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ORIGINAL RESEARCH

A review of nose picking in primates with new evidence of its occurrence in *Daubentonia madagascariensis*

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Abstract

Nose picking (rhinotillexis) is a common behaviour in humans which remains, however, poorly studied. Several species of primates are known to pick their nose and ingest the nasal mucus suggesting that this behaviour may actually be beneficial and showing it is not restricted to humans. Here, we review relevant literature and online sources, and document the species of primates observed to pick their nose. We also present the first occurrence of this behaviour in a species of strepsirrhine primate (lemurs and relatives) with a unique video showing an aye-aye picking its nose. While doing so this animal inserts the entire length of its extra-long, skinny and highly mobile middle finger into the nasal passages and then licks the nasal mucus collected. We further investigate the internal anatomy of the nasal cavity of the aye-aye in order to understand how it can introduce its entire finger in its nasal cavity and discover that the finger likely descends into the pharynx. We show that this behaviour is present in at least 12 species of primates, most of them also showing great manipulative/tool use skills and may have some associated benefits that need to be further investigated. Further comparative studies examining nose picking and mucophagy in other primate species and vertebrates in general may shed additional light on its evolution and possible functional role.

Introduction

The act of picking one's nose (i.e. the act of extracting nasal mucus, generally with a finger or an object, by oneself or someone else) or rhinotillexis remains poorly understood and only a few scientific studies have attempted to elucidate the origin and potential relevance of this behaviour. The handful of studies that investigated this behaviour mainly concern survey-based data in psychology showing that people regularly pick their nose (Andrade & Srihari, 2001; Jefferson & Thompson, 1995; Portalatin, 2009; Wertheim et al., 2006). Interestingly, although the studies were conducted in a handful of countries in Western and Indian populations and show that majority of humans in these populations pick their nose rather often, they are often ashamed to admit it (Jefferson & Thompson, 1995). Nose-picking is indeed considered as a repugnant, unhygienic and disgusting habit in Western cultures (Portalatin, 2009). The cultural evidence and history about the disgust-norm of any kind of body product (saliva, nose mucous, urine, vomit, faeces, dry blood scab, etc.) is widespread in the literature and can be traced throughout history (McGregor, 2016; Nichols, 2002; Rozin et al., 2000; Russell [1460], 1969). In the bible, the Koran and the four Vedas, for example, cleanliness and godliness are related (Curtis, 2001). In fact, disgusting habits related to bodily secretions seem to be considered as such worldwide. Darwin even discussed these and related this to a behavioural drive allowing humans to avoid the spread of disease (Curtis, 2001). To date, there is no scientific consensus about the potential costs or benefits of this behaviour. One study suggests that it can be due to the texture, crunchiness and saltiness of the snot (the composition of nasal mucus is 95% of water, 2% of glycoprotein, 1% of other proteins, 1% of immunoglobulin, traces of lactoferrin, lysozyme and lipids), as nasal mucus contains all these characteristics which are favoured by humans (Portalatin, 2009). Portalatin (2009) has also encouraged research in immunology by suggesting that the ingestion of nasal mucus could play an important role for the immune system by acting as an 'auto-

vaccination'. Another study showed that nose picking can distribute nasal bacteria (Wertheim et al., 2006) while another suggested that the oral ingestion of nasal mucus (mucophagy) can prevent bacteria from sticking to tooth surfaces and thus help to maintain oral health (Frenckel & Ribbeck, 2015).

The aim of the present study is to try to understand the origin and evolution of nose picking and mucophagy behaviour. We report the first video-documented observation of rhinotillexis followed by mucophagy (mucus consumption) in the strepsirrhine *Daubentonia madagascariensis*, commonly known as the aye-aye. We carry out a broad comparative survey on the distribution of nose picking in non-human primates.

Materials and methods

Review of the literature and online sources about primate nose picking and video recording of the aye-aye picking its nose

We reviewed relevant literature and online sources in order to document nose picking observations in primates. For the search online, we used the terms: 'nose picking', 'nose picking primates', 'nose picking evolution', 'nose picking behaviour', 'rhinotillexis', 'rhinotillexis primates', 'rhinotillexis evolution', 'mucophagy', 'mucophagy primates', 'mucophagy evolution', as well as the same term with the name of different primates' species. We recorded a video of an aye-aye (Kali, adult female born in 1998) picking its nose during a trial at the Duke Lemur Center (Durham, NC, USA) while working on a project documenting the evolution of grasping behaviour in primates. As the aye-aye is a nocturnal species, the video was recorded using a low light digital video camera (Sony HDR-SR11 10.2MP).

Visualization of the CT scan of the head and middle finger of the aye-aye

A tomogram of an aye-aye (*Daubentonia madagascariensis*) was obtained from the online depositary Morphosource (http://www.morphosource.org). The specimen is housed at the American Museum of Natural History (New York, NY, USA; AMNH-M-185640). The specimen is an entire body of an adult, of *Daubentonia madagascariensis*, collected in 1931-01-01 at Tampina (Province: Toamasina, Madagascar). A Nikon XTH 225 ST microtomograph was used in order to obtain the CT-scan, acquired at 160 kV and 164 µA. The geometry was set to obtain a 109.4 µm voxel size in the reconstructed three-dimensional images. The dataset consists of 1800 projections (with an average of 1) taken over 360° for the whole body of the specimen. ImageJ was used to mask the anatomical structures that were not of interest. Next, the volume rendering obtained was used to visualize in AVIZO v. 7.1 and 9.1 (VSG, SAS, Merignac, France, http://www.vsg3d.com) the sub-set of selected voxels of the digit (middle finger), paranasal sinuses, nasal cavity, pharynx, larynx and trachea.

This visualization was possible as the nasal cavity and paranasal sinuses were completely filled with air without fluid residues that could close the connection of the nasal and sinus cavities, thus allowing us to perfectly see the differences in densities between the different anatomical structures. In order to reproduce the position of the middle finger observed on the video and to visualize its possible passage in the nasal cavity, R.B carried out clipping planes and positioned the middle finger by performing translations and rotations between the phalanges. To understand the possible pathway of the finger in the nasal passage, we decided to initially position the finger in the lumen of the nostril and then have it follow those passages where the diameter was greater than that of the finger. Because each phalanx is elongated, reconstructing the path of the middle finger is facilitated by a reduced number of translation and rotations interventions on the orientations of the interphalangeal joints.

Visualizing known nose picking behaviour in primates on a phylogeny

In order to visualize the presence versus unknown nature of nose picking behaviour in primates at the family level using the Fleagle taxonomy (2013). The category of nose picking was defined as present if at least one species belonging to a family was observed picking its nose, otherwise it was defined as unknown. A consensus tree was used at the family level from the 10 k Trees Project (Arnold et al., 2010). To do so, we used the 'plot' function in ape v.5.6–2 R package (Paradis & Schliep, 2019; R Core Team, 2020). It is important to note that this is only a visualization of known occurrences of nose picking behaviour and does not represent an ancestral state estimation.

Results

Review of the literature and online sources about primate nose picking and video recording of the aye-aye picking its nose

The review of the literature and additional video evidence can be found Table 1 and shows that at least 11 species of primates pick their nose and ingest the nasal mucus. With the video that we recorded at the Duke Lemur Center (See Fig. 1 and Video S1), we show that the aye-aye inserts the entire length of its extra-long, skinny and highly mobile middle finger into the nasal passages and then licks the nasal mucus collected. This idiosyncratic behaviour is similar to the 'probing' or 'fishing' behaviour described in feeding contexts (Lhota et al., 2008, 2009; Peckre et al., 2022). Indeed, aye-ayes have been described as inserting their finger into fruit and retracting it to the mouth with many consecutive movements. The animals interrupted these movements to lick their third digit before resuming (Peckre et al., 2022). This video brings the number of species known to pick their nose to twelve.

Visualization of the CT scan of the head and middle finger of the aye-aye

We investigate the internal anatomy of the nasal cavity of the aye-aye in order to understand how it can introduce its entire

Table 1 Observations of primate species using either their fingers or a probe to pick their nose and ingest the mucus retrieved

	Common name	Species	Wild/captive	Videos and literature references	Finger/probe
Great apes	Human	*Homo sapiens*	Wild	Andrade & Srihari, 2001; Jefferson & Thompson, 1995	Finger and probes
	Eastern Gorilla	*Gorilla beringei*	Wild	https://www.youtube.com/watch?v=zLnjXA_0Wpc	Finger (II)
	Western Gorilla	*Gorilla gorilla*	Captive	https://www.youtube.com/watch?v=92Adc9wKc68	Finger (II&III)
				https://www.youtube.com/watch?v=PP121TSo06s	
	Bonobo	*Pan paniscus*	Wild	Marchant & McGrew, 1999;	
				Nishida & Nakamura, 1993	
	Chimpanzee	*Pan troglodytes*	Captive and wild	van Lawick-Goodall (1971a, 1971b);	Finger (II)
				Nishida & Nakamura, 1993;	
				Nishida et al., 2009;	
				https://www.youtube.com/watch?v=eKNaJIA4Ycg	
				https://www.youtube.com/watch?v=I0NviK3qKgA	
	Sumatran Orangutan	*Pongo abelii*	Captive	https://www.youtube.com/watch?v=ZnjdTnYPTRM;	Finger (I&II)
				https://www.youtube.com/watch?v=CD3fbf0Fnbw	Chewing gum
				https://www.youtube.com/watch?v=ifYxIpYpo0w	
Old World monkeys	Crested Macaque	*Macaca nigra*	Captive	https://www.youtube.com/watch?v=dfLpa_S6U1A	Finger (II)
	Crab-eating Macaque	*Macaca fascicularis*		https://www.youtube.com/watch?v=c3iBfPTqkCw	Stick
				https://www.youtube.com/watch?v=l0xCGviY80A	
				https://www.youtube.com/watch?v=yEydmt_3HhU	
	Tonkean Macaque	*Macaca tonkeana*	Captive	Bayart, 1982	Stick
New World monkeys	White-fronted capuchin	*Cebus* sp.	Captive	https://www.youtube.com/watch?v=d0n8OZKG2h0	*Finger (II)*
				https://www.youtube.com/watch?v=25hW6lFoOAc	
	Bearded Capuchin	*Sapajus libidinosus*	Wild	Haslam & Falótico, 2015	Stick
				https://www.youtube.com/watch?v=CEe7KDsbTsw	

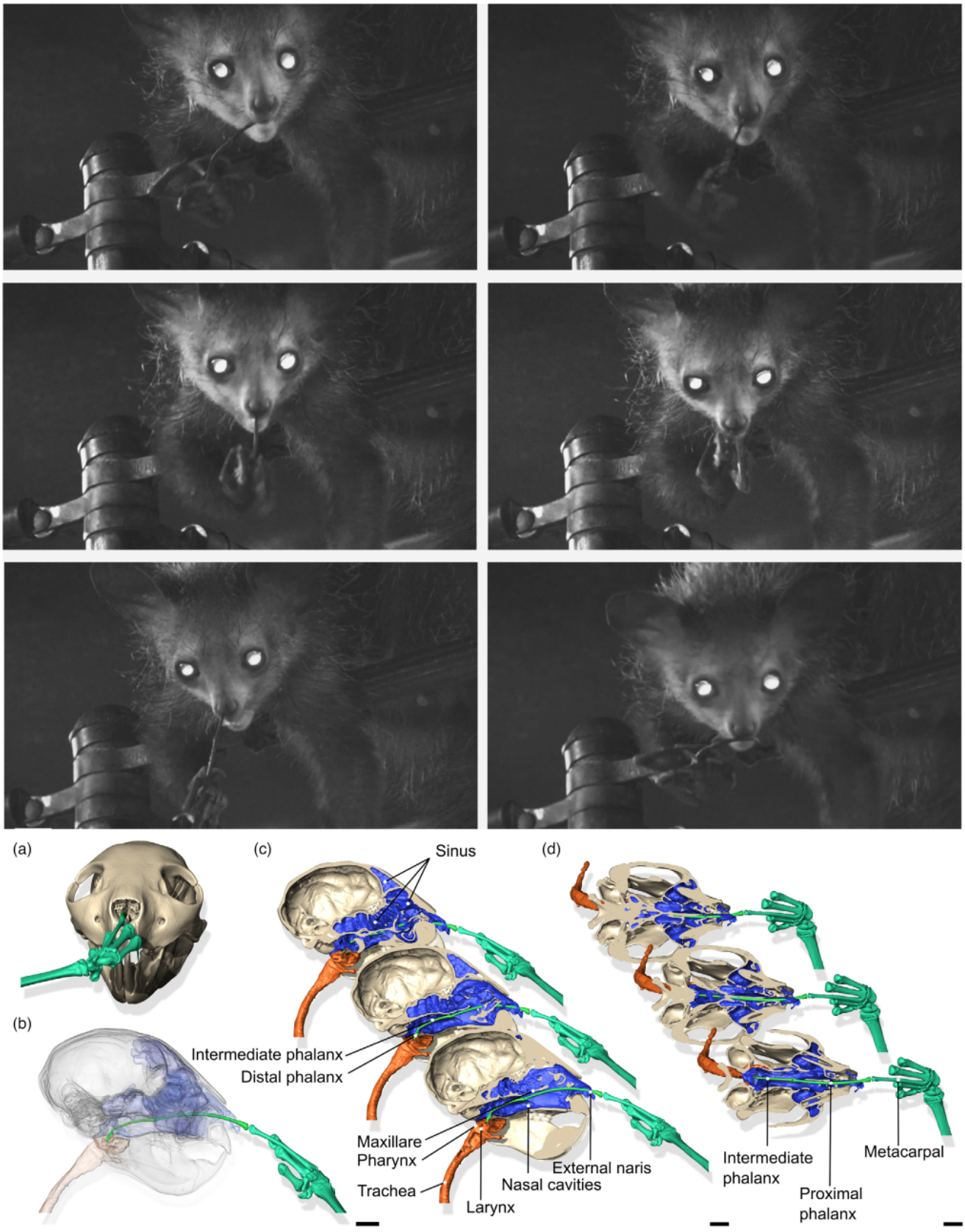
(a)
(b)
(c)
Sinus
Intermediate phalanx
Distal phalanx
Maxillare
Pharynx
Trachea
Larynx
External naris
Nasal cavities
(d)
Intermediate phalanx
Proximal phalanx
Metacarpal

Figure 1 Pictures of the footage of the aye-aye picking its nose at the top. Illustration of 3D visualization of the head and middle finger of the aye-aye: (a) in cranial view; (b) in lateral view; (c) in lateral view at different depth; (d) in dorsal view at different depth. Colour code is as follows: green represents the hand and forearm, orange represents the trachea and larynx, blue represents the sinus, nasal cavities and external naris. Scale bar = 10 mm.

elongated finger in its nasal system. The reconstruction of a skull and a hand of an aye-aye using an X-ray microtomography suggests that the finger likely descends into the oral cavity (Fig. 1).

Mapping of nose picking behaviour in primates

The results of the mapping of the presence/ unknown nature of nose picking behaviour on the phylogeny (Fig. 2) show that nose picking is present in four families of primates and unknown in the 10 other families suggesting a strong lack of observations on this behaviour.

Discussion

Our survey of previously published studies and additional video evidence shows that other primate species use either their fingers or a probe to pick their nose and ingest the mucus. We were able to find accounts of this behaviour for great apes (Marchant & McGrew, 1999; Nishida et al., 2009; Nishida & Nakamura, 1993; van Lawick-Goodall, 1971a, 1971b), Old World monkeys (Bayart, 1982) and New World monkeys (Haslam & Falótico, 2015) (Table 1). Moreover, our personal observations show that this behaviour is also present in strepsirrhines, more specifically it is a frequent behaviour in aye-ayes in general (personal observations). Videos recorded of an aye-aye manipulating food showed it using its thin and elongated middle finger to pick its nose and then licking the nasal mucus (Fig. 1 and Video S1). This action is unexpected because the aye-aye inserts its entire elongated (representing two-thirds the length of its hand) and highly mobile (Lhota et al., 2008; Soligo, 2005) third finger into its nasal cavity (Fig. 1). To better understand this behaviour, we used the CT scan of the skull and hand of an aye-aye and reconstructed the position of the middle finger traversing the nasal cavity. These reconstructions suggest that its finger likely descends into the pharynx. The function of this unusual behaviour involving the insertion of the finger into the pharynx remains unclear to date.

Based on the presence of rhinotillexis in all major lineages of primates, we suggest that this behaviour is most probably a widespread feature of primates which should be further investigated (Fig. 2). In addition, it is interesting to note that this behaviour mainly occurred in species having fine manipulative skills. Except for the aye-aye, none of the Strepsirrhines we worked with at the Duke Lemur Center were observed performing rhinotillexis and no other publications or videos reporting this behaviour could be found. Similarly, in New World monkeys, rhinotillexis was only observed in capuchins. Interestingly, aye-ayes and capuchins are exceptions among strepsirrhines and Platyrrhines, respectively, regarding their grasping abilities. Aye-ayes show feeding techniques involving finger individualization, while all other species of its group are thought to show a single stereotyped power-grip pattern consisting of a simultaneous movement of all digits to press the object against the palm (Bishop, 1962, 1964; Napier, 1960; Schöneich, 1993). Capuchins also stand out from their group (Plathyrhines) with a wide variety of precision grips involving finger individualization (Christel, 1993; Christel & Fragaszy, 2000; Reghem et al., 2013). Rhinotillexis seems to be particularly common among great apes and old-world monkeys, the groups known to show the highest degree of variation and accuracy of manipulative behaviours (Macfarlane & Graziano, 2009; Marzke et al., 2015; Pouydebat et al., 2011; Reghem et al., 2013). Tool use to pick the nose was also observed in most primates of these families (Table 1) except strepsirrhines. This is not particularly surprising given that rhinotillexis is observed in species having fine manipulative skills. In addition, the tool use skills of nose-picking primates might easily be coincidental since these are the most intensively studied and observed species in zoos and in the wild. Hence, the use of the finger and / or a tool to pick the nose (in opposition to directly licking the nasal mucus with the tongue) might be related to specialized anatomy and enhanced manipulative abilities of the animal (having fingers that are thin enough to enter into the nostril or having manipulative skills that are good enough to use tools). It will be interesting to further investigate this in other mammal species known to have elongated and thin fingers such as the common striped possum [*Dactylopsila trivirgata* (Rawlins & Handasyde, 2006)], for example.

The commonality of rhinotillexis across primates needs to be further investigated in order to understand whether it might have a functional role or was not selected against. This functional role may involve self-cleaning behaviour targeted at the accumulation of mucus in the nostril and might have no further advantage. However, the fact that several species (i.e. capuchins, macaques, gorilla) were observed to ingest the mucus even when using tools and that in many cases humans also ingest mucus instead of cleaning their hands suggest that this behaviour could potentially have another function. This casts a new light on nose picking as a behaviour and suggests that rather than being harmful or disgusting it may actually have an important functional role that remains to be understood, however. It is important to note that part of the species reported in the survey of this study come from captive environments. Nevertheless, as mentioned by van Lawick-Goodall (1971a, 1971b): 'if a primate shows behaviour in captivity which has not been observed in the wild, this by no means implies that it does not occur in the wild'.

As mentioned earlier, nose picking and mucophagy might be associated with cleaning behaviour. Future studies should investigate possible roles for this behaviour that transcend its

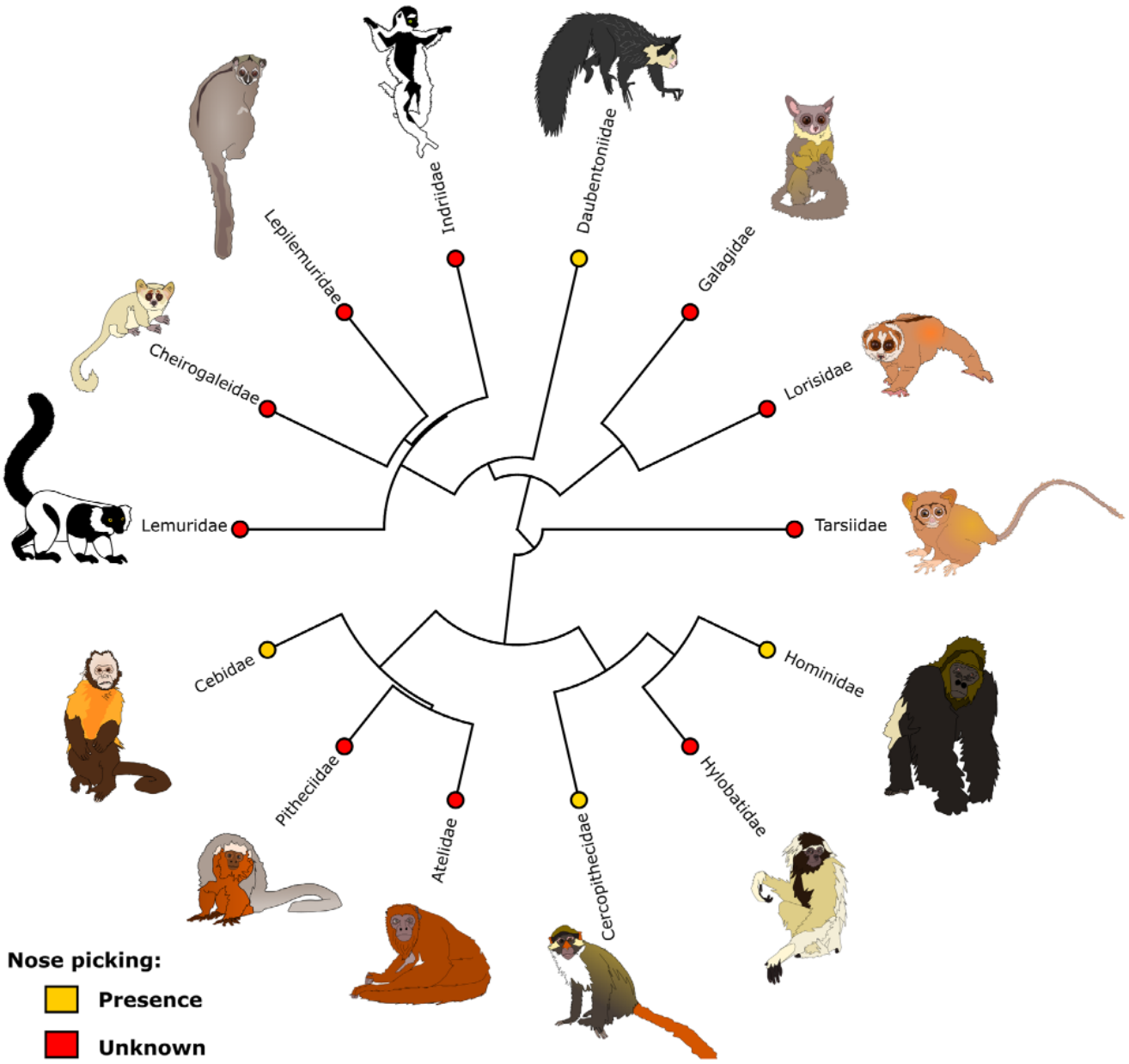

Figure 2 Mapping nose picking behaviour in Primates phylogeny. Colour code: gold circles represent presence of observation of nose picking behaviour in the family; red circles represent absence of observation of nose picking behaviour in the family.

characterization as a repugnant habit in humans. Comparative studies reviewing nose picking and mucophagy across additional primate taxa or even in vertebrates in general are likely to provide further insight into its origin, function and evolution and might provide interesting medical perspectives (Portalatin, 2009).

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Video S1. Aye-aye (kali) picking its nose at the Duke Lemur Center.