

## PARROT BEHAVIOR AT A PERUVIAN CLAY LICK

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**ABSTRACT.**—We documented the behavior of 13 parrot species at a geophagy site along the Tambopata River in southeastern Peru. These species use the lick in one or more multi-species aggregations composed predominantly of (1) large parrots and small macaws (81% of lick use), (2) large macaws (5%), or (3) parakeets and small parrots (5%). Monospecific flocks accounted for only 8% of lick use and lone individuals <1% of lick use. The multi-species aggregations sorted by body size and were generally composed of species with similar coloration suggesting that group composition was driven by a mix of competition and predation. Three species regularly used the lick in monospecific groups and these had the largest group sizes away from the lick, suggesting a causal relationship between intraspecific sociality and lick use in monospecific groups. All groups were wary when approaching the lick, probably due to the risk from landslides and predators. We suggest that clay lick use strategies are molded by predation risk and competition acting on a suite of species with varying body size, coloration, and gregariousness. Received 12 July 2009. Accepted 1 March 2011.

Geophagy, the intentional consumption of soil, has been documented for a wide range of mostly herbivorous mammals, reptiles, and birds (Sokol 1971, Klaus and Schmid 1998, Diamond et al. 1999, Brightsmith 2004). Hundreds of birds (up to 17 species) gather daily at river-edge ‘clay licks’ to consume soil throughout the western Amazon Basin (Emmons and Stark 1979, Burger and Gochfeld 2003, Brightsmith 2004). The birds, mostly psittacines, apparently consume soil for its high concentration of sodium (Brightsmith and Aramburú 2004, Brightsmith et al. 2008), but may also receive protection from dietary toxins (Gilardi et al. 1999). Aggregations of birds which use clay licks vary greatly in species composition and patterns of lick use, and much of this variation remains unexplained (Burger and Gochfeld 2003, Brightsmith 2004, Brightsmith and Aramburú 2004, Lee et al. 2009).

Observations suggest the birds’ behavior at clay licks has been molded by predation and competition, but few detailed studies have been conducted (Burger and Gochfeld 2003, Brightsmith 2004, Brightsmith and Aramburú 2004). Social forces such as information exchange, search for mates, and parental care favor group formation (Ward and Zahavi 1973, Wright et al. 2003). However, there are many costs to group membership including competition for resources (Grand and Dill 1999, Krause and Ruxton 2002) and disease transmission

(Hoare et al. 2000). Clay licks and other geophagy sites provide good opportunities to study mixed species aggregations. We studied the behavior of parrots using a large clay lick along the upper Tambopata River in southeastern Peru in an effort to document lick use strategies for comparison with research at other sites in the region (Burger and Gochfeld 2003).

### METHODS

**Study Area.**—Tambopata Research Center (13° 08' S, 69° 36' W) is in the Department of Madre de Dios in southeastern Peru in the Tambopata National Reserve (275,000 ha) near Bahuaja-Sonene National Park (1,091,000 ha). The area is tropical moist forest near the boundary with subtropical wet forest. The elevation is 250 m asl with 3,200 mm of rain per year and a wet season from October to March (Tosi 1960, Brightsmith 2004). The area contains a mix of mature floodplain forest, successional floodplain forest, *Mauritia flexuosa* palm swamps, and upland forest (Foster et al. 1994).

The clay lick studied was a 500-m long, 25–30 m high, cliff on the right bank (west side) of the upper Tambopata River. The lick was apparently formed by the river’s erosion of recently uplifted Tertiary age alluvial sediments (Räsänen and Salo 1990, Foster et al. 1994, Räsänen and Linna 1995). It consists of two large exposed areas ~150 m in length on the south end and 200 m in length on the north end. The two are separated by a landslide of ~150 m in width. The south end contains a clay layer ~15–17 m high, topped by a band of sand and cobble about 5 m thick. The north end has clay about 8 m high topped by 8 m of sand and cobble. The soils of the clay layer are rich in high cation exchange capacity clays with high sodium levels

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TABLE 1. Sociality of parrot species on the clay lick at Tambopata Research Center, Peru during 20 mornings from December 2002 to January 2003. The species are arranged by body mass. 'Green macaws' were recorded when observers could not distinguish between Chestnut-fronted and Red-bellied Macaws. Monospecific = percent of counts for which the species was recorded on the lick in a monospecific group. Large Parrot = percent of counts when the species was part of the large parrot aggregation. Parakeet and Large Macaw = percent of counts for which species were part of the parakeet and large macaw aggregations. Total = number of bird minutes recorded for the species. Body masses are from Dunning (1993) and Terborgh et al. (1990).

Species	Mass (g)	Large parrot	Large macaw	Parakeet	Mono-specific	Other	Totals
Red-and-green Macaw	1,250	40	52	2	7	0	124
Blue-and-yellow Macaw	1,125	49	45	1	6	0	1,137
Scarlet Macaw	1,015	56	42	0	2	0	574
Mealy Amazon	610	96	1	0	4	0	12,471
Yellow-crowned Amazon	510	79	3	2	9	6	130
Chestnut-fronted Macaw	430	95	3	0	2	0	2,267
'Green Macaw'		100	0	0	0	0	336
Red-bellied Macaw	370	96	0	4	0	0	1,076
Blue-headed Macaw	250	72	0	28	0	0	18
Blue-headed Parrot	247	83	13	2	0	2	1,210
White-eyed Parakeet	157	68	5	8	17	2	11,363
White-bellied Parrot	155	0	0	43	58	0	40
Orange-cheeked Parrot	140	69	1	22	1	7	259
Dusky-headed Parakeet	108	1	0	92	7	0	537
Totals (bird minutes)		25,400	1,727	1,555	2,580	280	31,542

(Gilardi et al. 1999, Brightsmith et al. 2008). The slope of the lick face ranges from moderate ( $\sim 30^\circ$ ) to nearly vertical ( $80^\circ$ ).

*Lick Counts.*—Data were collected during December 2001 and 2002, and January 2000 and 2003 from a point  $\sim 200$  m from the clay lick. Observers arrived before sunrise and stayed until the end of the early morning activity (0700 to 0730 hrs). Observers watched the staging birds and recorded when the first group of birds began to fly in slow circles in front of the lick in anticipation of landing. Observers counted all birds perched on each section of the clay lick every 5 min (Brightsmith 2004). More detailed location data were collected in December 2002 and January 2003 ( $n = 20$  mornings) for each bird on the lick to quantify the social group membership of each species using the lick.

*Arrivals and Disturbance.*—Observers recorded the numbers and species of parrots as they arrived in the area from a point on the opposite river bank  $\sim 400$  m to the east of the clay lick. It was not possible to record the birds that arrived from forests behind the lick (to the west).

Observers recorded the cause of the disturbance whenever  $>25\%$  of the birds simultaneously flew from the clay lick or surrounding trees.

*Data Analyses.*—The clay lick use by each species was calculated as the total number of 'bird

minutes' on the lick (Brightsmith 2004). Bird minutes were defined as the number of birds on the lick multiplied by the number of minutes they stayed on the lick (i.e., 4 birds for 15 min each = 60 bird min). We conducted principal component analysis of the data for birds which simultaneously shared each section of the lick to identify the groups of species which used the lick together. Only principal components with eigenvalues  $\geq 1$  are reported. We tested differences among species for group sizes arriving at the lick using Kruskal-Wallis and Mood's median test with 95% confidence intervals around the medians using StatGraphics Centurion XV. Normal variables are presented as mean  $\pm$  SD, while those that failed Shapiro-Wilks' test for normality are presented as medians with 95% confidence intervals. Alpha = 0.05 for all statistical tests.

## RESULTS

Thirteen species of psittacines used the clay lick in the early morning period (before 0730 hrs, Table 1). Over 99% of all lick use was in groups. Mixed species aggregations accounted for 92% of the total lick use, monospecific groups 8%, and single individuals  $<1\%$  (Table 1).

Five principal components (eigenvalue  $> 1$ ) together explained 58% of the variance in group composition on the clay lick (Table 2). These

TABLE 2. Weights for the five principal components which explain the most variance in group composition of psittacines at an avian geophagy site in southeastern Peru. All principal components have eigenvalues >1. Each principal component is identified with a text label which describes the bird aggregation it represents. The most abundant species in each aggregation are shown in bold.

Species	PC I	PC II	PC III	PC IV	PC V
	Large parrot	Large macaw	Parakeet 1	Parakeet 2	Parakeet 3
Red-and-green Macaw	0.09	<b>0.56</b>	-0.03	0.09	0.12
Blue-and-yellow Macaw	0.18	<b>0.47</b>	0.04	-0.01	0.00
Scarlet Macaw	0.17	<b>0.54</b>	0.11	0.03	0.03
Chestnut-fronted Macaw	<b>0.55</b>	-0.09	-0.08	0.16	0.12
Red-bellied Macaw	<b>0.45</b>	-0.15	-0.08	0.22	0.21
Mealy Amazon	<b>0.51</b>	-0.20	-0.04	0.10	-0.05
Yellow-crowned Amazon	0.15	-0.13	0.17	-0.14	-0.69
Blue-headed Parrot	0.21	0.13	<b>0.53</b>	-0.14	-0.34
Orange-cheeked Parrot	-0.03	-0.12	<b>0.66</b>	-0.15	<b>0.31</b>
White-eyed Parakeet	0.23	-0.22	0.08	-0.27	<b>0.21</b>
Dusky-headed Parakeet	-0.15	-0.10	<b>0.42</b>	<b>0.43</b>	<b>0.31</b>
White-bellied Parrot	-0.16	-0.07	-0.04	<b>0.49</b>	-0.22
Blue-headed Macaw	-0.01	0.02	0.16	<b>0.59</b>	-0.22
Percent variance explained	18	14	10	9	8

principal components represent three mixed species aggregations which use the lick as distinct entities. The large parrot aggregation was composed of three abundant species: Chestnut-fronted Macaws (*Ara severus*), Mealy Amazons (*Amazona farinosa*), and Red-bellied Macaws (*Orthopsittaca manilata*). These were regularly joined by up to seven additional species: White-eyed Parakeet (*Aratinga leucophthalma*), Yellow-crowned Amazon (*Amazona ochrocephala*), Blue-headed Parrot (*Pionus menstruus*), Blue-and-yellow Macaw (*Ara ararauna*), Scarlet Macaw (*A. macao*), Red-and-green Macaw (*A. chloropterus*), and Orange-cheeked Parrot (*Pyrilia barrabandi*). This aggregation, represented by PC I, accounts for 18% of the variance in lick use. The large macaw aggregations contained three common species: Red-and-green Macaws, Scarlet Macaws, and Blue-and-yellow Macaws (PC II, 14% of the variance) which were rarely joined by Blue-headed Parrots, Mealy Amazons, White-eyed Parakeets, and Chestnut-fronted Macaws. The principal components analysis identified three parakeet and small parrot aggregations, one with Dusky-headed parakeets (*Aratinga weddellii*), Orange-cheeked Parrots, and Blue-headed Parrots (PC III, 9% of the variance), one with White-bellied Parrots (*Pionites leucogaster*), Blue-headed Macaws (*Primolius couloni*), and Dusky-headed Parakeets (PC IV, 9% of the variance), and one with Dusky-headed Parakeets, Orange-cheeked Parrots, and White-eyed Parakeets

(PC V, 8% of the variance). These three groups were functionally similar: both formed around flocks of Dusky-headed Parakeets or occasionally White-eyed Parakeets and used the same part of the lick. Thus, these groups were considered collectively as the 'parakeet aggregation'.

Ten species were recorded using the lick in monospecific groups, but most were monospecific remnants of the mixed species aggregations. Only three species regularly used the lick in coherent monospecific groups: White-eyed Parakeets, Dusky-headed Parakeets, and White-bellied Parrots (Table 2). Single psittacines were recorded on the lick 58 times and these birds were often leading larger groups of birds to the lick (36%) or remained when larger groups abandoned the lick (31%) leaving only 19 instances of single birds using the lick.

We focused on the three mixed-species aggregations as they accounted for >90% of the clay lick use. The three mixed-species aggregations were independent, as they arrived, staged, and descended to the lick separately, and used different areas of the lick. They also rarely reacted to each other's alarm calls. The behavior of the birds at clay licks can be divided into three distinct phases: arrival in the area, descent to the lick, and lick use.

*Arrival in the Area.*—All birds arrived in monospecific flocks. Multiple species, when seen together, did not perch or stage together indicating they were just casual associations. Observers

TABLE 3. Group size for arriving birds at the Tambopata Research Center clay lick based on six mornings of observations. Birds were not detected arriving in mixed species groups. Species which share superscript letters do not differ (Mood's median test,  $P > 0.05$ ) in median group size.

Species	Median	95% CI		Group sizes (% of total)				<i>n</i>
		Lower	Upper	1	2	3 or 4	≥5	
Red-and-green Macaw <sup>a</sup>	2	1	2	36	64	0	0	22
Scarlet Macaw <sup>a</sup>	2	2	2	34	57	9	0	127
Chestnut-fronted Macaw <sup>a</sup>	2	2	2	31	54	11	4	455
Blue-and-yellow Macaw <sup>a</sup>	2	2	2	21	62	13	4	142
Mealy Amazon <sup>a</sup>	2	2	2	25	46	21	8	550
Blue-headed Parrot <sup>a</sup>	2	2	3	22	29	29	21	125
Red-bellied Parrot <sup>a</sup>	3	2	4	8	37	27	27	51
Dusky-headed Parrot <sup>b</sup>	10	6	14	0	0	21	79	34
White-eyed Parakeet <sup>c</sup>	22	12	28	2	9	3	86	65

could not usually detect arrivals of White-bellied Parrots or Orange-cheeked Parrots as they flew lower than other species and arrived quietly. However, all other species regularly arrived flying high above the canopy and were readily detected.

The members of the large parrot aggregation began to arrive  $8.4 \pm 5.8$  min before sunrise ( $n = 70$  mornings) and usually perched in trees immediately above and behind the clay lick. The median arriving group size was two except for Red-bellied Macaws which was three (Table 3).

The first large macaws began arriving at about the same time as members of the large parrot aggregation ( $9.3 \pm 11.7$  min before sunrise,  $n = 70$  mornings). The large macaws continued to arrive throughout the morning at a slow steady rate ( $1.1 \pm 0.3$  individuals/min,  $n = 577$  birds over 6 days). Macaws arrived in pairs (61%), singles (30%), and rarely groups of three or four (7%,  $n = 291$  groups; Table 3).

The members of the parakeet aggregation began to arrive  $21.7 \pm 15.6$  min after sunrise ( $n = 68$  mornings) and staged in short trees at the lick's left edge. Both common parakeets arrived in large groups: Dusky-headed Parakeet median = 10,  $n = 34$  groups, White-eyed Parakeet median = 22,  $n = 65$  (Table 3). The arriving groups of parakeets were relatively large, but waited and joined with other conspecifics before moving to the lick.

Our observations suggest many birds spend hours socializing in the trees around clay licks without descending to eat soil. We focus in this paper on birds that consumed soil and do not address the social aspects of gathering near clay licks.

*Descent to the Lick.*—Most species were able to join more than one type of aggregation, but the three aggregations commonly approached the lick

independently and in stereotypical patterns. The members of the large parrot aggregation began to move towards the clay lick by  $15.7 \pm 11.5$  min ( $n = 66$  mornings) after sunrise. There were at least  $424 \pm 152$  birds in the area ( $n = 6$  mornings) at this time. One or more small groups of birds (usually < 20) led the descent by flying in large circles in front of the lick. Birds from the trees joined these groups until there were up to 100 birds in flight. These flights lasted  $3.4 \pm 4.3$  min ( $n = 62$  mornings). The birds flew in slow circles in front of the lick, apparently choosing where to land. Detections of predators or landslides during these flights often caused the birds to choose an alternative section of the lick or break off approach completely.

The large macaw aggregations often formed as groups of 6–29 birds flew to the lick to join the tail end of the large parrot aggregation (19% of 69 mornings). Groups of up to 30 large macaws also initiated lick use on unoccupied sections of the clay lick (29% of 69 mornings). The latter occurred  $\sim 50 \pm 23$  min after sunrise ( $n = 26$  mornings) when they staged and flew to the lick in a manner similar to that described for the large parrot aggregation.

Members of the parakeet aggregation descended to the left edge of the lick starting  $\sim 101 \pm 21$  min ( $n = 34$  mornings) after sunrise. These groups did not engage in exploratory flights like the large parrot aggregation or large macaw aggregation, and instead moved deliberately through the trees progressively closer to the lick and then flew directly from the trees to the lick (usually a distance of <20 m). There were at least  $217 \pm 120$  parakeets in the area ( $n = 5$  mornings) by the time the first parakeet flocks descended to the lick.

*Lick Aggregation Dynamics.*—Groups of birds on the lick were fluid; large numbers of birds flew regularly between the surface of the clay lick and the adjacent trees. Some birds took pieces of clay and carried them to the trees for consumption. Thus, the maximum number of birds on the lick at any one time was substantially less than the total number of birds in the area. Entire feeding aggregations often abandoned the lick in response to alarm calls. No apparent cause for the alarm ( $n = 1,060$  disturbances) was detected in 90% of cases and the birds usually returned to the lick almost immediately. Documented causes of disturbance were rockslides (4%), raptors (2%), other large birds (2%), and people or boats (1%).

The large parrot aggregations formed on 97% of mornings ( $n = 71$ ) and accounted for 80% of the total lick use. Additional birds flew directly to the lick once the first birds landed, and numbers on the lick increased rapidly ( $152 \pm 85.2$  individuals on the lick 10 min after start,  $n = 65$  mornings). Birds continued to arrive in the area and perch in the trees even after the first birds began to use the lick. At least  $951 \pm 262$  birds (range = 791–1,428;  $n = 6$  mornings) arrived per morning of which 92% were species that joined the large parrot aggregation ( $874 \pm 260$  birds, range = 621–1,336;  $n = 6$  mornings). The daily maximum number of birds simultaneously on the lick in the large parrot aggregation averaged  $192 \pm 86$  (range = 24 to 497,  $n = 69$  mornings). The large parrot aggregation used the lick for  $59.6 \pm 19.2$  min ( $n = 46$  mornings).

The three large macaws used the lick in the early morning as part of the large parrot aggregation (50% of total early morning lick use) or in aggregations dominated by large macaws (49% of total early morning lick use, Table 1). The aggregations dominated by macaws formed on 46% of 71 mornings and accounted for 5% of the total lick use. The number of birds on the lick increased within the first 5 min ( $12 \pm 9$  at first detection,  $n = 28$  mornings) and remained fairly stable thereafter ( $14 \pm 7$ ,  $n = 11$ , 10 min after first detection). The average maximum number of individuals was  $17 \pm 10$  ( $n = 33$  mornings). About 10% of the total birds that arrived in the vicinity of the lick were large macaws ( $96 \pm 24$  birds, range = 66–122,  $n = 6$  mornings). The large macaw aggregations lasted  $19 \pm 13$  min ( $n = 33$  mornings).

The parakeet aggregations formed on 47% of 71 mornings and accounted for 5% of the total lick use.

The majority of the birds in the parakeet aggregation were flocking parakeets and these flocks were restless, usually remaining on the lick for only a few minutes before taking flight and returning to the lick or adjacent trees. The average number of the birds on the lick, despite these fluctuations, remained fairly stable with time ( $27 \pm 25$  birds,  $n = 35$  mornings, <5 min after descending to the lick vs.  $23 \pm 21$  birds,  $n = 8$  mornings, 10 min later). About 36% of all birds arriving at the lick were species that joined the parakeet aggregation ( $340 \pm 240$  birds, range = 95–653,  $n = 6$  mornings). The maximum number of birds on the lick in parakeet aggregations averaged  $40 \pm 26$  (range = 3 to 138,  $n = 34$  mornings). The parakeet aggregation used the lick for  $16.2 \pm 11.4$  min ( $n = 34$  mornings) before they dispersed.

*Spatial Distribution.*—The clay lick was >1 km in length. However, 85% of the total clay lick use occurred on only four small areas, totaling only 18% of the exposed cliff. Each aggregation regularly used the same few lick areas. The large parrot aggregation used two sections with exposed clay 9.8 to 15.2 m and 1.4 to 8.3 m above the cliff base. Neither section had vegetation immediately adjacent to the area used by the birds. The large macaw aggregation used two tall center sections of the lick with exposed clay 7.8 to 15.7 m high. Both were isolated from surrounding vegetation. Large macaw aggregations did not form on the lower portion of the lick. The parakeet aggregation used the far left edge of the lick almost exclusively. This section had exposed clay 8.6 to 16 m high and trees immediately adjacent to it.

*Lick Use by Other Psittacines.*—The White-bellied Parrot was uncommon on the lick (Table 1). It was difficult to detect when arriving, but apparently arrived in groups of up to 10 (Gilardi and Munn 1998; DJB, pers. obs.). This species did not depend on joining with other birds to use the lick. Small groups perched in the trees on the left edge of the lick and remained vigilant while a few individuals at a time descended to the lick ( $2.8 + 2.0$  individuals,  $n = 23$ ). This species usually used the lick in monospecific groups (47%) or with the parakeet aggregation (36%, Table 1). This species also use the lick until ~1000 hrs, well after termination of the early morning activity (Brightsmith 2004).

## DISCUSSION

*Aggregation Membership.*—Clay lick use was dominated by large mixed species aggregations

and all 13 psittacine species regularly joined at least one of the three types of mixed species aggregations. These aggregations were not observed away from clay licks except for casual associations of large macaws at fruiting trees (Gilardi and Munn 1998; A. T. K. Lee, pers. comm.). Group sizes at clay licks were much greater than those of birds away from clay licks (Gilardi and Munn 1998) and <1% of lick use was by lone individuals. These data suggest that birds adopt novel behavioral strategies when using clay licks.

Stratification by size was clear among the mixed species aggregations: (1) large macaws, (2) large parrots and small macaws, and (3) parakeets and small parrots (Table 1). Species may segregate by size as heavier species take flight slower, accelerate slower, and have wider turning radii making them stragglers when mixed species groups flee from aerial predators. Direct competition should also favor size stratification as aggressive interactions are common on clay licks: smaller species are usually displaced by larger species but numerically dominant smaller species can exclude larger species if the size difference is not too great (Burger and Gochfeld 2003). Thus, predation may select against larger species joining smaller ones while competition may select against smaller species joining larger ones. This may explain the relative uniformity of body size among aggregation members.

The cost of 'false alarms' may also be important in shaping foraging behavior and aggregation composition, as disturbances reduce foraging efficiency (Sirot 2006, Beauchamp and Ruxton 2007). Over 90% of the flights from the lick in our study had no apparent cause suggesting a high rate of false alarms. Smaller species have a higher risk of predation and expend less energy each time they fly from the lick, and should have a lower alarm threshold, give more unnecessary alarm calls, and have correspondingly higher rate of departures from the lick. Members of an aggregation often respond to alarms as a group and larger species may have greater energy expenditure when using the lick alongside more 'flighty' smaller species. This also favors formation of aggregations of similar sized individuals.

The coloration of the species in each aggregation was similar; the three large macaw species in flight were a mix of red, blue, green, and yellow while the large parrot and parakeet aggregations were composed predominantly of green birds with

dark green, blue or black heads and primaries. The formation of homogeneous groups (in size and color) is predicted where predators attacking groups focus on visually aberrant individuals (Landeau and Terborgh 1986, Theodorakis 1989, McRobert and Bradner 1998, Hoare et al. 2000).

The large macaws that occasionally join the large parrot aggregation are a notable exception to the tendency for visually similar individuals to join together on clay licks (see also Mee et al. 2005). However, when large macaws join the large parrots they usually do not integrate into the center of the group. Instead, they use the highest parts of the lick, ~3 m above the center of the aggregation, where the soil quality is inferior (i.e., 50 to 75% less sodium), but where they have the best chances for rapid escape (Brightsmith et al. 2008; DJB, unpubl. data). The large macaws at Tambopata Research Center spent <10% of their total lick use in the presence of the large parrot aggregation. In addition, large macaws rarely join parrot aggregations at other clay licks and instead usually use licks during the late mornings and afternoons (Burger and Gochfeld 2003; DJB, unpubl. data). Why large macaws join parrot groups is unclear, but it may be because their large size makes them vulnerable to a smaller number of raptor species, and because early morning is the only time when lick use is temporally predictable. Large macaws during the rest of the day may wait near the lick for up to 3 hrs before a group successfully initiates lick use.

White-bellied Parrots were least likely to join mixed species groups and were the most visually distinct small parrot at the site. They are green with a bright yellow head when seen in flight from above and behind while all other local species are green and have green, dark blue or black heads. However, both the large macaws and White-bellied Parrots are likely using the best of the available options for lick use and probably benefit from joining mixed species groups as even 'oddballs' receive protection from predators when group sizes are sufficiently large (Landeau and Terborgh 1986).

Lick use aggregations similar in structure to those at Tambopata have been documented by Burger and Gochfeld (2003) at a lick 250 km to the west and by DJB at numerous other licks throughout southeastern Peru. The similarities in behavior observed across these localities suggest that generalizations discussed here may apply to avian aggregations at many geophagy sites.

However, there is evidence that group composition, relative abundance, and timing of lick use vary among sites (Mee et al. 2005) suggesting birds may be responding to a variety of undocumented site-specific circumstances. Comparative studies would be highly informative.

Only three of 13 parrot species used the clay lick in cohesive monospecific groups: White-eyed Parakeet, Dusky-headed Parakeet, and White-bellied Parrot. These species, when not using the clay lick, normally occur in the largest monospecific groups of the 13 species (Gilardi and Munn 1998, Table 3). Other psittacines in the region, Cobalt-winged Parakeets (*Brotogeris cyanoptera*), Rose-fronted Parakeets (*Pyrrhura roseifrons*), Black-capped Parakeets (*P. rupicola*), and Dusky-billed Parrotlets (*Forpus modestus*) also occur in large groups away from clay licks and initiate lick use in monospecific groups (Gilardi and Munn 1998; DJB, unpubl. data). These findings suggest there is a causal link between species' intraspecific sociality and monospecific lick use.

*Arrival and Descent to the Lick.*—Animals approaching geophagy sites are normally wary (Izawa 1993). The two approach behaviors we documented, slow circular flights and moving deliberately through adjacent trees likely serve to (1) check the lick area for predators, (2) watch for landslides, and (3) recruit individuals to the lead group. Birds would break-off their approach or shift to alternative areas of the lick when predators or landslides were detected. Parrots would also break off their approach if the first group was not joined by others.

*Spatial Distribution.*—Bird use was confined to four small areas of the cliff even though the soil was useable across the majority of the lick (DJB, unpubl. data). This suggests the pressure to congregate (as protection from predators) is stronger than the pressure to disperse across the lick (likely due to competition). The large macaws used the highest and most open areas of the clay lick most frequently while the smallest species used the areas closest to cover. This is similar to findings from previous studies (Burger and Gochfeld 2003, Mee et al. 2005). Why lick site selection varies with body size is unknown, but likely relates to methods of approaching the lick and avoiding predators displayed by the different species.

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