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Melanism in the Ussuri Pitviper (*Gloydius ussuriensis*) from the Republic of Korea, with Remarks on Color Variations

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Abstract: *Gloydius ussuriensis* is a species of pitviper inhabiting eastern Asia. Body coloration of this species is highly variable, but the extent of this variation has not been documented in detail. Herein, this work reports a melanistic individual of this species observed on Jeju island, Republic of Korea. This study confirms that this melanistic *G. ussuriensis* has never been observed outside Jeju. The geological environment of the island and the insular melanism can be considered as potential explanations.

Keywords: Melanism, Color variation, *Gloydius ussuriensis*, Jeju Island, Republic of Korea

Introduction

Gloydius ussuriensis is a species of pitviper (subfamily Crotalinae) inhabiting the Russian Far East, northeastern China, and the Korean Peninsula (Orlov, *et al.*, 2014). The body coloration of this species generally ranges from brown to grey (Lee *et al.*, 2012); however, it is highly variable within these color shades, and individuals often exhibit body coloration ranging from reddish or orange brown to reddish grey (Lee, *et al.*, 2012). The current study reports an observation on the melanistic *G. ussuriensis* individual from Jeju Island, Republic of Korea, with remarks on color variations in the species.

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Materials and Methods

During a field survey on 3 July 2019 at 3:07 p.m., we found an adult *G. ussuriensis* with an unusual melanistic body coloration in a forest of Seonheul-ri, Jeju Island, Republic of Korea (33.52684829 N, 126.7281346 E; WGS 84; 80 m asl). The individual was approximately 40 cm snout-to-vent length, and its overall body coloration was black with large circular patterns of a lighter color distributed irregularly along the length of the body (Figure. 1A). The coloration was significantly darker than the typical body coloration of *G. ussuriensis* (Figure. 1B ~ Figure. 1C).

Results and Discussion

As imminent shedding, dirt, and other debris accumulated between scales can make a snake's body coloration appear darker than the original coloration, we examined the scales closely to ensure that the original body coloration of the individual was not obscured by such factors. It was noted that this individual had shed recently at the time of observation; judging from the clear eye caps, dorsal scales, and shiny ventral scales with clearly visible mottled patterns. Also, it was noticed that no accumulated debris existed between the scales. Therefore, the original body coloration of this individual was not affected by any confounding factors, and thus it represents a melanistic form of *G. ussuriensis*.

According to the observations of *G.*

Figure 1. Body color and pattern variation in *Gloydius ussuriensis* observed in the Republic of Korea. (A) A melanistic individual observed in Seonheul-ri, Jeju Island, on 3 July 2019 reported herein. Note the coloration of this individual is significantly darker than the individuals of typical color form (B and C). (B) A grayish brown individual observed in Woraksan National Park, Republic of Korea. (C) A reddish brown individual photographed in Odaesan National Park, Republic of Korea. All photographs by YS.

ussuriensis uploaded on the citizen science platforms Naturing (https://www.naturing.net) and iNaturalist (https://www.inaturalist.org), and to our personal observations on the species in the wild, it seems that the frequency of dark grey and melanistic color morphs is higher in Jeju (thirty-seven cases) compared to the Korean mainland and elsewhere (six cases; GBIF occurrence download, https://doi.org/10.15468/dl.t693qz). Furthermore, completely melanistic individuals have not been recorded outside Jeju so far (Naturing observation,https://www.naturing.net/o/504616; https://www.naturing.net/o/498972; GBIF occurrence download, https://doi.org/10.15468/dl.t693qz). These lines of evidence suggest the possible existence of regional scale color variations between Jeju and the Korean mainland.

One of the possible reasons behind this color variations is the geological history of Jeju island and its environment. Due to its volcanic origin in the Quaternary, Jeju island is mostly composed of basalt. Therefore, the background substrate coloration on the island is generally darker than that of the mainland, which is composed mostly of other igneous (e.g. granite) and metamorphic rocks (Park, *et al.,* 2010; Chough, 2013). This difference in substrate coloration coupled with differential

predation pressure on the island (Kang, *et al.,* 2018) may have benefited the survival of individuals with darker coloration. For example, the population of the Oriental fire-bellied toads (*Bombina orientalis*) on Jeju island show a dark brown dorsal coloration exclusively, whereas the mainland populations generally show green but highly variable dorsal colorations (Kang, *et al.* 2017). Related predation experiments have linked body color to predation pressure on Jeju island compared to the Korean mainland (Kang, *et al.,* 2017; 2018).

Another possible explanation for the darker coloration on Jeju island is the general effect of island environments on phenotypes (Russell, *et al.*, 2011; Novosolov, *et al*., 2012). The island effect, or syndrome, can lead to the divergence of various organismal traits, including morphology, life history and reproductive biology (Adler and Levins, 1994; Roulin and Salamin, 2010, Novosolov, *et al.*, 2012). In vertebrates, there are numerous examples of island populations exhibiting markedly different phenotypes from their mainland counterparts (Adler and Levins, 1994; Fitzpatrick, 1998; Goltsman, *et al*., 2006; Luther and Greenberg, 2011). These include behavioral variations, with, for instance, insular lizard species differing in life history traits from the closely-related mainland species (Novosolov, *et al*., 2012; Novosolov and Meiri, 2013). Furthermore, there are other examples of body color variation and insular melanism, such as the lizard genus *Podarcis* (*P. hispanica atrata*; Castilla, 1994; Buades, *et al.*, 2013), and the owl *Tyto alba* (Roulin and Salamin, 2010). Jeju island is known to impact the phenotype of several species, and another example is the Japanese treefrogs (*Dryophytes japonicus*), displaying a larger overall body size in Jeju (Jang, *et al*., 2011; Koo, 2014).

Regarding *B. orientalis*, the colonization of Jeju island followed a single dispersal event from the mainland shortly after the formation of the island during the Early Pleistocene (Fong, *et al*., 2016). A similar process of dispersal and isolation is likely responsible for the presence of melanistic *G. ussuriensis* in Jeju. Additional studies are needed to investigate the frequency of different color variants across the range of *G. ussuriensis* and to test whether there is selective pressure on body coloration at the regional scale.

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