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A REVIEW OF CASES OF GEOPHAGY IN CORVIDS (AVES: CORVIDAE) AND A NEW REPORT OF GEOPHAGY IN AZURE JAY (*Cyanocorax caeruleus*)

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Abstract: Geophagy is the intentional ingestion of soil or sediments by different animal species. In birds this behaviour has been widely reported in Psittacidae and Columbidae, but less so for other families, such as Corvidae. The goal of the present study was to review cases of soil ingestion by corvids and also report a new observation of geophagy in Azure Jay (*Cyanocorax caeruleus*). Geophagy was mentioned only for 11 of the 130 species of the familiy Corvidae, and there is a particular scarcity of reports for Neotropical species. On 26 August 2018 an adult individual of Azure Jay was observed removing and ingesting pieces of dry clay from a nest of Rufous Hornero (*Furnarius rufus*). Hypotheses about this behaviour include mineral supplementation and grinding of food.

Keywords: Crows; *Furnarius*; Mineral supplementation; Neotropical jays; Soil ingestion.

Geophagy is the intentional ingestion of soil or sediments by different animal species, including vertebrates and invertebrates (Diamond *et al.* 1999). Hypotheses about this behaviour in birds include: i) the intake of nutrients contained in soils, such as essential minerals (e.g. calcium or sodium) (Gionfriddo & Best 1999, Brightsmith & Phillips 2008); ii) detoxification, due to soil properties in neutralizing toxic food compounds (Gilardi *et al.* 1999, Brightsmith & Phillips 2008); and iii) ingestion of grit for mechanical grinding of food (Gionfriddo & Best 1999). The function of this behaviour may vary between species, between individuals, and within the same individual, varying temporally (Chhangani 2004, Downs 2006).

In birds, geophagy has been widely reported in families such as Psittacidae (Diamond *et al.* 1999, Brigthsmith & Muñoz-Najar 2004, Severo-Neto 2012, Costa-Pereira *et al.* 2015, Dornas *et al.* 2016) and Columbidae (Brigthsmith & Muñoz-Najar 2004, Symes *et al.* 2005, Downs 2006), but not as much for other families, such as Cracidae (Brigthsmith & Muñoz-Najar 2004), Corvidae (Diamond *et al.* 1999) and others (see also Gionfriddo & Best 1999). For the family Corvidae (Aves: Passeriformes), which includes 130 species distributed worldwide (dos Anjos & Bonan 2019), records of soil ingestion are particularly scarce and scattered in the literature. Therefore, here I reviewed observations of geophagy by corvids described in the literature and present a new report of this uncommon behaviour in the Azure Jay (*Cyanocorax caeruleus*), an endemic species of the Atlantic Forest biome (Bencke *et al.* 2006).

Soil ingestion was mentioned only for 11 of the 130 species of the Corvidae familiy. Seven of these species belong to the genus *Corvus*: *C. tristis* (Diamond *et al.* 1999, Symes *et al.* 2005), *C. splendens*, *C. macrorhynchos* (Chhangani 2004), *C. corax* (Kilham 1989, Soler *et al.* 1993, Nogalez & Hernandez 1994, Chhangani 2004), *C. brachyrhynchos* (Kilham 1989), *C. corone* and *C. monedula* (Soler *et al.* 1993). For the genus *Cyanocorax*, there is one report of *C. cyanomelas* occasionally visiting a clay lick

(Brigthsmith 2004) and one report of small stones (varying from 3 to 8 mm) in the stomach contents of *C. caeruleus* (Reinert & Bornschein 1998). Soler *et al.* (1993) also mentioned soil ingestion by *Pica pica* and *Pyrrhocorax pyrrhocorax*. With exception of *C. cyanomelas, C. caeruleus* and *C. corax*, none of the species mentioned above are distributed in the Neotropical region, what emphasises the absence of information about geophagy in Neotropical corvids.

On 26 August 2018 at about 10:00 h, a group of six Azure Jay (*C. caeruleus*) was seen in a forest corridor that constitutes the riparian zone of the Córrego Grande River (27º36'21.3''S, 48º30'17.1''W), in the municipality of Florianópolis, Santa Catarina state, southern Brazil. This forest corridor is 30 to 70 m wide and connects the Maciço da Costeira Municipal Park to the mangroves of Itacorubi in the North Bay crossing 2.5 km of urban area. After some minutes observing the flock, an adult individual of Azure Jay jumped on the roof of an unfinished nest (in construction, with a wide entrance) of Rufous Hornero (*Furnarius rufus*) constructed in a Brazilian Firetree (*Schizolobium parahyba*) at approximately 15 m from the ground. The individual started to violently peck the top of the nest, and then removed and ingested a piece of dry clay from the nest. This behaviour was repeated another three times (lasted between 1-2 min), and on all occasions a small piece of dry clay was ingested. The behaviour used to remove the piece of clay was similar to the feeding behaviour used by Azure Jays to feed on hard seeds (e.g. seeds of Paraná Pine, *Araucaria angustifolia*), in which an individual holds a seed between the feet and uses the beak to vigorously peck the seed (*personal observ.*). Unfortunately, as the observation was opportunistic, no documentation was obtained of the event.

The ingestion of soil seems to be uncommon in the genus *Cyanocorax*, since only two previous reports were found in literature for the genus (Brightsmith 2004, Reinert & Bornschein 1998). Moreover, a long term study about foraging behaviour of *Cyanocorax chrysops* (Plush-Crested Jay), in which the researchers made 1080 hours of observation, did not report any event of soil ingestion by the species (Uejima *et al.* 2012). A possible explanation for the observed behaviour in *C. caeruleus* is the ingestion of minerals for eggshell formation during the reproductive season (Soler *et al.* 1993). This is because, on 23 September 2018, a nest of the species was found in construction approximately 40 m from the Rufous Hornero's nest, where the behaviour was observed. The consumption of soil is mentioned as an important source of calcium for two corvid species during the period of eggshell formation, the Jackdaw (*Corvus monedula*) and the Carrion Crow (*Corvus corone*) (Soler *et al.* 1993). However, this hypothesis is merely speculative, since it is not possible to state that the bird that ingested clay is the same bird that reproduced nearby. Since *C. caeruleus* is an omnivorous species and can feed on hard food items, such as seeds, arthropods and even crustaceans (Reinert & Bornschein 1998), another possible explanation for the behaviour is the ingestion of grit for mechanical grinding of food. Lastly, as the nest of Rufous Hornero was unfinished with a large entrance, the search for eggs or nestlings as a food resource was discarded in the occasion. Therefore, more studies are necessary to understand the most likely drivers of this behaviour in *C. caeruleus*.

The consumption of clay from Rufous Hornero's nest was mentioned in the literature only for a single bird species, the Blue-winged Parrotlet (*Forpus xanthopterygius*)(Sazima 2008), and also for a primate species (*Alouatta caraya*) (Bicca-Marques & Calegaro-Marques 1994). Therefore, the Azure Jay seems to be the first corvid species observed ingesting clay directly from a nest of Rufous Hornero. Sazima (2008) suggested that ingestion of soil from this source could be related to neutralization of toxic food compounds and also mineral supplementation. A recent study (Costa-Pereira *et al.* 2015) reporting the consumption of soil from termite nests by Yellow-chevroned Parakeets (*Brotogeris chiriri*), also found that soil of termite nests had higher concentrations of macronutrients (e.g. Ca; Mg; K) than ground soil. Therefore, it also is necessary to verify if chemical properties of clay from Rufous Hornero's nest differ from the surrounding sources of soil, to properly test the hypothesis of mineral supplementation from this source. Nevertheless, a possible advantage of consuming clay from the nest of Rufous Hornero could be that there is then no need to get down on the ground to ingest soil, thus avoiding possible terrestrial predators (Bicca-Marques & Calegaro-Marques 1994).

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