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Elemental Composition of Rhinoceros Wallow Soils in Danum Valley, East Malaysia

It is well documented that many herbivores and birds have the ability to seek specific nutrients from their environment (Emmons & Stark 1979), especially from natural mineral licks. Several studies on the nutrient requirement of herbivores have shown that sodium is the main element sought by animals that visit such licks (Weeks & Kirkpatrick 1976); thus, sodium compounds of the lick soil appear to be the source of attraction to big game animals (Knight & Mudge 1967, Beath 1942). This, however, does not exclude the possibility that trace elements may sometimes be important (Beath 1942, Cowan & Brink 1949). In contrast, Murie (1951) and Van Loon (1937) have suggested that some wild animals use salt licks as an acquired habit without much nutritional importance. Little is known about the nutritional requirements of the Sumatran rhinoceros *Dicerorhinus sumatrensis* (Fischer 1814) and its dependence on salt licks. It has been suggested that the latter are an important source of minerals for these animals (J. Payne, pers. comm.; Van Strien 1985). Although the licks do attract *D. Sumatrensis*, no such terrestrial mineral sources have been found in the habitats of this animal in Endau Rompin (Flynn & Abdullah 1983) and Danum Valley (Ahmad Darus 1987) in Malaysia. Perhaps in these habitats, the rhinos have alternative means for meeting their mineral requirements. One possible source is the rhinoceros wallow. In Danum Valley of East Malaysia (*ca* 5°00′N, 117°30′E), *D. sumatrensis* makes numerous wallows in the primary forest and visits them frequently (Ahmad Darus 1987). It is not known whether the wallows are used as mineral licks, apart from providing relief from overheating during daylight hours. The purpose of this study was to determine whether *D. sumatrensis* wallows could potentially function as a mineral source.

Soil samples were collected from ten wallows located in Danum Valley, East Malaysia, which were known to be made and used by Sumatran rhinos. One soil sample was collected from a spot near the central pool of each wallow and an additional one was taken about two meters from the wallow's outer rim. The latter sample functioned as a "control." To provide a comparison of the mineral content of wallows with that of a known mineral lick, a salt lick formed from an active mud volcano and situated near the Tabin Rhinoceros Conservation Centre (*ca* 5°10′N, 118°30′E) was sampled. Soil samples from this known salt lick were collected in the same way as the wallow soil samples. All samples were dried at 130°C, crushed, sieved, and weighed before extraction with either 200 ml of ammonium acetate (1 mole/liter) for cation analysis (Emmons and Stark 1979) or with distilled water for anion analysis. The cations Na, K, Ca, Mg, Mn, Zn, Cu, and Fe were analyzed by using a Perkin-Elmer 2410 atomic absorption spectrophotometer. The anions analyzed were chloride, phosphate, sulfate, and nitrate. As these anions were extracted into water, the standard procedures for analysis of these anions in water as recommended by the American Public Health Association (APHA 1986) were adopted. Chloride was determined by silver nitrate titration, phosphate by the ascorbic acid method, sulfate by barium sulfate turbidimetry, and nitrate by the cadmium reduction procedure. Sulfate and nitrate were measured by using a Hach set which was carefully calibrated with standard solutions of the anions before and in between measurements. No attempt was made to establish the ionic balance in this study as only a few ions of interest were analyzed.

TABLE 1. *Average cation content of soil samples (mg/L).*

Cation	Wallow soil	Control	Lick soil
Na	50.6 ± 5.7	50.4 ± 12.1	10,834 ± 4319
K	513 ± 170	456 ± 176	698 ± 24
Ca	151.8 ± 49.4	85.5 ± 38.5	3825 ± 270
Mg	8.6 ± 2.5	8.5 ± 3.5	6502 ± 1177
Mn	26.4 ± 12.2	21.3 ± 11.5	122.5 ± 6.5
Zn	1.9 ± 0.7	1.5 ± 0.7	0.73 ± 0.15
Cu	nd[1]	nd	2.73 ± 0.90
Fe	nd	nd	5.0 ± 4.3

[1] nd = not detected. Detection limits: Cu = 1 μg/L, Fe = 10 μg/L.

TABLE 2. *Average anion content of soil samples (mg/L).*

Anion	Wallow soil	Control	Lick soil
Cl^-	nd[1]	nd	12,099 ± 4671
PO_4^{3-}	6.05 ± 3.53	1.72 ± 1.88	24.7 ± 4.17
SO_4^{2-}	0.104 ± 0.02	0.09 ± 0.02	0.33 ± 0.24
NO_3^-	4.07 ± 0.53	5.69 ± 1.27	2.63 ± 0.20

[1] nd = not detected.

The average cation content for 8–10 wallow soils and their controls are shown in Table 1. K, Ca, and Na are the major elements present in the wallow soil and the controls. A comparison between the concentration of elements in the wallow soil and the control shows that for the cations K, Ca, Mn, and Zn, concentrations seem higher in the wallows than in soils obtained from outside the wallows. For K, Mn, and Zn, the difference is small and *t* tests revealed that such differences were not significant ($0.10 < P < 0.25$). For Ca, however, the concentration in wallow soils was significantly higher than that of the control samples ($P < 0.01$). For Na and Mg, there was no significant difference between the content of these elements in the wallow and in the control.

Table 2 illustrates the average content of chloride, sulfate, phosphate and nitrate of 8–10 wallow soils and their controls. From these data, both the concentrations of sulfate and phosphate are significantly higher ($P < 0.05$) in the wallow compared to the control. Nevertheless, nitrate concentration was much lower in the wallows ($P < 0.05$). For chloride, its concentration in the samples was very low and could not be detected by the silver nitrate titration method (Detection limit: 6 mg/liter).

Calcium and phosphorus are important minerals in the nutrition of the Sumatran rhinoceros especially during pregnancy and lactation. The concentration of Ca and P in the diet can influence the other's absorption and a similar amount of intake of both elements should be ideal for the animal's diet (Van Strien 1985). The food plants commonly eaten by rhinos in the Danum Valley area have been shown to contain a Ca:P ratio of 1:2 (Ahmad Darus 1987), a ratio which is necessary for the absorption and metabolism of these elements (Robbins 1983). Analysis of food plants eaten by the *D. sumatrensis* for minerals has shown that a majority of the plants eaten provide most minerals at levels exceeding the minimum requirement for a horse (Ahmad Darus 1987), especially the minerals Ca, P, K, Mg, and Mn. If the minimum mineral requirement for the *D. sumatrensis* can be assumed to be similar to that of a horse (Van Strien 1985), then it is clear that the *D. sumatrensis* in the Danum Valley will not be deficient in minerals. Thus it is unlikely that rhinos need to lick the wallow for both Ca or P even though the wallow soils contain more of these two elements than the surrounding soil.

Defecation in the wallow may be a reason for the elevated Ca and P content. The content of Ca, P, Mg, and K in the feces of *Dicerorhinus* (Van Strien 1985) indicates that defecation can contribute significantly to the presence of these minerals in the wallow. Thus, if defecation in the wallow by rhinos is assumed, content of these minerals in the wallow should be high. This was not observed except for Ca and P (Table 2). In captivity, the *D. sumatrensis* is known to defecate in its wallow but in the wild such behavior is unusual (Van Strien 1985). Perhaps, defecation by other animals which use the wallow, especially the wild boar *Sus barbatus* (Ahmad Darus 1987) may be the reason for the higher amount of Ca and P in the wallow. If other animals defecated in the wallows, nitrate would probably be high, assuming that nitrification can occur in this environment, but the concentration of nitrate observed was low. Whatever the origin of the P and Ca content, it is obvious that the wallow does not function as a lick. This can be further confirmed by comparing the mineral content of the wallow with that of the salt lick (Table 1) which shows high concentration of most ions. Thus, more needs to be known of the actual mineral requirements of *D. sumatrensis* from captive studies before predictions of how these requirements are met in the wild can be made.

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