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**Parrot colpa and geophagy behaviour from the El Gato region of  
the Tambopata-Candamo Reserved Zone, Amazonia, Peru.**

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## Summary

This study was part of an expedition to the Tambopata-Candamo Reserved Zone of the Peru Amazon run by Biosphere Expeditions from 27 May to 8 July 2001. It investigated parrot geophagy in an effort to elucidate behavioural patterns and reasons for geophagy behaviour, as well as human and tourist impact on the clay licks (colpas) and the area in general. A small colpa was discovered by the expedition and 7 parrot and 1 pigeon species were observed feeding at it over a period of 23 observation days. The study found that the most likely reason for clay eating is detoxification. It also found that on the small colpa discovered, there was evidence of a correlation between parrot body size and feeding behaviour: the smaller species were more likely to feed more often, whereas the larger species tended to be wary and fed less often, or stayed off the colpa altogether. Whilst the smaller species appeared to be unaffected by human interference around the study site, the larger ones were thought to be dissuaded from feeding by the presence of the researchers, even though hides were constructed. Because of this the study concludes that, in contrast to large and open clay licks, small colpa sites as the one discovered are unlikely to be suitable for prolonged and sustainable tourism use.

Geophagy, defined as the ingestion of soil, is a common occurrence for many species of birds and other animals, including humans. Diamond *et al.* (1999) and Gilardi (1996) list a host of examples including isopods, butterflies, parrots, pigeons, cracids, grouse, bears, koala, rabbits, rodents, tapir, zebra, cow, goat, sheep, tortoises, many lemur and monkey species, chimpanzees, and last but not least, humans, especially pregnant women of traditional hunter-gatherer societies. Despite this, the function of geophagy remains unclear, although there is convincing evidence to shown that in New Guinea and Peruvian birds (Diamond *et al.* 1999) and in African elephants (Houston *et al.* 2001), geophagy serves to bind poisonous and/or bitter-tasting secondary fruit and seed compounds of the animals' diet, thereby removing potentially harmful substances from the digestive system and minimising their effects. There is also evidence that geophagy provides grit to many weak-billed birds (Best & Gionfriddo 1991), essential minerals to mammals and butterflies, buffers against gastric pH swings to ruminants (Jones & Hanson 1985), as well as a cure for diarrhoea in chimpanzees (Krishnamani & Mahaney 2000, Mahaney *et al.* 1996).

Reported here are incidences of geophagy by 7 species of parrots and 1 species of pigeon from a small colpa along the El Gato river in the Peru Amazon. This colpa has never been studied before and showed no evidence of human impact. Although not analysed, soil samples from the colpa as well as random samples from other mud cliff walls along the El Gato were taken. It is hoped that these samples will be analysed at a later stage in an effort further to elucidate the function of geophagy in the birds observed. As it is, this study concentrated on the behavioural patterns displayed by the birds visiting the colpa.

There are currently over a dozen ecotourist lodges in Tambopata with plans for more to be built in the future. Visitors are attracted by the spectacular bird gatherings at colpas. However, colpas are a limited resource and to date there are no restrictions in place to

control colpa visitor numbers. Data gathered during this expedition provides important baseline information for decision-makers in Peru who are considering the management options for tourism in the area.

## **Location, Material and Methods**

### Location

This study was carried out as part of a research expedition conducted by Biosphere Expeditions. The expedition ran from 27 May to 8 July 2001, and studies were conducted between 3 June and 4 July 2001 along the El Gato river in the Tambopata-Candamo Reserved Zone. The Tambopata-Candamo Reserved Zone lies within the confines of the Amazon basin in South East Peru with a sub-tropical climate and distinct wet and dry seasons. It originated in the late 1970s as the small Tambopata Reserved Zone comprising about 5,000 hectares, but was much enlarged to 1.5 million hectares in 1990 and now covers altitudes from 240 to 3,500 metres, and habitats ranging from sub-tropical moist forest, to cloud forest, to tropical savannah. In September 2000 it was central in the creation of the Bahuaja-Sonene National Park which now covers 2.7 million hectares, protecting an ecosystem which holds several world records in flora and fauna species numbers and is recognised as one of the planet's hotspots of biodiversity (Mittermeier *et al.* 1997, Mittermeier *et al.* 1998). Rainfall averages 2,000 mm per year and humidity is about 75%.

The expedition was based in a fairly remote region along the Tambopata river, about 4½ hours upriver from Puerto Maldonado (see Figure1). Transport to and from base camp was by boat, most studies were conducted on foot or from hides. The expedition base was

at the confluence of the small El Gato and the much larger Tambopata river (S 12° 51.415', W 69° 26.752'), the colpa further upriver along the El Gato (S 12° 51.419', W 69° 26.739'), about 2 kilometers or 40 minutes walk from base.

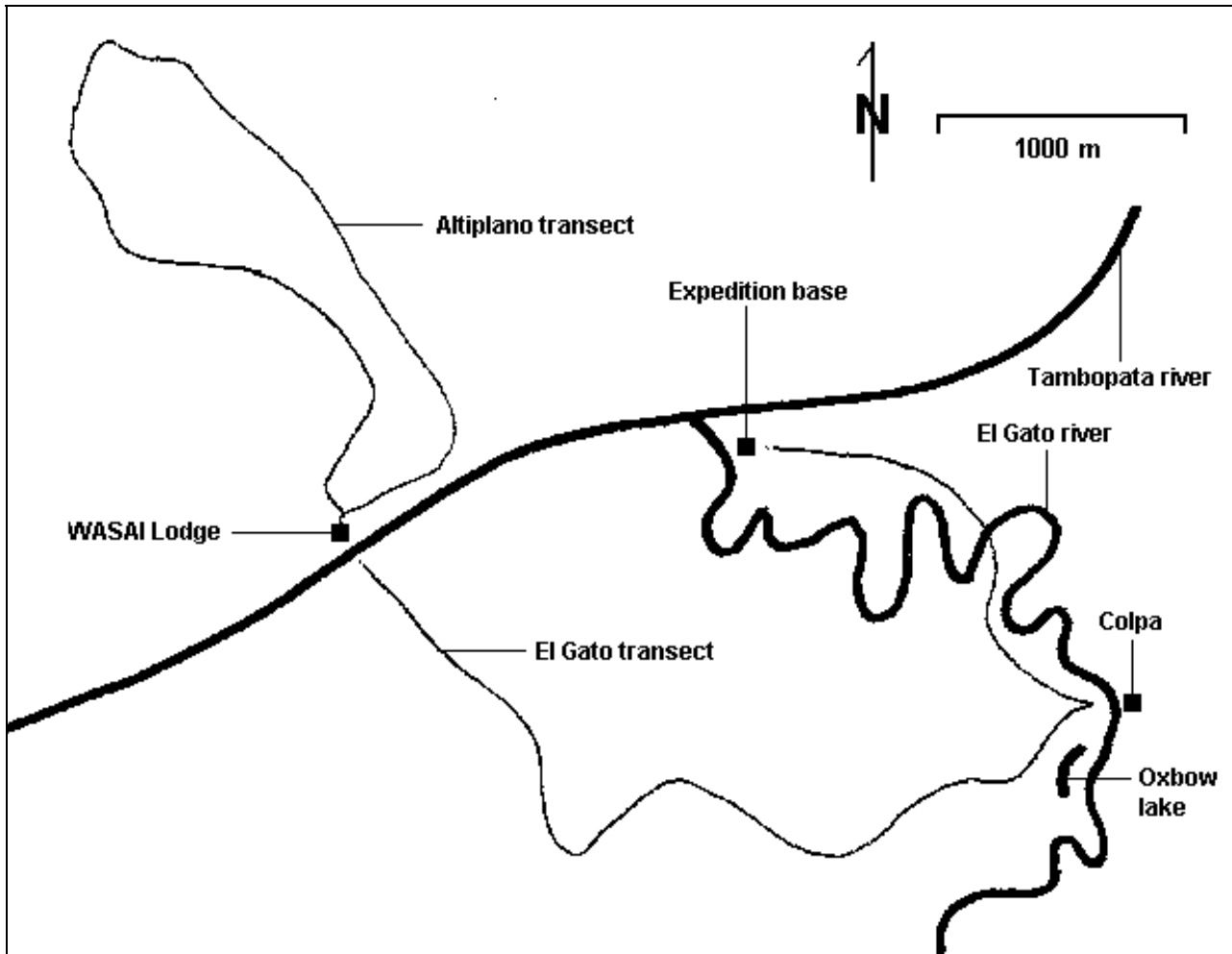


Fig. 1. Study site and transect trails (transect trails shown for illustration only as they are not relevant to this study). Expedition base S 12° 51.415', W 69° 26.752', colpa S 12° 51.419', W 69° 26.739'.

The colpa site was 'discovered' after conversations with local people who led the expedition to the site. The colpa itself consisted of 2 vertical pillars of mud, which had eroded out of the continuous mud cliff along the El Gato river. The pillars were between 6 to 8 metres tall, standing about 1 metre apart. The mud cliff wall was about 12 metres high. The El Gato river is a small tributary to the much larger Tambopata. It is shallow and rarely deeper than 2 metres. Its width at the colpa was 8 metres. It meanders strongly and high mud cliff walls are usually found on the outside bend, whilst the inside bend is flat. This pattern was present at the colpa and a hide was constructed directly opposite the colpa on flat ground covered in thick bamboo growth, which turned into rain forest about 10 metres from the river banks.

The distance between the hide and the colpa was about 15 metres. The colpa faced North East so that the sunrise point was almost exactly behind the colpa as seen from the hide. That meant that the colpa was in the shade for most of the day, only getting some diffuse sunlight in the afternoon.

The habitat around the colpa consisted of mixed primary and secondary rain forest with relatively little human impact. Some trails were in existence on either side of the El Gato, but they were rarely used and the expedition did not encounter any local people on the trails at any time during the expedition. Some hunting is practiced by relatively few people for subsistence. Human activity is concentrated along the Tambopata river and rapidly drops off with increasing distance from that main waterway. Before the declaration of the National Park, large-scale timber extraction was common, but has since then disappeared save for some small-scale subsistence extraction. Some localized small-scale gold mining is also practiced illegally.

## Survey methods

The expedition's survey team consisted of several paying, untrained expedition team members who gave up their holiday time to assist in this research project. Their work and the expedition contribution they paid made this research possible. Teams were on site for 2 weeks and then changed over, with some people staying for more than 1 two week slot. Team sizes varied between 5 to 7 expedition team members + 1 expedition leader + 1 guide + various support personnel (the latter not participating in the survey). Expedition team members were trained in animal including bird recognition on site by the guides, the expedition leader and by other team members with experience in ornithology and natural history. Field guides were also provided.

From the expedition base a trail was constructed to the far side of the colpa and a hide was built directly opposite. Hide surveys were conducted daily in the period 3 June to 4 July, interrupted 7 to 10 June for an expedition excursion and a team changeover, and 17 to 21 June by another team changeover and a friaje (a freak weather event in the form of a periodic cold front from the Antarctic reaching Peru bringing with it high winds and rain and dropping temperatures to around 8° C). During such friajes there is very little bird or other animal activity and the expedition retreated to Puerto Maldonado. In total 23 observation days were logged.

For the first 4 days, 12 hour daylight observations were made to ascertain hours of parrot feeding activity. As locals suggested and Gilardi & Munn (1998) found, these were found to be in the morning and from then on the expedition concentrated on the morning hours. At least 2 people would walk around 40 minutes to the hide and stay there in shifts of between 2 to 3 hours before being relieved. In the beginning observations were only made

from within the hide, which consisted of a box made from branches and covered on three sides and on top by foliage. There was a small observation 'window' facing the colpa. Towards the end of the expedition, when we felt that the birds were sufficiently habituated to our presence, we made observations from the cliff above the colpa and from the riverbank opposite the colpa to the left of the hide with observers in the open, in clear view of the birds. These studies were conducted 28 June to 4 July to ascertain flight paths and behavioural patterns before and after feeding at the colpa. All observations were recorded in a central log.

On 3 July samples were collected from the colpa at preferred feeding sites on the 2 pillars, from random mud cliff sites along the river, and from what was thought could be another colpa site because it showed faint signs of beak activity. These samples were sealed in standard 35 mm film cartridge containers and await analysis.



## Results and Observations

During the 23 observation days 7 parrot and 1 pigeon species were observed feeding at the colpa (see Table 1). In addition 6 other parrot species were seen in the area (see Table 2).

Table 1. Species observed at the colpa (by frequency of observations). Observations made from hide.

Species	Mass (g) <sup>1</sup>	Feeding times observed	Preferred feeding site	Days observed (out of 23)	Av. group size	Remarks
Dusky-headed Parakeet <i>Aratinga weddellii</i>	110	06.30 – 09.30	A, then B	15	21	Clear and hot days seem to encourage early feeding, usually first to feed.
Orange-cheeked Parrot <i>Pionopsitta barrabandi</i>	140	06.30 – 08.40	A, B, once D	9	13	Large variation in group size 2 – 40.
Pale-vented Pigeon <i>Columba cayennensis</i>		08.00 – 09.50	B	5	2	Always small groups 1 – 3, feeding long, often spooking parrots.
Rock Parakeet <i>Pyrrhura rupicola</i>	75	08.40 – 10.20	C, sometimes B	4	6	Always in groups of 5 or 6, wary.
Cobalt-winged Parakeet <i>Brotogeris cyanoptera</i>	67	08.20 – 10.20	A and B	4 <sup>2</sup>	13	Only species seen gathered in afternoon around colpa but not feeding <sup>3</sup> .
Blue-headed Parrot <i>Pionus menstruus</i>	293	06.40 – 08.30	A and B	1	4	Small groups, always let other species go first.
White-eyed Parakeet <i>Aratinga leucophthalmus</i>	190	08.20 – 08.35	no information	1	1	Only 1 observation.
Scarlet Macaw <i>Ara macao</i>	1015	15.39 – 16.28	n/a	1	1	Only 1 observation, fed 50 m to right of colpa. Wary.

Feeding sites: A = lower part of right hand pillar = site 3 of clay sample collection (see Table 3), B = upper part of right hand pillar = site 4 of clay sample collection, C = behind top part of left hand pillar = site 5 of clay sample collection, D = upper part of left hand pillar. Superscript notes: 1 = according to Terborgh *et al.* (1990), 2 = days observed feeding only, 3 = this supports observations by Gilardi and Munn (1998) who report an afternoon peak of activity for *Brotogeris spp.* (see also *Brotogeris sanctithomnae* in table below).

Table 2. Other parrot species observed at or around the colpa, along the trail to the colpa and around base.

Species	Mass (g) <sup>1</sup>	Remarks
Red-and-green Macaw <i>Ara chloroptera</i>	1250	Frequently seen throughout study area, perched in trees around colpa. Observed looking down on hide.
Blue-and-yellow Macaw <i>Ara ararauna</i>	1125	Not very frequently seen, but seen perched in forest and flying over base camp. Not observed perching at the colpa.
Chestnut-fronted Macaw <i>Ara severa</i>	430	Often seen in flight crossing Tambopata river. Not observed perching at the colpa.
Mealy Parrot <i>Amazona farinosa</i>	800	Ubiquitous. Gathered every day in very large numbers around colpa in early morning, very vocal. Only once attempted to descend to colpa but was disturbed and departed. Observed looking down on hide.
White-bellied Parrot <i>Pionites leucogaster</i>	155	Sometimes seen in forest and 3 times observed perched near colpa, usually in trees in background some distance from the colpa.
Tui Parakeet <i>Brotogeris sanctithomnae</i>	67	Seen flying in flocks, usually in afternoon, confirming similar observation by Gilardi and Munn (1998). See also <i>Brotogeris cyanoptera</i> in table above.

Superscript notes: 1 = according to Terborgh *et al.* (1990).

## General behavioural observations

During the 6 week expedition period it appeared that the birds were feeding on a daily basis. Days when we did not observe feeding activities were either short observations days (like 6, 11, 12 June when observations were conducted only until 07.30, or 22 June when there was only one afternoon shift), or days just after the friaje (like 23 June). Towards the end of the study, birds, especially the smaller and more agile species, appeared more habituated, and total activity increased. We could even have several observers in full view and close to the colpa without being able to discern a change in behavioural patterns from purely hide-based observations. Indeed in the last 7 days when we conducted open-air observations, there was more feeding activity than in previous days, when observations were only made from within the hide. Notable exceptions were the larger-bodied species like *Amazona farinosa* (Mealy Parrots) and the macaws that

were frequently observed perching in the trees around the colpa, but either never fed, as in the case of the Mealy Parrots, or were only observed feeding once, as in the case of a pair of *Ara macao* (Scarlet Macaw). All this may have implications for tourist activity at colpas.

The peak activity period was in the early morning, there was little or no activity during the hottest part of the day, and little activity in the afternoon, except for *Brotogeris* spp. The weather appears to have a definite effect on activity patterns. Most noticeably during the cold, windy and rainy periods of the friaje there is no activity. Conversely, and as a general rule, hot sunny weather seems to encourage early and vigorous feeding activity, whereas low cloud cover and mist seem to discourage it.

On 1 July this was very apparent when it was very misty until the sun had burnt off the mist by 06.45. Almost as soon as this had happened, birds started arriving and feeding. 27, 29 and 30 June show similar patterns with very early feeding starting 06.35 on hot and sunny days. On 28 June there was low cloud early in the morning and on that day activities did not start until 08.42. However, there are clear exceptions to this general rule as on 14 June, an overcast and grey day with heavy rain around noon, there was very pronounced activity, starting very early in the morning at 06.40. Whatever the starting time, activities were usually over and the birds gone by 10.20 at the very latest.

Mealy Parrots and *Aratinga weddellii* (Dusky-headed Parakeets) were usually the first to arrive, with the Dusky-headed Parakeets trailblazing their way to the colpa. Strangely, the Mealy Parrots, stayed in the trees and were never observed feeding (although they made an attempt at descending to the colpa once on 15 June, but were spooked). A general pattern was that the parrots perched in the trees around the colpa, mostly vocalising

loudly, until what appeared to be a critical mass of support was reached. This was especially apparent on one day when some Dusky-headed Parakeets perched in the trees, but did not descend for what appeared to be lack of numbers. This was in stark contrast to all other days, when they would usually arrive in larger numbers, descend and feed. The descent would start by some individuals flying what could be described as reconnaissance turns around the colpa and back to their original perch position. Small groups of 1 to 4 individuals would then cross over to the trees and bushes surrounding the colpa and gradually move vertically and horizontally through the foliage until they could mount the clay cliffs. Departure, on the other hand, was usually in large, often multi-species flocks, either as a result of the birds being spooked or in what appeared to be normal behaviour once all the birds had fed.

The only afternoon activity observed was by *Brotogeris cyanoptera* (Cobalt-winged Parakeet) who were seen on several occasions perched around the colpa, but not feeding, at between 15.30 and 17.30. This observation supports those made by Gilardi & Munn (1998) who also report afternoon activity for *Brotogeris* spp. in Manu, an area not far from the present study area. The only descending and feeding observed for a pair of Scarlet Macaws was also in the afternoon, from 15.39 to 16.26.

The El Gato colpa was somewhat limited in size (compared to the huge clay cliffs at places like El Chuncho or the Tambopata Research Centre, an ecolodge), so the maximum number of birds to fit on the colpa was 60 – 70 of the relatively small-bodied Dusky-headed Parakeets, usually together with some other species. Despite forming such large multi-species assemblages on the colpa, the birds always arrived in small groups (like reported by Diamond *et al.* 1999), and usually flushed as a big flock (unlike reported by the same authors). Those authors also observed, as we did, birds evidently flying into

the site from far away. From our base camp we could often observe small groups coming from across the Tambopata river and heading for the colpa, thus covering a distance of at least 3 to 4 kilometres. As in Diamond *et al.*'s New Guinea expedition, this would suggest that colpas are few and far between. However, talking to local people gave us the impression that they were quite common and that the birds would always have alternative sites they could use in case they were disturbed. A few years ago only a handful of colpas were known in the area, but with increasing pressures of tourism and more research being conducted new sites are being found frequently. We could even 'discover' a colpa on our 4 hour boat ride from Puerto Maldonado to base camp, right on the Tambopata and next to a well-known ecolodge, which seemed to be unaware of the colpa on its doorstep, or if not, seemed to be reluctant to show it to its tourists - a highly unlikely scenario.

All birds, except perhaps *Columba cayennensis* (Pale-vented Pigeon), and less so *Pionus menstruus* (Blue-headed Parrot), seemed wary and nervous approaching the colpa, and were very easily flushed during the approach or once on the colpa. We agree with Diamond *et al.* (1999) that this is likely to indicate alertness to predators, especially hawks. Wariness can probably also explain the practice of posting 'sentinels', whereby not all the individuals of a flock feed at once, but some are positioned on surrounding lianas, facing away from the colpa and seemingly observing. Feeders and sentinels would then frequently change positions. This was observed in species that tended to visit the colpa in larger flocks numbering 10 or more. Those visiting in smaller numbers, like for example the Blue-headed Parrot, never committed themselves to the colpa first, but always waited for other species to start feeding, before they would approach.

Observations on individual species are as follows:

### Dusky-headed Parakeet

Usually fed in big groups of 10 up to 70, but arrived and crossed over to the colpa as small groups of 1 to 4. The Dusky-headed Parakeet was the lead species and thus almost always the first to feed. They would arrive early, perch in the trees until what appeared to be a critical mass of other individuals of the same species was assembled. Then the descent out of a number of 'launch trees' would start. These launch trees were tall trees on the far side of the El Gato out of which the colpa could be seen clearly. The Dusky-headed Parakeets would gather in these trees, usually on the very top branches, some would fly reconnaissance turns, and then small groups would descend into the foliage next to the colpa and start working their way towards the clay. Many small groups would follow in quick succession once the first group had gone. Some birds would then feed, whilst others would act as sentinels. The birds were very vocal throughout. Their preferred feeding site was the lower half of the right hand pillar.

### Orange-cheeked Parrot

Usually fed in groups of less than 10, but were also observed once in a group of more than 40. Would never arrive first at the colpa. Mostly after and in association with Dusky-headed Parakeets, but much more quiet and unobtrusive. They would usually perch deeper in the foliage of the launch trees, but then display similar behaviour to the Dusky-headed Parakeets of crossing and working their way to the colpa. They were once observed to fly a reconnaissance turn. They appeared more aggressive and were observed displacing each other and other species from the colpa. They did not appear to post sentinels, relying on associate species instead, but also appeared to be very wary and exceptionally quiet. However, when spooked they would take flight noisily. They did not seem to have a preferred feeding site, ranging all over the colpa to wherever there was space.

### Rock Parakeet

Fed in small groups of around 5. Closely associate with other parakeets on and around the colpa. When leaving colpa or flushed, they take off noiselessly. They would usually perch deeper in the foliage of the launch trees, but then display similar behaviour to the Dusky-headed Parakeets of crossing and working their way to the colpa. They post sentinels and are very wary, even getting spooked by an Oropendula flying over once. Once seen to displace a Dusky-headed Parakeet aggressively. Preferred feeding site behind the upper part of the left pillar.

### Cobalt-winged Parakeet

Flew around colpa in very large groups and usually fed in groups of at least 10. Very vocal, but also cautious, posting sentinels. Approach like Dusky-headed Parakeets out of launch trees with reconnaissance turns, and then through thin foliage and lianas. Also fed by themselves, usually later than Dusky-headed Parakeets. When flushed they showed the highest persistence of all species, often settling deep into the foliage of nearby trees and bushes, then flying in small groups into launch trees, then back towards the colpa. Also observed around colpa in large noisy flocks on several afternoons, but not feeding. Preferred feeding site on right hand pillar.

### Blue-headed Parrot

Fed in small groups of a few individuals (although they were observed during an excursion to the large colpa at El Chuncho to feed in much larger groups). Do not appear to go through complicated approach procedure – instead seem to rely on Dusky-headed Parakeets or Orange-cheeked Parrots which they always associate with. Once these species feed, the Blue-headed Parrots fly into trees on top of colpa. Approach from then on is quite slow. Not easily spooked once approaching or feeding. Not very vocal and no reconnaissance turns observed. Preferred feeding site top right hand pillar.

### White-eyed Parakeet

Only once observed feeding in group of 4. Came by themselves from launch tree and fed for 15 minutes.

### Pale-vented Pigeon

Feed in small groups of 1 or 2 and are very hard to spot on the approach, probably because of their silent advance and camouflage colours (hence lack of data). Do not appear to associate with any of the parrots but follow their own schedule. They often spook parrots when approaching or landing on the colpa, perhaps because of their size, colouring (reminiscent of some raptors?) and being quite cumbersome. Once feeding, they are the least wary of all the birds and usually feed for a long time, hardly getting spooked. No conclusive data on approach behaviour or preferred feeding sites.

### Scarlet Macaw

Only observed feeding once, in the afternoon and about 50 metres to the right of the colpa on some mud cliff overgrown by vegetation. Pair arrived and perched in an emergent tree above colpa, vocalising loudly, then proceeded towards cliff quietly. One bird then dipped its head under the vegetation to feed, whilst the other stayed outside the vegetation displaying what appeared to be sentinel behaviour. After some 10 minutes of this both birds slipped behind the foliage and could be seen feeding on the clay cliff. Throughout this process only very faint and quiet vocalisations could be heard. On take-off vocalisations were loud and distinct. Other macaws were regularly seen around the colpa, perching in trees and vocalising (see Table 2). They were also seen twisting their heads to look straight down onto the hide. Whether our presence prevented them from feeding is unknown, but perhaps likely, as local people have reportedly disturbed macaws feeding several times around the El Gato colpa.



## Mealy Parrot

This species was never observed feeding, but is mentioned here because it gathered in trees around the colpa every day in very large numbers, vocalising loudly. 5 individuals of this species were observed once coming close to the colpa and starting to descend, but they were spooked and never returned. More typically numerous small groups of this species would arrive at around the same time as the Dusky-headed Parakeets first thing in the morning, perch in high trees and vocalise so much so that the forest would be filled with the calls of what would be over a hundred individuals. However, they would never approach the colpa but instead leave in groups until most of them had disappeared by about 09.00. Like the macaws, they were also seen twisting their heads to look straight down onto the hide. Whether our presence prevented them from feeding is unknown, but perhaps likely.

## Soil samples & preferential feeding sites

Different species seem to prefer particular feeding sites either on or behind one of the two pillars. Preferences are given above and samples were collected from these preferred feeding sites on 3 July, as well as from random mud cliff sites along the river, and from what we thought could be another colpa site because it showed faint signs of beak activity (see Table 3). These samples were sealed in standard 35 mm film cartridges and await analysis.

Table 3. Soil samples taken. To date these samples have not been analysed and thus no discussion about them appears below.

#	Type	Position S	Position W	Remarks
1	Random	S 12° 51.517'	W 69° 26.754'	Very hard clay wall ca. 250 m upstream from El Gato colpa.
2	Macaws	S 12° 51.439'	W 69° 26.733'	Soft clay behind foliage. Macaw feeding site.
3	Colpa	S 12° 51.419'	W 69° 26.739'	Medium soft clay. Taken from lower part of right hand pillar (area A) on colpa.
4	Colpa	S 12° 51.419'	W 69° 26.739'	Medium soft clay. Taken from upper part of right hand pillar (area B) on colpa.
5	Colpa	S 12° 51.419'	W 69° 26.739'	Soft clay in shade. Taken from behind upper part of left hand pillar (area C) on colpa.
6	Random	S 12° 51.142'	W 69° 26.858'	Medium hard clay, broke off in chunks. From exposed cliff ca. 2,300 m downstream from El Gato colpa.
7	Random	S 12° 51.303'	W 69° 27.196'	Random sample from small cliff immediately to left of potential colpa, ca. 2,300 m downstream from El Gato colpa.
8	Colpa?	S 12° 51.303'	W 69° 27.196'	Small cliff (potential colpa with bill marks?). On El Gato. Sample from one side of potential colpa.
9	Colpa?	S 12° 51.303'	W 69° 27.196'	Small cliff (potential colpa with bill marks?). On El Gato. Sample from other side of potential colpa.
10	Random	S 12° 51.303'	W 69° 27.196'	Random sample from small cliff immediately to right of potential colpa.

## Discussion

Not much work has been done on avian geophagy, either in the tropics, or elsewhere. James Gilardi and others have published some important contributions on parrot geophagy (Diamond *et al.* 1999, Gilardi *et al.* 1999, Gilardi & Munn 1998), but the bulk of it remains poorly understood. What then can this study add to current knowledge, what are the answers it can give and what new questions does it raise?

### Geophagy's function

Psittaciformes, or parrots, are one of the most diverse avian orders numbering in excess of 300 species. Although spectacular in appearance and, for better or for worse, prized as pets, their ecology and phylogeny remains poorly understood. Parrots generally feed on seeds and fruit, have low reproductive output, are long-lived and occupy a variety of different habitats (Forshaw 1989, Juniper & Parr 1998). Their activity patterns in the Neotropics during the dry season show a peak in the morning and again in the late afternoon; away from colpas they show little evidence of aggregating at roost sites or forming multi-species groups (Gilardi & Munn 1998). May to August, the period during which this expedition was conducted, is the dry season, which usually presents frugivores with minimum food availability (Janson & Emmons 1990). However, parrots by specialising in eating seeds and unripe fruits inedible to most other animals, appear to have escaped this limitation. Evidence for this comes from habitat use and foraging behaviour studies by Gilardi & Munn (1998) and from interference competition studies by Fleming (1979), showing that parrots appear to have superabundant resources. They achieve this through adaptations such as strong bills, muscular tongue, high bill, tongue and foot dexterity, but most importantly through behavioural and physiological adaptations

that allow them to tolerate the high level of bitter-tasting and toxic substances present in unripe seeds and fruits. Diamond *et al.* (1999) and Gilardi *et al.* (1999) have shown that parrots can tolerate quinidine doses up to 40 times higher than humans (relative to body weight), and that Peruvian soil consumed by them binds even more quinine and tannic acid than does pure kaolin, thereby reducing its toxicity by at least 50%.

It is well known that parrots pre-masticate their food and in doing so quickly expose themselves to plant toxins. By feeding on clay in the morning, parrots in effect pre-dose themselves with toxicity-reducing soil, before foraging for the day. In this context this study supports the findings of Gilardi & Munn (1998), and goes some way to answering Diamond *et al.*'s (1999) question of why parrots feed early in the morning.

#### Feeding behaviour – timid mealies and macaws

One of the biggest puzzles of this study was why macaws and Mealy Parrots were often at the site, but were only once observed feeding, as is the case for the former, and never in case of the latter. We thought that body size and perhaps resultant agility may have something to do with it. Species most often seen feeding and in the biggest numbers tended to be the smaller ones ranging from 67 – 140 g (see Table 1). The Dusky-headed Parakeets were by far the most active species at the colpa and also appeared to be one of the most agile in terms of their ability to move onto and off the colpa, to move through the branches around the colpa, and quite literally to take flight quickly. Similarly, the Cobalt-winged Parakeets, although not observed as often as other species, appeared to be particularly persistent in their attempts at feeding, returning quickly to the colpa even after having been spooked several times in quick succession. Both of these species would act independently of others and usually appear at the colpa first.

Contrast with this the behaviour of the Orange-cheeked Parrot. Although seen feeding quite often, it always associated with other species (usually Dusky-headed Parakeets) and never fed by itself. Although Terborgh *et al.* (1990) list their mass difference as only 30 g (110 vs. 140 g), at El Gato at least the Orange-cheeked Parrots appeared appreciably larger and less agile than the Dusky-headed Parakeets. A similar argument can be made for the Blue-headed Parrots, weighing in at almost 300 g and also always associative and appearing cumbersome.

It is not unreasonable to suppose that Mealy Parrots at 800 g and macaws at over 1000 g must find it even more difficult to move around on a small colpa, and escape from potential predators. We are here aware of the danger of anthropomorphising, but to us it also seemed that these species were the ones most aware of our presence. On several occasions we noticed them sitting in the trees above our hide, tilting their heads and looking down on us. It is well known that macaws are very intelligent and aware (Juniper & Parr 1988, Sparks & Soper 1990). Could it be that a combination of risk of predation and heightened awareness of our presence was responsible for them not feeding? We thought so.

Compared to the huge mud cliff colpas at El Chuncho, the Tambopata Research Centre and Manu, the El Gato colpa is tiny and much more 'claustrophobic'. The opening created by the El Gato is no wider than 15 metres, with overhanging trees and branches. The El Chuncho river, on the other hand, creates an opening of 100 metres or more between the colpa and the opposite bank. The approach of an aerial predator would thus be much harder to notice at El Gato with much shorter response times. Was there simply not enough space on the small El Gato colpa once the 'lead' species (such as the Dusky-headed Parakeets) had taken the risk of descending? Or did the conditions favour small,

agile birds with short reaction times? But why would the Mealy Parrots and to a lesser extent the macaws then waste energy and come to the colpa every single day without feeding? Did they want to feed, but were too wary to descend because we were there? It is interesting to note that at El Chuncho, Mealy and Blue-headed Parrots would often feed and in much larger groups. It is also interesting to note that the single pair of Scarlet Macaws that eventually did come down to feed did so in the afternoon and not on the actual colpa but some distance away, under cover of the vegetation.

Unfortunately none of these questions can be answered conclusively by this study, but our hypothesis to be tested by future studies would be that conditions at El Gato favoured the smaller, more agile species and that the large parrots, already wary, wanted to feed, but were put off by a combination of unfavourable conditions and our presence. Perhaps a much better and less detectable hide or remote camera studies would be a way forward.

### Site selection

What makes parrots chose one site over another? What makes them chose a particular spot on the colpa? All along the El Gato and other rivers there is an abundance of mud cliffs that to our human eyes look just like the colpas. The chemical properties of the mud certainly makes a difference and selection for toxicity-reducing mud will be strong and rule out many sites. The samples collected by this expedition awaiting analysis may go some way to answer this question. For now we have to content ourselves with our observation made during sample collection that our random samples were invariably composed of much harder clay that came off in chunks, whereas the clay from the colpa was much softer and more pliable. It thus appears likely that a combination of chemical (such as anti-toxicity) and physical properties (such as sufficiently soft mud for the parrots to be able to scrape off in edible portions) play an important role. The El Gato site was in the shade

most of the day, thus keeping the mud pliable and soft. If risk of predation as discussed above plays its part too, as it almost invariably does, then it becomes clearer how a multitude of possible sites will fall by the wayside for one reason or another, and how colpas may actually be a relatively rare commodity. Having said that, local people have told us that the El Gato colpa over the last years has oscillated from left to right by a few tens of metres, with the birds preferring the cliff and pillars to the right of the current feeding site for some, and to the left in other years. We were not able to verify this and the current study cannot explain why this should be so. Similarly, why different species seem to prefer different areas on one and the same colpa remains a mystery. On this, however, soil analysis may be able to throw some light.

#### Colpas and tourism

Everyone who has seen parrots feed on a colpa knows why people travel large distances to see this, one of nature's great spectacles. The discovery of colpas and their value to tourism has spawned a remarkable change in the area. Where previously there were only subsistence farmers, loggers and gold miners, there are now over a dozen ecotourist lodges with plans for more in the near future. Colpas are a limited resource in this sense, so the question of how to use them sustainably is an important one.

The El Gato site does not lend itself to tourism use. It cannot be reached conveniently by boat, it is quite small and it lacks the presence, on a regular basis, of the most spectacular macaw species. In a way, our study was a miniature ad-hoc experiment on the impact of prolonged human presence, because we behaved how tourists would behave, coming into the hide in the morning, sitting there and observing, and leaving once the birds had left. We may have been more aware and careful about our impact than the average tourist, but to the birds this would have made little difference. What would most likely make a difference is that we occurred in much smaller numbers.

Our miniature ad-hoc experiment appeared to show that the small, agile species were hardly affected. In fact they became so accustomed to our presence that we were even able to conduct observations in full view and quite close to the colpa. The story is different for the larger species, exactly those that would be more interesting for tourists. As discussed above we are likely to have made a difference to them and regrettably altered their behaviour, preventing them from feeding, despite our best efforts at trying to conceal our presence. However, at large sites like El Chuncho where observation points are much further away than at El Gato, even the large-bodied species appear to behave normally.

It appears, then, that small-scale tourism on large colpas, conducted sensibly from observation points that are sufficiently far away is less likely to have a detrimental effect than tourist activity on small colpas. We stress here the words small-scale, sensibly and far away. Mass tourism on small colpas would almost certainly destroy natural behaviour patterns and may deprive parrots of a much-needed resource.

It would be very interesting to know what the 'tourist carrying capacity' of a colpa is; that is at what point does regular tourist observation have a detrimental effect? Unfortunately this study can provide no clues to what would be an important figure.



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