pigmented conspecifics in an open foliage roost on November 13, 2013, Colon Province, Panamá.

Glossophaga soricina (Phyllostomidae: Glossophaginae) is a nectarivorous bat distributed from Mexico to Argentina (Griffiths and Gardner 2007). In contrast to *Uroderma bilobatum*, these bats are usually found in dark, sheltered day-roosts, such as caves or hollow trees. Although this species is relatively common and widely distributed, records of individuals with pigmentation disorders are still scarce (Alvarez et al. 1991, García-Morales et al. 2010, Ruelas et al. 2016, Zalapa et al. 2016).

We incidentally mistnetted two irregularly pigmented individuals of *Glossophaga soricina* (Gsor1, Gsor2) in Panamá (Gsor1) and Costa Rica (Gsor2), respectively. We determined body mass using a spring balance (Pesola AG,

Switzerland) to the nearest 0.5 g and measured forearm length with a caliper to the nearest 0.1 mm. Species identification was realized following the identification keys of Handley (unpublished) (Gsor1) and Timm and LaVal (1998) (Gsor2). We documented the bats by taking photographs and performed measurements of surface areas with aberrant pigmentation in Gsor1 using ImageJ (1.50i, National Institutes of Health, USA). All bats were released after taking measurements and photographs. Gsor1 was mistnetted on November 3, 2013 within the settlement El Giral, Colon Province, Panamá (permit ANAM SE/A-75-13) in front of a flowering banana plant. It was an adult non-reproductive female, with a body mass of 12.0 g and a forearm length of 36.8 mm. It showed numerous hypopigmented patches on both wings and on the uropatagium, covering 15% of the entire membrane surface (right wing: 18%, left wing: 12%, uropatagium 21%). These patches covered parts of the wing membrane, partially across finger bones (Figure 2). Gsor2 was caught on January 16, 2016 in Santa Rosa National Park, Guanacaste, Costa Rica (permit ACG-PI-059-2015). It was an adult male with a body mass of 11.0 g and a forearm length of 34.6 mm. It exhibited one hypopigmented patch (ca. 2×2 mm) in its dorsal head fur (Figure 3). The hairs in this patch were completely white from base to tip and formed the only visible aberrant pigmentation. Both bats seemed to be healthy and in good physical condition.

All three bats still exhibited regularly pigmented areas on their body surface (Gsor1, Gsor2) or at least regularly pigmented eyes (*Uroderma bilobatum*). They therefore can be classified as non-albinistic hypopigmented individuals. Although we are not able to make assumptions regarding the underlying causes of the observed hypopigmentations (i.e. congenital, ontogenetic or acquired), our observations visually match records described as leucism (Sánchez-Hernández et al. 2012, Rocha et al. 2013, Ruelas et al. 2016) or piebaldism (Treitler et al. 2013). With regard to phenotypic categories that were recently suggested by Zalapa et al. (2016), who compiled cases of atypical coloration in bats, our observations might be classified as the phenotypes "colorless" and "white spotting". The bats varied strongly in the manifestation of their respective hypopigmentation patterns. Associated with this variation, we suggest differing impacts to the affected individuals. Nocturnal animals like bats might be generally less affected by negative effects of hypopigmentation. The lack of sunlight during their nightly periods of activity might obscure negative consequences of a reduced protection against ultraviolet radiation and, to some extent, diminish a potentially increased visibility to visually hunting predators (Uieda 2000, Rocha et al. 2013). It is nevertheless well conceivable that hypopigmented body areas may be conspicuous for visually hunting predators like owls, at least during moonlit nights (Ortolani 1999). Hereby, larger hypopigmented areas (cf. Gsor1: Figure 2) are presumably more conspicuous than smaller areas (cf. Gsor2). During the day, especially dark, sheltered roosts such as those usually used by *Glossophaga soricina* might promote survival of bats with pigment deficiency, by serving as protection from daylight. This circumstance was discussed by Uieda (2000), who reviewed records of albinistic bats observed inside their roosts. Hereby, 38 out of 39 albinistic individuals were found in dark roosts like caves or hollow trees, while only one albinistic *Artibeus planirostris* was found in an external foliage roost. This disparity might indicate a higher selective pressure against hypopigmentation in species roosting in open and illuminated foliage roosts, where pigments like melanin in skin and fur are presumably important to generate fur camouflage patterns and as protection against the ultraviolet radiation

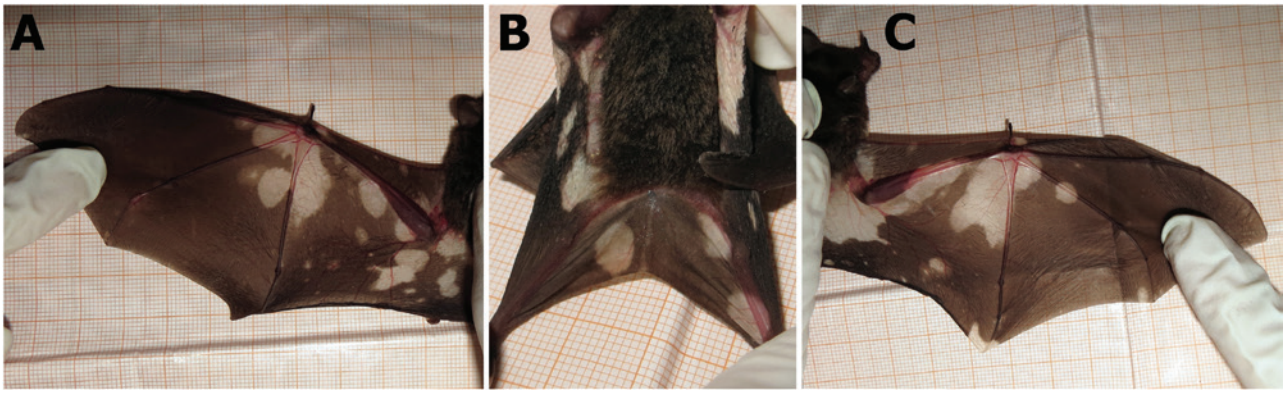

Figure 2: One adult female of *Glossophaga soricina* (Gsor1) with hypopigmented patches on (A) left wing, (B) uropatagium and (C) right wing was caught in a mistnet on November 3, 2013, Colon Province, Panamá.

Figure 3: One adult male of *Glossophaga soricina* (Gsor2) with one hypopigmented patch in its dorsal head fur was caught in a mistnet on January 16, 2016, Santa Rosa National Park, Guanacaste, Costa Rica.

of the sun (Uieda 2000). There is no doubt that pale or whitish fur can have a camouflage effect as well by diminishing the contrast to the sunlit leaf background (Uieda 2000, Mantilla-Meluk and Jiménez-Ortega 2011) and that some foliage roosting bat species exhibit whitish fur (e.g. *Ectophylla alba*: Rodríguez-Herrera et al. 2007) but, depending on the roosting situation, uniformity with conspecifics could be important for a sufficient camouflage effect. A single different-colored individual might be predestined prey for visually hunting predators, especially if it exhibits a lack of the facial stripes, which might contribute to masking the contours of a single individual within a cluster of foliage roosting bats (Foster and Timm 1976, Fenton 1992, Uieda 2000). However, our observation on *U. bilobatum* indicates, that even in open foliage roosts, hypopigmented individuals might survive a certain time without being predated or deceasing from ultraviolet radiation of sunlight.

Presumably important for gregarious animals like bats, but generally sparsely discussed, is the potential influence of pigmentation disorders and aberrant color patterns on interactions with conspecifics and social behavior in general (Uieda 2001, McCardle 2012, Rocha et al. 2013). Beside anecdotal observations (Uieda 2001), there is by now no evidence that hypopigmented bats are treated differently by conspecifics when it comes to social behavior. Inside dark day roosts, hypopigmented individuals were found roosting normally among conspecifics (e.g. *Plecotus auritus*: Buys et al. 2002) and were observed to be well-integrated in their social groups (*Carollia perspicillata*: Rocha et al. 2013). Further, there are several reports of reproducing hypopigmented individuals (e.g. *Myotis lucifugus*: Talerico et al. 2008; *C. perspicillata*: Rocha et al. 2013; *Phyllostomus discolor*: Treitler et al. 2013). However, so far there are no comparable observations on social behavior of hypopigmented bats in well-illuminated open foliage roosts, where the aberrant coloration is potentially visible to conspecifics. Our observation of an individual of *Uroderma bilobatum* with prominent hypopigmentation was roosting within a cluster of regular colored conspecifics might indicate that aberrant coloration does not necessarily mean social shunning, even in illuminated roosts. We suggest that behavioral observations on hypopigmented bats roosting in open foliage might offer valuable options to learn about the role of fur color patterns for intraspecific communication and social behavior in bats, and we encourage everyone to report similar observations.

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