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SOIL-EATING BEHAVIOR OF THE HYBRID MACAQUE OF KOWLOON

F. D. Burton', K. Bolton[2] and V. Campbell
University of Toronto at Scarborough
[1]Dept. of Anthropology, [2.] Dept. of Environmental Science

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Abstract : This study reports on 142 incidences of geophagy observed over 700 hours in 1995 amongst the hybrid macaques of Kowloon. These synanthropic monkeys live in the southern region of the Peninsula along Tai Po Road. The purpose of this study is to describe the behaviour of geophagy and consider the implication of it for this population. Soil is an important component of the diet: nutrients are derived from soil, plant toxins are neutralized and/or adsorbed. While all age groups and both sexes eat soil, adult females were the most frequent users. Soil is sought and purposefully selected, and some sites are preferred. Geophagy increases after holiday provisioning. The population has grown over time, encouraging the use of plants high in secondary compounds the ingestion of soil with significant levels of kaolin probably mitigates these factors.

INTRODUCTION

Geophagy, the deliberate act of eating soil, is widespread in vertebrates (Beyer *et al.*, 1994). Soil- eating is also well attested in a number of families of non-human primates (see Table 1). There is growing evidence that soil-eating may assist in maintaining population size, or even increase, especially where populations are under pressure from human activity.

Species	Source
Lemuridae	
Lemur catta	Ganzhorn, 1987
Lemur fulvus	Ganzhorn, 1987
Callitrichidae	
Sauginus mystax	Heymann & Hartmann, 1991
Callicebus personatus	Muller *et al.*, 1997
Cebidae	
Chiropotes albinasus	Ferrari, 1995
Alouatta seniculus	Julliot & Sabatier 1993; Izawa, 1993
Ateles belzebuth	Izawa, 1993; Izawa,Kimura & Samper-Nieto1979
Cercopithecidae	
Macaca fuscata	Inoue, 1987; Mahaney *et al.*, 1993 Mahaney *et al.*, 1995
Macaca mulatta	Hladik & Hladik, 1972
Macaca sinica	
Colobinae	
Presbytis rubicunda	Davies & Baillie, 1988
Presbytis senex	Hladik & Guegen 1974; 1997
Presbytis entellus	Hladik & Guegen 1974; 1997
Colobus guereza	Oates, 1978
Hominidae	
Gorilla gorilla beringei	Fossey, 1983; Fossey & Harcourt, 1977; Mahaney *et al.*, 1995; Mahaney, *et al.*, 1996 Nishihara,*et al.*, 1991
Gorilla gorilla gorilla	Goodall, 1968; Hladik &
Pan troglodytes	Guegen,1974; Mahaney *et al.*, 1996

14 continued

The hybrid macaques of Kowloon Hills, (Hong Kong), have been observed eating soil since 1984. Elsewhere we have presented the analyses of Eaten, Control and Refused soil samples taken after direct observation (Bolton, Campbell and Burton, 1998) which complement the growing knowledge on the chemical composition of geophagous soils. These studies, (e.g Mahaney *et al.*, 1993; 1995; 1996) note that soil is eaten, but do not focus on the behaviour of geophagy per se. The purpose of this paper, therefore, is to describe the participants, amount, and dietary associations of geophagy in these feral, synanthropic, hybrid macaques. In addition, we are concerned with selection of the soil, and aspects of the diet in order to evaluate the significance of soil-eating for these monkeys.

BACKGROUND

The study site: Kowloon is a subtropical area, whose warm climate and monsoons have caused the soil to be highly weathered. Due to the oxidation of iron, they have become red or yellow in colour. The clay–size fraction contains mostly quartz, with kaolinite comprising approximately 35% (Lumb and Fan 1975). The Kowloon Hills (Burton and Chan 1987; 1996), and its reservoirs, is heavily forested as the result of the reforest-ation program begun in 1946 (Hong Kong Annual Report, 1947; Burton and Chan, 1987; 1996). The study area extends from Black College Road at the south, to the Kowloon Reservoir in the west, the Kam Shan Road at the north, and the Kam Shan Park Management Centre to the east across Tai Po Road.

The monkeys: The segment of the total population of monkeys in the Kowloon Hills which frequented the main study area numbered between 350-400 animals. The current population of hybridized monkeys derives from rhesus monkeys (*M. mulatta*) which were probably indigenous, and released animals of several other macaque species. These include: the long-tail macaque, *M. fascicularis*; Pere David's macaque, *M. thibetana*,· the pig-tailed macaque, *M.nemestrina*; the Japanese macaque, *M. fuscata*; and probably the Formosan Rock macaque, *M. cyclopis*. The history of these monkeys has been detailed elsewhere (Burton and chan 1996; Burton, 1989). They are synanthropic, that is they live with humans or due to human agency. They are 'urban' as they live amongst humans, in their parks, and along their roads (Bishop et. al 1981), and they are "food enhanced" (Fa and Southwick, 1988) as they receive food donation. People come to feed the monkeys as recreation, religious act and, a few, because they believe the monkeys require it. The population has increased considerably, (Burton 1989; Fellowes, 1992; Burton and Chan, 1996; Wong 1994) since the Southwicks' first observations of just over 100 monkeys in the

early 1980s (Southwick and Southwick, 1983). By the end of the decade, there were reports of nearly 700 monkeys (Fellowes,1992). This extraordinary growth parallels the phenomenon noted by Sugiyama (1982) for indigenous monkey in Japan attributed to food donations. Wong (1994) estimates the monthly food donations at about 1180 kg. Under the supervision of the department of Agriculture and Fisheries, they are culled from time to time (Wong, p.c.), but are not provisioned by this agency, neither is breeding nor predation controlled. Departmental figures indicate that adults constitute 60% of this group, juveniles 26% and infants 14% (Wong, 1994).

The monkeys' diet: The diet comprises provisioned and gathered foods. Food donations, mostly from nine families of domesticated plants, depend on the donors' purpose (Burton, unpub.). Recreational feeders tend to give out less nutritive food (e.g. sweets, crisps, pork rinds) in order to attract the monkeys to them, while religiously inspired donors are inclined to put out fruits and vegetable for the monkeys to find (Burton,1989; Burton and Chan, 1987, 1989, 1996). The forests, however, provide the basic and varied diet. The monkeys gather from fifty-one genera in thirty - three families of plants taking leaves, buds shoots, fruits, seeds, berries and nuts (Burton, unpub.). Local wisdom has it that these macaques were brought to Kowloon to protect the human water supply by ridding the reservoirs of the toxin from strychnos plants a food source for non-human primates (Burton and Chan, 1987). Fabled as

this event may be, it is certainly true that these monkeys eat plants whose parts contain a variety of secondary compounds, primarily alkaloids and terpenes (Burton, unpub.). The different kinds of toxins include substances like the poisonous alkaloids, or initially harmless compounds which decompose to form poison products e.g. amygdalin which when hydrolised forms hydrocyanic acid (Ho, 1981).

Monkeys are selective in their use of plants, and generally avoid the most 'poisonous' part of the plant, such as the seeds of *Leucaena leucocephala* which concentrate selenium and can cause poisoning (He,1981), and take the less toxic shoots and pods of this plant. Domesticated fruits and vegetables given to the monkeys also contain secondary compounds, some of which, raw and in quantity, can be toxic: *Mangifera indica*, the mango, contains oleoresins which can cause contact dermatitis (Glasby, 1991; Harborne, 1993); members of the Solanaceae (e.g. potatoes and tomatoes) contain steroidal alkaloids as well as sesquiterpenoids (Lewis *et al.* 1977) and Brassica members contain glycosides as well as substances which can be muta- genic. The monkeys' intake of toxins, however, will be related to the amount of foods available to them at a particular time of year (Mathur *et al.* 1992), as well as competition due to group size, and above all, the quantity that is ingested.

METHODS

The sample: Geophagy has been observed since 1984. The 142 discrete incidences reported here, however, are described from an intensive sample of geophagy recorded in 1995. In 704 hours of observation, all occurrences were recorded by a team of 8 people. Soil samples were taken for analysis and are detailed elsewhere. The eaten samples had a higher buffering capacity, and were considerably higher in certain elements important to the diet such as iron and magnesium than were the refused samples.

The observations: Soil - eating was noted by location, depth at which the soil was removed, amount taken, duration of the eating bout and, where possible, by age and sex of the gatherer. Age attribution was based on size and reproductive status. Amongst these hybrid monkeys, size can be problematic (Burton, 1989; Burton and Chan, 1987; 1996). Hence juvenile-sized macaque females with infants at their teats are adults. We did not use a separate category for pregnant

females because pregnancy is visible only after basic formation of the fetus is achieved. This means that teratogenic influence is strongest when pregnancy cannot be distinguished (Burton and Chan, 1989). The sex of immature animals (infants and juveniles) was assigned only after direct observation of genitalia. Attempts to ascertain what was ingested before soil was eaten were found to be equivocal or impossible to discern.

RESULTS

Sites: there were 43 soil-eating sites within the study area

Table 2: Sites in the Study Area

Location	Number of sites	Num. of observations	Number of caves
'Toilet Road'	3	96	2
Black's Coll. Rd.	3	11	1
Blue fences	1	10	
Kam Shan	5	09	1 large
Kowl. Hills M.C.	4	01	2 caves
Byewash Res.BBQ Pit 2	1	01	
Water Works Access Rd.	7	14	3 precaves; 4 caves
Totals	**24**	**142**	**13**

These sites included surface scrapings or pickings, from location used opportunistically and not necessarily returned to. In addition, however, were the 'caves' (see Table 2 and Fig. I)-sites which have been mined for so long they are veritable caverns into cliffsides. Six of these were found along the "Toilet Road" down to the bottom of the Water Works Access Road (WWAR). Some of these caves had been noted in 1984 and there is video of them being excavated since 1986. The largest of these is 100 cm wide, 45 cm high and 60 cm. deep. There were also

'pre-caves'- sites where there had been a lot of digging which would, if not repaired, eventually become caves. Over the years, erosion, and especially that caused by monkey geophagy, caused the government to coat the slopes with concerete. These structures drain through small pipes or apertures. As the monkeys returned to pick at these openings the slopes would again erode. Where the government was in the process of repairing the concrete, there were scaffolds that the monkeys used as a means of getting to the exposed soils. They would brush the soil, or scrape at it causing avalanches and revealing soil at deeper levels. From 1988 to 1990, there was major construction along the Tai Po Road as overpasses were built. The soil exposed by bulldozers became a prime source of geophagy during these years. Most recently, in 1996, the government filled the caves along the WWAR with cement.

Subjects: Ninety-ftve individuals were identified by sex as well as age in the 142 incidences observed over the study period. The overall sex ratio for these known consumers of soil was just under 1:1.4 (m:f), while the adult sex ratio was 1:2.2. Adults constituted 56% of the total sample, and immature (juveniles and infants) the balance (44%).

Amount and duration: Most of the observations were of surface pickings, whether on the cave floor, ceilings or walls, or along roadsides and cliffsides. That is, the monkeys would use their nails to scrape, or their hands to brush across the surface of the ground and then pick up a 'ball' of soil, or a particle to eat, or scoop the loosened soil up with the hand. Monkeys would also use their teeth to gnaw and dig at more compact soil, and would take the particles with their fingers or directly with the mouth or tongue. The quantity taken was estimated at about 5ml. In the majority of observations (77%), followed by 15 ml. portions(l3%), but soil was also taken in compact 5 cm handfuls which were bitten like a piece of fruit (48%). The remaining observations (6%) were small fragments.

In the majority of instances (91%), brief soil-eating bouts lasted up to two minutes or less. Monkeys would go to a site, get a Portion of soil, and eat it as they moved on. Alternatively, the monkeys would sit choosing bits and then leave. Long soil-grazing episodes (9%) clustered between two to three minutes, but could extend to 5 minutes. In these instances, individuals moved around a site, actively seeking a portion of soil. On slopes of exposed soil, they would sit digging the soil into avalanches until a piece was chosen and eaten. Movement to the site was direct, with clear intent. Video footage confirms that monkeys would go abruptly to a soil-eating site from wherever they had been or whatever activity they had been engaged in. Nevertheless, there might be considerable brushing or scraping until an acceptable piece of soil was found. Some bits that were chosen were tasted, and smelled and consequently rejected. There were 14 clear cases of such evaluation. One vignette is ambiguous: an adult male cross between *M. fascicularis* and *M. mulatta*, licked the grayish-white soil and ate some moving it around his mouth with his tongue. He then rubbed his tongue and repeatedly

spat but whether it was the soil that he was trying to get rid of, or something he ate before he took the soil is not known.

Frequency: All occurrences of geophagy were recorded for the main study area [along WWAR]. Soil-eating took place most frequently in the late morning and mid-afternoon. Thirty-three percent of geophagy was between 10:00 and 11:00 and 43% between 13:00 and 15:00 hours. The average daily rate was just under 16 per day, or nearly two per hour of observation. The highest frequency of geophagy (62%) fell during the celebration of the Lunar New Year, especially the important days of the Spring Lantern Festival in February, when provisioning was particularly high. All age groups ate soil. Infants were the least involved (9%) while a little over one-third of geophagy was done by juveniles, and adults represent 57% of the total incidences. Of these, of individuals known by age and sex (67% of sample), adult females were marginally more inclined to ingest soil (54%) than were adult males.

DISCUSSION

Geophagy in many non-human primates is casual. Hladik and Hladik (1972) report that *P. entellus*

(*Semnopithecus entellus*) eat soil; 'accidentally' while Nishira *et al.* note that soil contributes little to the diet of the western gorilla. The purpose of soil-eating is often ambiguous as the soil comes from termite or leaf-cutting ant mounds, so that whether it is the soil of the mound itself, or the insects associated with it that is the dietary object, is not always clear (Juillot *et al.*; Heyman *et al.* 1991). In the hybrid monkeys of Kowloon, however, geophagy is incontestably for the soil itself. These monkeys know and return to specific locations for their soil as is evident from the depths and number of caves. Opportunism, however, is also evident in the monkeys' behaviour of taking fresh soil as available (scaffolded areas and construction sites).

Unchecked by predators other than humans, and provisioned by holiday visitors, the number of monkeys in Kam Shan Park have been increasing since Southwick and Southwick first doucmented group size (Southwick and Southwick, 1983; Burton, 1989; Wong, 1994; Burton and Chan, 1989, 1996). Population increase due to food donations has been well documented (e.g. Sugiyama, 1982; Fa *et al.* 1996).

Adsorption of plant toxins, and aid to digestion, have consistently received the strongest support as an explanation for non-human primate soil-eating and have been extended to explain human soil ingestion as well. Johns (1986) significant study correlated samples of soil eaten in four different South and North American locations with their ability to neutralize tomatine, an alkaloid, found in potatoes. and concluded that the behaviour was an efficient adaptation to eating this otherwise toxic substance. Robbins(1993) and Gates (1978) have each demonstrated the efficacy of soil elements in maintain stomach pH, especially in colobines. Recently, Struhsaker and Gooney(1997) have found the highest population density of colobus living in Indian almond and mango 'garden' habitat adjacent to forest. Here the colobines tolerate high levels of toxins by supplementing the diet with digestive adsorptives, in this case, charcoal.

As synanthropic animals, the Kowloon monkeys' excavations for soil are often thwarted by conflicting human activities, for example, the addition of concrete to the slopes to prevent erosion. There may well have been a greater number of habitual, deep sites had these not been covered over. In the measure that soil constitutes an important part of the dietary, such exclusion would become significant.

The demographic structure of the monkeys in this study conforms in sex ratio and percent of various age groups to the overall structure of the segment of the Kowloon Hills population frequenting the area. The large number of immature monkeys (44%) eating soil was unexpected even though it is consistent with the

exploratory nature of young in general. Whether they eat nearly as much soil as adults because they are exploring that material more frequently, or because they are using it in conjunction with plants they are experimenting with, will require further research. The high proportion of Adult females to Adult males cannot be discounted by the 6.5 percent of unknowns in the adult category. Amongst humans, pregnancy is often an additional incentive for geophagy, and this may be similar amongst adult female monkeys.

The monkeys of Kowloon have been receiving enormous amounts of donations for some time, with a concomitant impressive increase in population size. As population increases, choice of wild food sources becomes less discriminatory. In this dual context, the high rate of soil-ingestion during the study period- an average of 16 incidences per day peaking in the early afternoon- and the small amounts taken, seems to implicate the neutralizing effect of soil, especially given the significant amount of kaolinite in it. Kaolin is a common ingredient in preparations for human indigestion due to its neutralizing and adsorptive properties (Vermeer and Ferrel, 1985). The analysis of these soils (Bolton etal., 1998) confirm its buffering and adsorptive capacities. These contribute an important aid to digestion (Davies and Baillie, 1988). Adsorption of secondary compounds like tannins and alkaloids is assisted by the presence of clay minerals like kaolinite, but sorption of other toxins such as oxalates is increased by the presence of Fe and Al oxides which were significant in the soil eaten (Bolton *et al.* 1998)

CONCLUSION

Our findings indicate that soil-eating is important in the diet. Soil is sought and purposefully selected. The monkeys choose soils that are red or red-orange in colour. The iron content of such soil assists in neutralizing and adsorbing metals and in reducing toxicity (Bolton *et al.*, 1998). Certain sites are preferred over others, and indeed, within a site some kinds of pieces of soil are refused while others are avidly taken. Adult females were the most frequent users of soil, and adults as a group were more inclined to geophagy than were the other age groups, but immature animals, including infants also eat soil. Monkeys in Kowloon eat soil especially when they have been heavily provisioned by holiday visitors. The monkeys showed a decided preference for geophagy in the early hours of the afternoon, during the Spring Lantern holiday.

The size of this population has been increasing since it was first described (Southwick and Southwick, 1983; Burton and Chan, 1987,1989,1996), at times exponentially (Wong, 1994). Provisioning of these monkeys for religious and recreational reasons has been increasing over this same period (Burton, 1989; Burton and Chan, 1989, 1996). As the population increases, the natural diet expands with less discrimination, incorporating more substances some of which are noxious or toxic. The amount of secondary compounds in the diet of this growing population is probably mitigated by the ingestion of the high kaolin in the soil.

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