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Multiple leucism in a nest of the yellow-spotted Amazon River turtle, *Podocnemis unifilis*

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Distributed throughout the Amazon, Tocantins-Araguaia, and Orinoco River Basins, the vulnerable yellow-spotted Amazon River turtle (*Podocnemis unifilis*) is one of the few species of freshwater chelonians found in all countries covered by the Amazon forest (Rueda-Almonacid et al. 2007, Salera-Júnior et al. 2009, Uetz & Hošek 2014). With its cryptic colouration and accentuated sexual dimorphism (Ernst & Barbour 1989, Rueda-Almonacid et al. 2007), *P. unifilis* is the second largest species in the genus and can reach 50 cm in carapace length (Pritchard & Trebbau 1984, Rueda-Almonacid et al. 2007), which is a size that allows females to produce up to 47 eggs per clutch (J. Erickson pers. obs.).

Recent studies have revealed cases of multiple paternity, suggesting that *P. unifilis* has a polyandrous mating system (Fantin et al. 2008). While the chances of fertilisation increase through this type of mating system, the possible hazards of polyandry remain unknown (Watson et al. 1998, Roques et al. 2006, Wright et al. 2013). Multiple mating may favour the exchange of recessive genes with a negative impact as well as embryonic malformations and the occurrence of individuals with anomalous colourations, such as albinos (Turkozan & Durmus 2001).

Albinism is caused by an enzyme deficiency that affects the metabolism of melanin during the development of an organism, leading to the partial or complete absence of pigmentation (Boncinelli 1998, Veena et al. 2011). Besides being associated with an inherited genetic disorder derived from the combination of recessive genes from the parents (Hiler 1983), environmental factors related to habitat quality, diet, shocks, injuries, or senility may exert an influence on the occurrence of albinism (Hayley-McCardle 2012). For example, partial albinism has been suggested to be related to feeding conditions during the early growth stages in crows (Slagsvold et al. 1988). The term leucism has been widely employed to describe individuals with partial albinism, in which pigmentation is absent from the skin, but is retained in the eyes (Bechtel 1995, Berdeen & Otis 2011, Veena et al. 2011). Albinism has been reported for a number of vertebrates, such as sharks (e.g., Veena et al. 2011), frogs (e.g., Elgue et al. 2013), snakes (e.g., Noronha et al. 2013), birds (e.g., Bensch et al. 2000), and bats (e.g., Souza et al. 2013). However, this anomaly has been reported for few chelonians. In this study, we describe the first observation of leucism in hatchlings from a nest of *P. unifilis* in the wild and discuss its implications for the conservation of this overexploited Amazonian species.

During mapping and monitoring campaigns of chelonian nesting sites in the Piagaçu Purus Sustainable Development Reserve (PP-SDR) in the state of Amazonas, Brazil (4°15'28.1" S, 61°55'52.9" W), a *P. unifilis* nest was located on 9 October 2013 in a seasonally flooded area (várzea) at the margin of a muddy lake (Fig. 1A). Knowing that the offspring of the species take an average of 60 days to hatch and remain in the nest for another 15 days (Pritchard & Trebbau 1984, Rueda-Almonacid et al. 2007), the nest was re-examined on 12 December 2013 for quantifying the size and characteristics of the offspring. Individuals that had already hatched and those in the process of hatching were taken to the research base of the Piagaçu Institute for measuring with digital callipers (Digimess, precision: 0.01 mm). The following morphometric measures

were taken: rectilinear carapace length (RCL), rectilinear carapace width (RCW), rectilinear plastron length (RPL), rectilinear plastron width (RPW), and shell height (SH). Body mass was established using a dynamometer (Pesola, precision: 1 g). The Shapiro-Wilk W test confirmed a normal distribution of the set of morphometric and body mass data. Differences between normal individuals and those exhibiting leucism were tested using the Student's t- and Mann-Whitney U-tests. All statistical analyses were conducted in the R environment (R Development Core Team 2014).

The clutch consisted of 37 eggs, one of which was infertile and one embryo was dead. The hatching rate thus amounted to 94.59%. The litter comprised 19 individuals with normal and 16 without body pigmentation, but with the retention of eye colour, thereby classifying some newborns as leucistic (Table 1, Figs 1B–D). No differences were found regarding the formation of the carapace, plastron or amongst shell dimensions. Unexpectedly, the body mass of the leucistic individuals was greater than that of siblings with normal pigmentation (Table 2).

There are few reports of complete or partial albinism in free-ranging chelonians in the literature. Records from freshwater turtles are normally restricted to single individuals (e.g., Williams & Arnold 1992, Saumure & Rodrigue 1998: *Chelydra serpentina*; Norden 1996: *Chrysemys picta*; Hossain & Sarker 1999: *Lissemys punctata*; Bager 2010: *Trachemys dorbignyi*). Reports of albinistic marine turtle hatchlings, the nesting areas of which are more commonly monitored, are more informative and describe a relative frequency of albinos per nest (e.g., Marcovaldi et al. 1995, Godfrey & Mrosovsky 1995: *Caretta caretta*; Sönmez & Özdilek 2011: *Chelonia mydas*; Hitchins & Bourquin 2005: *Eretmochelys imbricata*). In *C. caretta* and *C. mydas,* albinistic individuals recorded account for only 1% of all offspring (Kaska & Downie 1999). Moreover, abnormalities of the head and scutellation are more commonly found in albinistic than in normally coloured individuals (Kaska & Downie 1999, Turkozan & Durmus 2001). If albinistic individuals have a greater incidence of abnormalities, one might infer that this rare anomaly is related to a reduced likelihood of the afflicted individual reaching adulthood in the natural environment (Turkozan & Durmus 2001). The absence of camouflaging pigmentation appears to be a disadvantage in nature, as albinistic individuals are more easily spotted by predators and more likely to develop fatal diseases (Hayley-McCardle 2012). One possible advantage of leucistic animals over complete albinos is that

Figure 1. Nesting area of the yellow-spotted Amazon River turtle in the Piagaçu Purus Sustainable Development Reserve (A). Leucistic individuals during hatching (B). Normal and leucistic hatchlings from a single nest in captivity (C, D).

Table 1. Morphometric measurements (mm) and mass (g) of 35 *Podocnemis unifilis* hatchlings in the Piagaçu Purus Sustainable Development Reserve, state of Amazonas, Brazil. Values are presented as mean ± standard deviation (range). Abbreviations: RCL – rectilinear carapace length; RCW – rectilinear carapace width; RPL – rectilinear plastron length; RPW – rectilinear plastron width; SH – shell height.

	Normal (n = 19)	Leucistic (n = 16)
RCL	42.86±1.24 (39.47–44.65)	43.37±1.22 (41.21–45.35)
RCW	37.67±1.34 (33.97–39.87)	38.70±0.86 (37.12–40.12)
RPL	40.80±1.28 (37.23–42.86)	41.46±1.09 (39.56–44.28)
RPW	33.00±1.22 (30.42–35.43)	33.98±1.53 (31.25–36.58)
SH	21.37±0.69 (19.17–21.97)	21.13±0.51 (20.23–21.89)
Mass	15.30±0.30 (14.50–15.80)	15.95±0.22 (15.40–16.30)

Table 2. Tests for morphological distinctiveness between normal (n = 19) and leucistic (n = 16) hatchlings from a nest of *Podocnemis unifilis* in Brazilian Amazonia. Measurements are coded according to the main text. Abbreviations: RCL – rectilinear carapace length; RCW – rectilinear carapace width; RPL – rectilinear plastron length; RPW – rectilinear plastron width; SH – shell height.

	t	df	p
RCL	-0.42	29.00	0.67
RCW	-1.26	30.12	0.21
RPL	-0.54	28.23	0.59
RPW	-1.46	28.28	0.15
Mass	-2.90	22.60	< 0.01
	U	Z	p
SH	143	-0.57	0.56

normally coloured eyes may be less prone to impaired vision, which is commonly reported from albinos (e.g., Heiduschka & Schraermeyer 2007).

The only previously recorded case of multiple albino turtles in the same nest stems from the coast of Brazil in 1994, where the hatching of 22 albino offspring of *C. caretta,* accounting for 22.4% of a total of 98 individuals, was observed (Marcovaldi et al. 1995, Godfrey & Mrosovsky 1995). The proportion of leucistic hatchlings in the present report is even higher (43.24% of the nest). In *C. mydas,* albinistic offspring were found to be larger than individuals with normal pigmentation (Burgess et al. 2006). The authors suggest that a larger body size may compensate for the drawbacks of albinism, as such individuals are better swimmers and their larger girth may improve their chances of escaping at least some smaller predators. In the present study, however, no correlations were found between leucism and body size or the occurrence of malformations in *P. unifilis*. The only difference was the larger body mass among leucistic individuals. Therefore, more records of litters including albinistic individuals are needed to investigate possible associations between anomalous pigmentation and the occurrence of other morphological abnormalities in chelonians.

In the Brazilian Amazon, species of the genus *Podocnemis* are considered Vulnerable (Tortoise & Freshwater Turtle Specialist Group 1996) and constitute the main targets of conservation strategies meant to lessen the strong pressure from hunting by traditional communities as well as poaching (Kemenes & Pezzuti 2007, Waldez et al. 2013). It is possible that isolation caused by human activities leads to a reduction in gene flow among populations and increased inbreeding in *P. unifilis* (Escalona et al. 2009). A possible consequence of this increased likelihood of consanguinity is the emergence of weaknesses linked to deleterious recessive alleles in the population (Frankham 2003). Indeed, leucistic individuals are more common in small and isolated populations: a semi-isolated population of great reed warblers (*Acrocephalus arundinaceus*) subjected to a genetic bottleneck in Sweden had a much higher frequency of partially albinistic individuals (Bensch et al. 2000). Thus, the occurrence of albinos of *P. unifilis* should be quantitatively monitored to detect possible signs of inbreeding in this overexploited and vulnerable species.

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