A STUDY OF CROCODILIAN COPROLITES FROM WANNAGAN CREEK QUARRY
(Paleocene — North Dakota)

ICHNOFOSSILS II

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ABSTRACT — 205 coprolites are described from the Upper Paleocene (Bullion Creek Formation) of western North Dakota. Most are allocated to *Leidyosuchus formidabilis,* a large eusuchian crocodile.

INTRODUCTION

Over the past decade the Paleocene deposits of Wannagan Creek Quarry in western North Dakota (Bullion Creek Formation NW¼, Sec. 18, T.141N., R.102W., Billings County) have yielded numerous ichnological materials as well as many floral and faunal specimens. While the geological aspects of this site have been described (Melchior and Erickson, 1979; Erickson, 1980), much of the fossil material must still be described and a considerable amount of paleoecological work needs to be done.

From 1971 through 1977 a total of 205 coprolites were collected at Wannagan Creek Quarry from a study area measuring 145 by 50 feet. This high concentration provides an unique opportunity for a population study.

Leidyosuchus formidabilis (Erickson, 1976), a large (4 m long) eusuchian crocodile, is the animal to which most of the coprolites are allocated.

This paper describes these coprolites in detail, including their distribution, color, degree of flattening, shape, weight, density, inclusions, and surface features. Various parameters are compared to each other and the results tabulated and discussed.

MATERIALS AND METHODS

153 of the 205 coprolites from the site have reliable coordinate data. Their distribution can be seen in Figure 1. The irregular heavy lines represent a beach line and presumed wave base respectively (Melchior and Erickson, 1979). A lignitic deposit representing paludal sedimentation occurs throughout much of the quarry. Its limits are defined by the wave base line and the largest section within the limits of the study area. A straight line drawn through the study area divides the thinnest portion (zone A, with lignitic material up to a thickness of 10 cm) from the thickest portion (zone B, where the thickness is up to 30 cm) of this deposit. An approximately equal number of coprolites occur in each zone. Specimens are grouped according to their location and groups are compared. The chi-square test is used to evaluate data significance.

Matrix associated with 100 of the 205 coprolites was examined.

Color. – The Munsell Color Chart (G.S.A., 1963) was used to identify the color of each specimen. Numbers and letters represent hue, value, and chroma. Outside surfaces are generally a slightly different color than the interiors of the specimens. Four separate coprolite surface-interior color combinations are identified as follows (arranged from darkest to lightest):

Color #(1) 5 yr 5/2 inside (pale brown) and 10 yr 2/2 outside (dusky yellowish brown)

Color #(2) 5 yr 5/2 inside (pale brown) and 5 yr 3/2 outside (greyish brown)

Color #(3) 5 yr 6/4 inside (light brown) and 5 yr 4/4 outside (moderate brown)

Color #(4) 5 yr 8/4 inside (moderate orange pink) and 10 yr 6/6 outside (red orange)

The matrix tends to be one of the two following colors:

1. - 10 yr 6/2 (pale yellowish brown)

2. - 10 yr 2/2 (dusky yellowish brown)

The distribution of the various colors in each zone is calculated in percentages. These results are shown in Table 1. The distribution of each color in the study area is also shown (in parentheses). Similar percentage calculations were done for other distribution and comparison studies and the results presented in Tables 2 through 10.

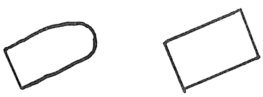
Degree of Flattening. – The degree of specimen flattening is indicated as "marked," "mild," or "none" in all but 5 of the 153 specimens. Only coprolites that are greater than 90% complete and with known coordinates are included. Zone distribution for coprolite flattening is shown in Tables 2 and 3.

The degree of flattening is also compared to color, shape and weight (Tables 7, 8, 9).

Shape. – The shape of each coprolite, as seen in silhouette, is determined only when greater than 90% complete. The three primary shape categories are as follows:

A. Ovoid (Fig. 2)

B. Dome (Fig. 3) and cylinder



C. Teardrop (Fig. 4)

In this paper the distal portion of a coprolite is described as the portion that is excreted by the animal first and the opposite end is considered proximal. The distal end of the dome-shaped coprolite is characteristically flat with or without coarse, irregular ridges. The cylinder forms may be incomplete dome forms broken off in the excretory process. The distal end of the teardrop-shaped coprolite is usually rounded but may be somewhat flattened. The proximal end is tapered in the teardrop form and rounded in the dome-shaped coprolite. Ovoid shapes do not have identifiable distal and proximal portions. Occasional specimens are apparently distressed and do not show these features.

Table 4 shows coprolite shape zone distribution.

Weight. – 162 of the 205 coprolites were weighed on a balance scale. Several specimens with special features that were desirable to preserve were left in matrix. All other coprolites over 90% complete, however, were weighed.

Although weights ranged up to 155 gms., most of the specimens weighed less than 50.0 gms.

Zone distribution for various weight categories is detailed in Table 5 and shape vs. weight under 50.0 gms. is shown in Table 10.

For reasons to be described later, the ovoid-shaped coprolites under 5 gms. are considered separately. Table 6 shows the zone distribution for this special type and Table 11 details their weight distribution.

Density. – The densities of 100 coprolites were obtained by immersing each specimen in water. The volume thus obtained was used to calculate the gms./cc. Average densities were calculated for each color, flattening variation, shape and weight category.

Inclusions. – All 205 specimens were examined for presence of inclusions by magnification (5x) and by X-ray. The X-ray exposures ranged from 35 kv, .1 sec., and 25 ma to 65 kv, .2 sec., and 25 ma. Color, degree of flattening, shape, weight, and location of those found with inclusions were studied to determine if they are different from the overall coprolite population.

Surface Features. – Surface features of some of the coprolites, such as possible "anal sphincter marks" and impressions left by leaves, sticks and small bones, were studied.

Measurements. – Measurements of the largest and smallest coprolites in each of the basic shape categories are recorded in Table 12.

C. niloticus. – Finally, recent fresh frozen feces from *Crocodylus niloticus* were compared to the coprolites described in this paper.

RESULTS

Color. – Color number 3 is, by far, the most common (116 of 205), while color number 4 is the least common (9 of 205) (Table 1). All of the specimens with the darkest color (number 1) are within the lignitic layer. All with the lightest color (number 4) occur in the sand of the beach area (Fig. 1). Both of the intermediate colors (numbers 2 and 3) are found in all areas of the quarry site but somewhat more often in zone A.

Of 46 specimens with the darkest color, over two-thirds (67.4%) are in zone B (Table 1; $x^2 = 5.565$; $p = < 0.05$).

Without exception, all of the coprolites with the darkest color are associated with the darkest matrix.

Degree of Flattening. – Of 200 specimens examined, 93 are unflattened, 60 have mild flattening, and 47 have marked flattening (Table 2). All of the markedly flattened coprolites are in the lignitic zones and the majority (74.4%) are in the B zone. Coprolites located close to or in the sand of the beach area tend to be unflattened.

Table 7 shows that 52.0% of coprolites with the darkest color are markedly flat ($x^2 = 8.176$; $p = < 0.05$). On the other hand, 88.9% of specimens with the lightest color show no trace of flattening ($x^2 = 20.667$; $p = < 0.01$).

Shape. – 169 specimens were inspected to determine their shape; 42 are ovoid, 79 have a dome or cylinder shape, and 48 resemble teardrops (Table 4). In the non-lignitic area only 6.2% of specimens are ovoid while 68.8% are dome- or cylinder-shaped ($x^2 = 9.943$; $p = < 0.01$). The percentage of dome-cylinder specimens decreases toward zone B. Teardrop-shaped specimens are almost equally distributed.

When the degree of flattening is compared to shape (Table 8), one finds more (47.1%) of the ovoid shapes in the markedly flat category ($x^2 = 6.706$; $p = < 0.05$), and that most (58.5%) of the markedly flat specimens are ovoid in shape ($x^2 = 11.500$; $p = < 0.01$).

Weight. – Table 5 shows the weight distribution under 50.0 gms. Of 149 coprolites, 112 have known coordinates and 97 are in the lignitic zones. The greatest number (32.5%) of specimens in zone B occurs in the 0 - 4.9 gm. weight category.

Table 9 shows that 61.5% of markedly flattened specimens weigh less than 9.9 gms. The mildly flattened and unflattened coprolites tend to be heavier.

85.7% of the markedly flattened specimens weighing less than 5 gms. are in zone B (Table 3; $x^2 = 16.600$; $p = < 0.01$).

Shape vs. weight under 50.0 gms. is detailed in Table 10. 59.5% of specimens weighing under 5.0 gms. are ovoid ($x^2 = 11.750$; $p = < 0.01$)

and 62.8% of the ovoid specimens weigh less than 5.0 gms. The largest number of dome- and cylinder-shaped specimens, as well as teardrop-shaped specimens, are in the 5.0 - 9.9 gm. weight class.

Since the largest number of specimens weighing under 5.0 gms. are ovoid, these 22 coprolites were studied more intensively. This category is later described and discussed as Type I (Fig. 5).

Density. – The densities of 100 coprolites can be seen in Figure 6. When the densities were calculated for each parameter, no clear trend could be found. No color, shape, weight, or degree of flattening category is any more or less dense than any other.

Inclusions. – Inclusions can be seen on the surface of 49 specimens with 5x magnification and only in 32 of the entire collection of 205 coprolites with X-ray. A total of 69 coprolites contain inclusions. Most cannot be identified. Some appear to be *Lepisosteus*.

Coprolites with inclusions are not more numerous in any color, shape, weight, or degree of flattening category; nor are they more numerous in either zone A or zone B.

Surface Features. – Longitudinal grooves near the proximal end of a coprolite (Fig. 4) are interpreted as probable "anal sphincter marks." They are seen on 11 (5.4%) of the total collection of 205 specimens. Seven of these coprolites have a teardrop shape and the "marks" are present near the narrow, proximal ends. The other 4 specimens are dome-shaped and "marks" are present near the rounded, proximal ends. No correlation can be found between other features and "anal markings". Their distribution appears to be random.

Several coprolites show surface impressions of small sticks or bone (Fig. 7). These impressions are usually on one surface only, which is often relatively flatter than the rest of the specimen (Fig. 3). The two coprolites shown in Figure 7 are partly complete and therefore one cannot be certain of their shape or degree of flattening. Both are color number 3 and have no inclusions.

The matrix was left undisturbed around one specimen (Fig. 8) because it shows clear leaf impressions on both dorsal and ventral surfaces. This specimen is ovoid, non-flattened, number 3 in color, and has no inclusions. It is located in zone A. The leaf is unidentified.

Measurements. – The size range for each basic shape is shown in Table 12.

C. niloticus. – Analysis of fresh frozen feces from *Crocodylus niloticus* demonstrated an ovoid, unflattened specimen weighing 102.2 gms. and having a density of 1.07 gms./cc. No inclusions are present.

DISCUSSION

Color. – A coprolite's color clearly depends upon the color of the matrix in which it occurs (Table 1). All of the darkest coprolites (color number 1) are found in the darkest matrix, and the lighter-colored coprolites are always associated with light colored matrix. This finding is reinforced by the fact that all coprolites with the lightest color are found in the sand facies (beach) where no carbonaceous material exists. Furthermore, all specimens having the darkest color are found in zone A or B within the lignitic layer. The majority of darkest coprolites are in zone B and the largest percentage of the specimens in zone B have the darkest color. The lignitic layer is thicker in zone B than in zone A (Melchior and Erickson, 1979); therefore, a coprolite's color appears to have no special significance at Wannagan Creek Quarry other than to suggest its relative location.

Degree of Flattening. – There is a clear trend toward more flattening away from the beach area to zone B (Table 2). No markedly flattened coprolites are present in the beach area. Approximately three-fourths of the markedly flattened specimens are in zone B.

A recent examination of Paleocene coprolites associated with the large aquatic reptile *Simoedosaurus* from Cernay and Berru in France shows only minimal flattening of the specimens. There is a marked amount of wear of specimens at Cernay, somewhat less in the specimens at Berru, suggesting fluvial deposition at both locations. The relatively minimal wear of coprolites at Wannagan Creek Quarry suggests paludal conditions of sedimentation. Degree of flattening may simply be related to the intensity of paleocurrents, or, in the presence of numerous crocodiles, flattening may have been caused by bioturbation. Since zone B was an area of relatively deep quiet water (Erickson, 1981), the increased flattening in this zone could be the result of relatively insignificant water movement.

Shape. – Häntzschel, et al (1968), in an extensive review of the literature, found that coprolites have been described in many different forms. It appeared also that shape and size depended primarily on the animal of origin and, to a lesser extent, on the mode of deposition and the state of preservation.

Of the three shape categories at Wannagan Creek Quarry, the ovoid shape is represented by the smallest number of specimens. The frequency of ovoid shapes increases from the beach area to zone B, where the water was deeper at the time of deposition (Table 4).

The site distribution of the ovoid forms (Table 4) is very different from the distribution of the dome and cylinder forms, which are more frequent in zone A. This suggests the possibility of a different origin for each of these two types of coprolites. For example, at least some of the smaller ovoid shapes, which are more numerous in the relatively deeper water of zone B, could be assigned to *Champsosaurus,* for this reptile probably frequented somewhat deeper water than did the crocodiles and was primarily adapted to a dependence on underwater predation (Erickson, 1972, 1981).

The dome and cylinder shapes, which represent the largest number of specimens, on the other hand could be related to *Leidyosuchus. L. formidabilis* is the only frequent large vertebrate known in the study site.

No distinctive distribution pattern can be seen with regard to the teardrop shape.

Weight. – 32.5% of the coprolites in zone B are under 4.9 gms., whereas only 18.6% of the coprolites in zone A are in the same weight category (Table 5). It is unlikely that this distribution is a result of sorting by water currents. In zones A and B there is no evidence of appreciable bottom currents. For example, there is no sorting of smaller and larger bones; and many of the skulls of *Leidyosuchus* have teeth still in place, indicating very little water movement (B. Erickson, pers comm., 1980). Fossil floral studies (R. Melchior, pers comm., 1980) show a number of species that are characteristic of quiet water. Layer after layer of intact large fossil leaf specimens, especially in zone B, suggests that the leaves remained relatively undisturbed after settling to the bottom.

Since the coprolites in zone B are smaller and more ovoid, these two parameters were studied separately (Tables 6,10,11). Most (62.8%) of the ovoid coprolites weigh less than 5 gms. Only 10.2% of the dome-cylinder forms and 17.8% of the teardrop-shaped coprolites are in this weight class. This suggests that these small ovoid coprolites are of a separate and distinct origin. They are referred to as Type I in this paper and examples can be seen in Figure 5. Of 35 ovoid specimens that could be weighed, 22 are

Type I and 11 fall into a narrow weight range of 1.00 - 1.99 gms. (Table 11). If it is true that these small ovoid coprolites are of a separate and distinct origin, the animal responsible certainly was not abundant in the fauna.

It is usually difficult to ascribe a coprolite to the animal that may have produced it. Animals of very different systematic position produce coprolites that are quite similar. Even under the most favorable conditions, only a few of the various kinds of animal excrement are eventually fossilized. Many rapidly deteriorate in water. Positive assignment to the animal of origin is therefore only rarely possible (Häntzschel, et al, 1968).

The small ovoid (Type I) coprolites at Wannagan Creek Quarry could be related to the activity of small individuals of *Leidyosuchus,* a small alligator (Erickson, in press), or *Champsosaurus*. However, bone material from *Leidyosuchus* is abundant in the study area, whereas the evidence of the other two forms is relatively scarce.

The dome and cylinder forms, the large ovoid form, and at least some of the teardrop-shaped coprolites are probably related to *Leidyosuchus* because of its abundance. These will be referred to as Type II in this paper (Figs. 2,3,4). This type represents the vast majority of specimens in the study area. They tend to be somewhat heavier and less flattened than the Type I specimens. Most dome-, cylinder- and teardrop-shaped coprolites, for example, are represented in the 5.0-9.9 gm. weight category (Table 10). Zone distribution study shows that Type II specimens are most frequent in zone A. Table 4 shows that the dome-cylinder shape, in particular, is best represented in zone A.

Density. – Coprolite density does not appear to vary significantly in different areas of the study site even though the lithology varies greatly, ranging from sand in the beach area to carbonaceous shale in the lowest layer of zones A and B. Specimen size, therefore, is measured by weight (in gms.) throughout the study.

Inclusions. – Nürnberger (1934) has described "coprolites" discovered by Weigelt in the Geiseltal (Eocene) lignitic deposits of Germany. He states that these specimens contained "bones of frogs, bones of young crocodiles and stomach stones." Some of the brown elongated forms which Weigelt considered crocodile "coprolites" were found "in the bodies" of fossil crocodiles and therefore could easily be fossilized gastro-intestinal contents rather than fossilized feces. Certainly, the relative absence of well defined bones in feces of extant crocodiles reflects their very high gastrointestinal acidity (Skoczylas, 1978).

A few inclusions appear to be scales of ganoid fishes. Small, unidentified teeth are rarely present and bits of fragmented bone can be seen in some of the specimens. Although Fisher (1981) has suggested, after a series of feeding experiments, that demineralization is a constant feature of crocodilian digestion, these inclusions are not demineralized. Furthermore, demineralized microvertebrate bone and teeth are only rarely found in Wannagan Creek Quarry, even though crocodiles were numerous (B. Erickson, pers comm., 1981). The presence of ganoid scales in probable Type II coprolites indicates that *Leidyosuchus* preyed upon ''garfish,'' which are moderately abundant in the quarry.

Surface Features. – ''Anal sphincter marks'' are found only on Type II coprolites. Even though a relatively small number show these ''marks,'' it is a feature worthy of note.

Other surface features occur where the feces have mixed with bone, sticks, and leaves that were on the soft bottom of the swamp. Coprolites with imbedded small bones and sticks are all from zone B, an area that previously had relatively undisturbed water. Two specimens showing this feature (Fig. 7) are, for example, both at map coordinates R-23. A coprolite in leaves (Fig. 8) was found at H-13 in zone B.

There appears to be a need for a uniform approach to coprolite population analysis so that in the future groups of specimens from widely separated sites may be easily compared. How should one approach the description and/or analysis of a new batch of coprolites from a site? What features are important?

Color, degree of flattening, and density are not useful when attempting to establish the animal of origin. Shape, size, and associations are most important. Location within a quarry site of any particular shape or size category and proximity to vertebrate fossils should be noted. Surface features often suggest the nature of the depositional environment and inclusions indicate diet.

SUMMARY

This paper describes 205 coprolites from the Paleocene deposits of the Wannagan Creek Quarry in western North Dakota.

The evidence indicates the following:

1. The color of the specimens depends entirely upon the color of the matrix in which they occur.

2. The degree of flattening is related to amount of water movement around fecal deposits or bioturbation.

3. Coprolite density does not correlate with color, degree of flattening, shape, weight, or location.

4. Color, degree of flattening, and density are not useful when attempting to establish the animal of origin. Shape, size, and associations are most important.

5. Most specimens lack inclusions. However, 69 of the 205 coprolites contain inclusions, some of which appear to be fragmented ganoid scales. The inclusions are not demineralized.

6. Marks interpreted as ''anal sphincter marks'' are occasionally found on specimens. In the present collection these are thought to be those of the large crocodile *Leidyosuchus*.

7. Coprolite surface features aid in understanding the depositional environment for they indicate the relative amount of water movement, and adjacent sticks, bone, and leaves occasionally leave their imprint.

8. Two separate and distinct coprolite types are present. Type I is a small ovoid variety found primarily in areas where, at the time of deposition, the water was relatively deep and quiet. *Champsosaurus,* a small alligator, and small individuals of *Leidyosuchus* are all possible sources for this type.

Type II includes large ovoid forms, dome and cylinder varieties, and teardrop-shaped coprolites. Since Type II is predominant, it is allocated to *Leidyosuchus,* the only abundant large form available. Moreover, large ovoid extant feces of *Crocodylus niloticus* appeared quite similar to this variety.

The large coprolite population described here is, therefore, primarily crocodilian and allocated to *Leidyosuchus,* although there are a small number of small ovoid specimens that could be from a different source.

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TABLES

TABLE 1 — Color distribution.

Color Number	Totals (all specs.)	Totals (known location)	Totals (lignitic zones only)	A			B		
				# specs.	%		# specs.	%	
1	50	46	46	15	22.1	(32.6)	31	46.3	(67.4)
2	30	28	27	18	26.5		9	13.4	
3	116	73	62	35	51.4		27	40.3	
4	9	6	0	0	0		0	0	
TOTALS	205	153	135	68	100.0		67	100.0	

TABLE 2 — Distribution of flattening variation.

Degree of Flattening	Totals (all specs.)	Totals (known location)	Totals (lignitic zones only)	A			B		
				# specs.	%		# specs.	%	
Marked	47	43	43	11	16.7	(25.6)	32	49.2	(74.4)
Mild	60	51	48	22	33.3		26	40.0	
None	93	54	40	33	50.0		7	10.8	
TOTALS	200	148	131	66	100.0		65	100.0	

TABLE 3 — Distribution of flattening variation ("marked" category only).

Weight	Totals (all specs.)	Totals (known location)	Totals (lignitic zones only)	A			B		
				# specs.	%		# specs.	%	
< 5 gm.	14	14	14	2	20.0	(14.3)	12	46.2	(85.7)
> 5 gm.	25	22	22	8	80.0	(36.4)	14	53.8	(63.6)
TOTALS	39	36	36	10	100.0		26	100.0	

TABLE 4 — Shape distribution.

Shape	Totals (all specs.)	Totals (known location)	Totals (lignitic zones only)	Non-lignitic zones # specs.	Non-lignitic zones %	A # specs.	A %	B # specs.	B %
Ovoid	42	38	37	1	6.2	15	25.9	22	41.5
Dome or Cylinder	79	52	41	11	68.8	26	44.8	15	28.3
Teardrop	48	37	33	4	25.0	17	29.3	16	30.2
TOTALS	169	127	111	16	100.0	58	100.0	53	100.0

TABLE 5 — Weight distribution under 50 gms.

Weight (gms.)	Totals (all specs.)	Totals (lignitic zones only)	Totals (lignitic zones only)	A # specs.	A %	B # specs.	B %
0.0- 4.9	37	25	24	10	18.6	14	32.5
5.0- 9.9	38	28	23	12	22.2	11	25.6
10.0-14.9	11	7	6	3	5.5	3	7.0
15.0-19.9	13	12	10	7	13.0	3	7.0
20.0-24.9	14	9	8	5	9.3	3	7.0
25.0-29.9	14	11	10	7	13.0	3	7.0
30.0-34.9	7	6	5	2	3.7	3	7.0
35.0-39.9	7	6	4	3	5.5	1	2.3
40.0-44.9	5	5	4	3	5.5	1	2.3
45.0-49.9	3	3	3	2	3.7	1	2.3
TOTALS	149	112	97	54	100.0	43	100.0

TABLE 6 — Ovoid shape distribution under 5 gms.

Total # specs.	Non-lignitic areas # specs.	Non-lignitic areas %	A # specs.	A %	B # specs.	B %
22	1	4.5	8	36.4	13	59.1

TABLE 7 — Degree of flattening vs. color.

Color number	# specs. markedly flat	%		# specs. mildly flat	%		# specs. not flat	%		TOTALS
1	26	55.3	(52.0)	14	23.0	(28.0)	10	10.9	(20.0)	50
2	4	8.5	(13.8)	10	16.4	(34.5)	15	16.3	(51.7)	29
3	17	36.2	(15.2)	36	59.0	(32.1)	59	64.1	(52.7)	112
4	0	0.0	(0.0)	1	1.6	(11.1)	8	8.7	(88.9)	9
TOTALS	47	100.0		61	100.0		92	100.0		200

TABLE 8 — Degree of flattening vs. shape.

Shape	# specs. markedly flat	%		# specs. mildly flat	%		# specs. not flat	%		TOTALS
Ovoid	24	58.5	(47.1)	18	33.3	(35.3)	9	12.2	(17.6)	51
Dome or Cylinder	8	19.5	(10.1)	25	46.3	(31.6)	46	62.2	(58.3)	79
Teardrop	9	22.0	(23.1)	11	20.4	(28.2)	19	25.6	(48.7)	39
TOTALS	41	100.0		54	100.0		74	100.0		169

TABLE 9 — Degree of flattening vs. weight.

Weight (gms.)	# specs. markedly flat	%		# specs. mildly flat	%		# specs. not flat	%		TOTALS
0.0-9.9	24	61.5	(32.0)	17	34.0	(22.7)	34	46.6	(45.4)	75
10.0-154.9	15	38.5	(17.2)	33	66.0	(37.9)	39	53.4	(44.9)	87
TOTALS	39	100.0		50	100.0		73	100.0		162

TABLE 10 — Shape vs. weight under 50.0 gms.

Weight (gms.)	# specs. ovoid	%		# specs. dome and cylinder	%		# specs. tear-drop	%		TOTALS
0.0-4.9	22	62.8	(59.5)	7	10.2	(18.9)	8	17.8	(21.6)	37
5.0-9.9	5	14.2	(13.2)	19	27.5	(50.0)	14	31.1	(36.8)	38
10.0-14.9	0	0.0	(0.0)	7	10.2	(58.3)	5	11.1	(41.7)	12
15.0-19.9	3	8.6	(25.0)	7	10.2	(58.3)	2	4.4	(16.7)	12
20.0-24.9	2	5.7	(14.3)	10	14.5	(71.4)	2	4.4	(14.3)	14
25.0-29.9	1	2.9	(7.1)	7	10.2	(50.0)	6	13.3	(42.9)	14
30.0-34.9	0	0.0	(0.0)	5	7.2	(71.4)	2	4.4	(28.6)	7
35.0-39.9	0	0.0	(0.0)	4	5.7	(57.1)	3	6.8	(42.9)	7
40.0-44.9	1	2.9	(20.0)	3	4.3	(60.0)	1	2.3	(20.0)	5
45.0-49.9	1	2.9	(33.3)	0	0.0	(0.0)	2	4.4	(66.7)	3
TOTALS	35	100.0		69	100.0		45	100.0		149

TABLE 11 — Shape vs. weight under 5.0 gms. (ovoid category only)

Weight (gms.)	# specs.	%
0.00 - 0.49	0	0.0
0.50 - 0.99	1	4.6
1.00 - 1.49	5	22.8
1.50 - 1.99	6	27.3
2.00 - 2.49	1	84.5
2.50 - 2.99	3	13.6
3.00 - 3.49	2	9.1
3.50 - 3.99	2	9.1
4.00 - 4.49	2	9.1
4.50 - 4.99	0	0.0
TOTALS	22	100.0

TABLE 12 — Measurements of the basic shapes (in cm).

Shape	Relative Size	SMM Number	Length	Width	Depth
Ovoid	Largest	P79.6.97	16.8	3.2	3.1
	Smallest	P79.6.193	1.8	1.1	1.0
Dome	Largest	P79.6.88	11.5	5.3	3.1
	Smallest	P79.6.172	1.6	1.1	0.9
Cylinder	Largest	P79.6.13	8.2	4.7	3.8
	Smallest	P79.6.62	2.5	1.1	0.8
Teardrop	Largest	P79.6.99	16.0	4.5	3.8
	Smallest	P79.6.142	2.5	1.2	0.7

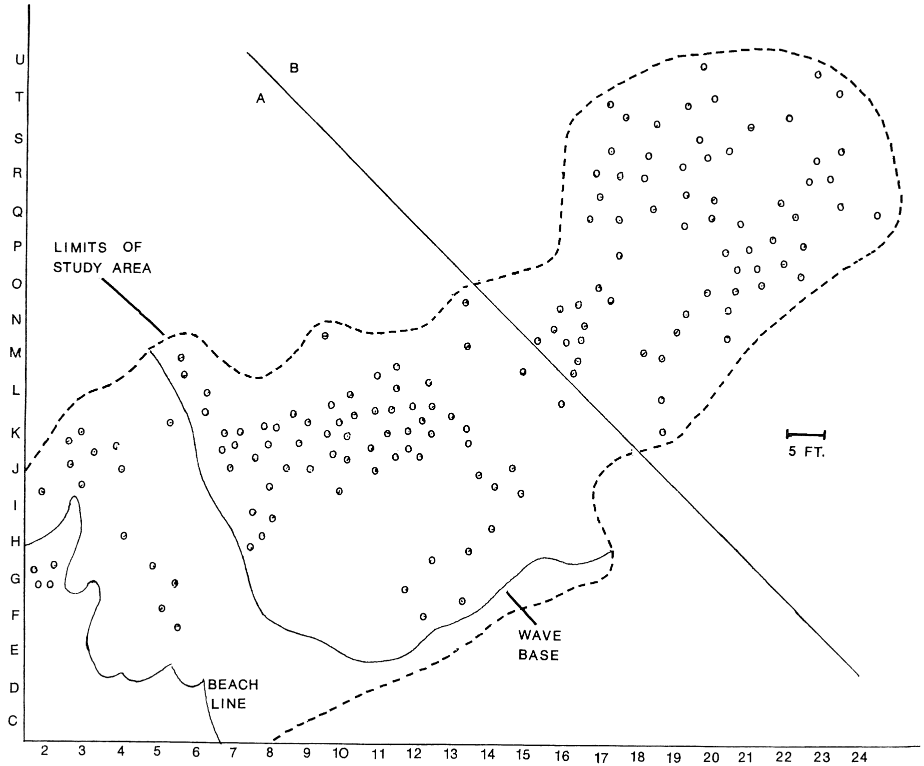

Figure 1. Distribution map for all specimens of known location.

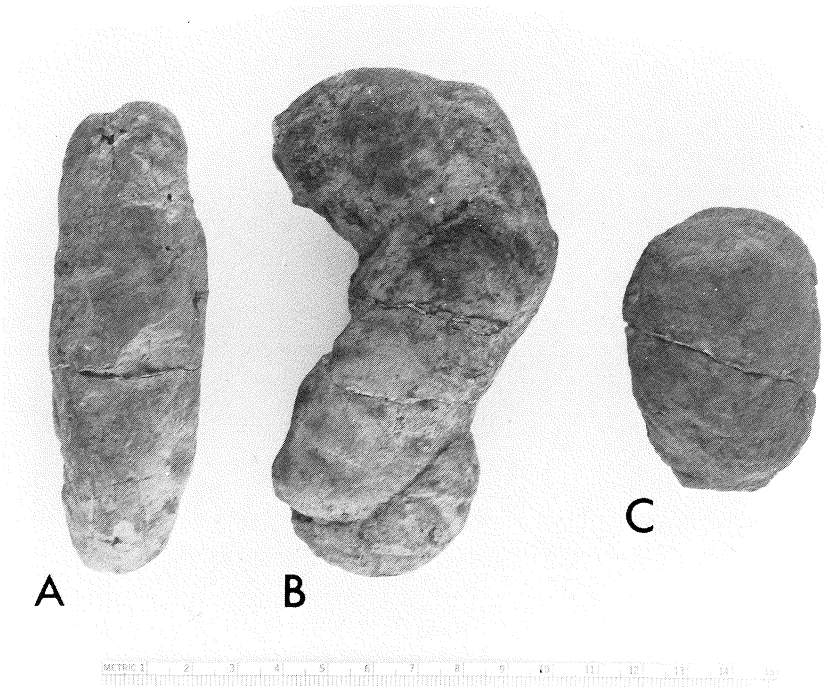

Figure 2. Large ovoid coprolites. A, SMM P79.6.53. B, SMM P79.6.50. C, SMM P79.6.35.

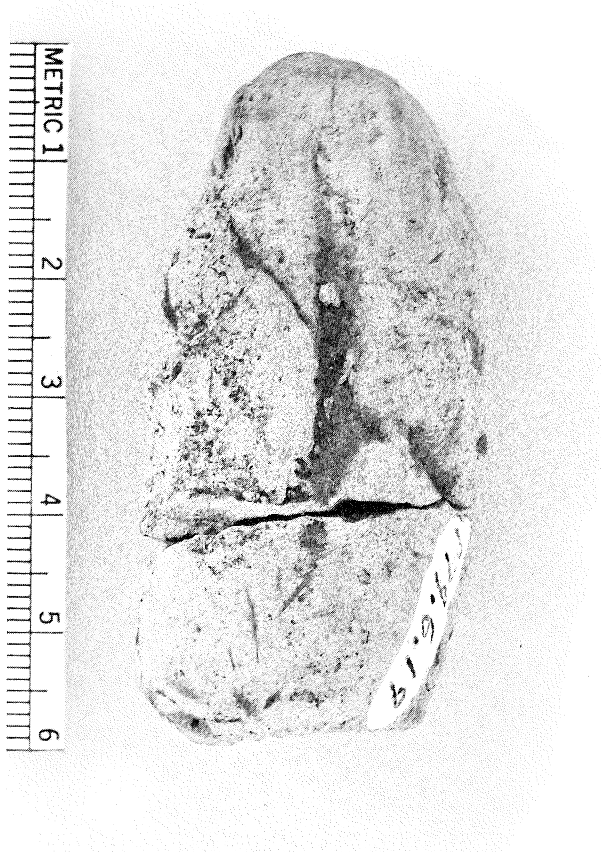

Figure 3. A dome-shaped coprolite, SMM P79.6.19.

Figure 4. A teardrop-shaped coprolite with "anal sphincter marks," SMM P79.6.9.

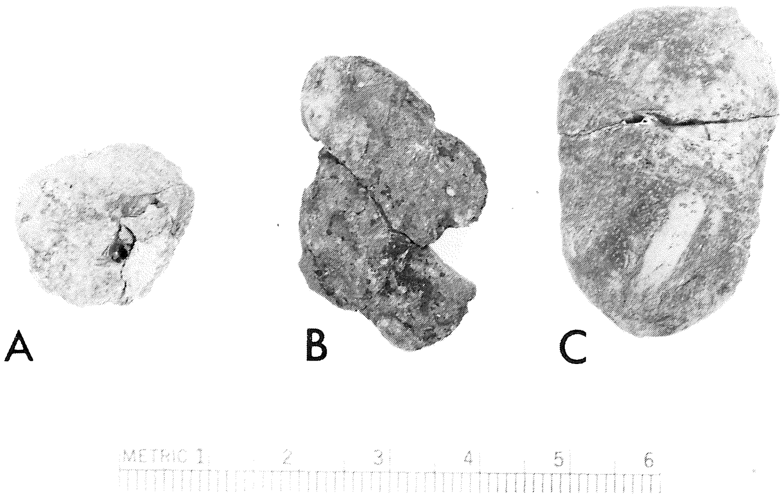

Figure 5. Small ovoid (Type I) coprolites. A, SMM P79.6.195. B, SMM P79.6.133. C, SMM P79.6.98.

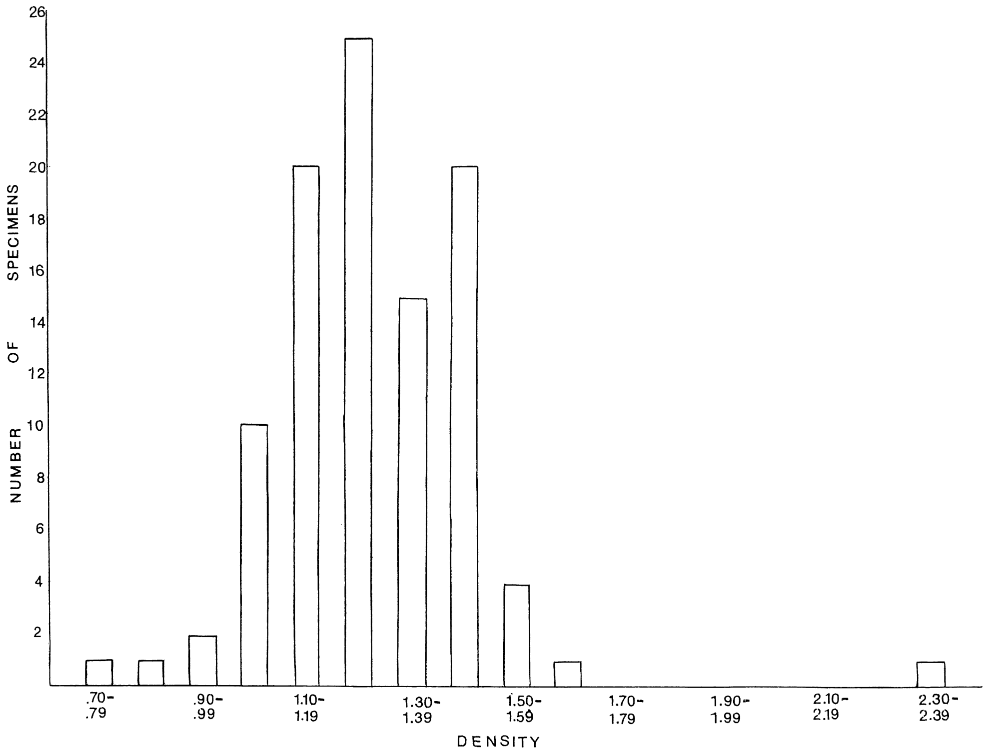

Figure 6. Densities of first 100 specimens.

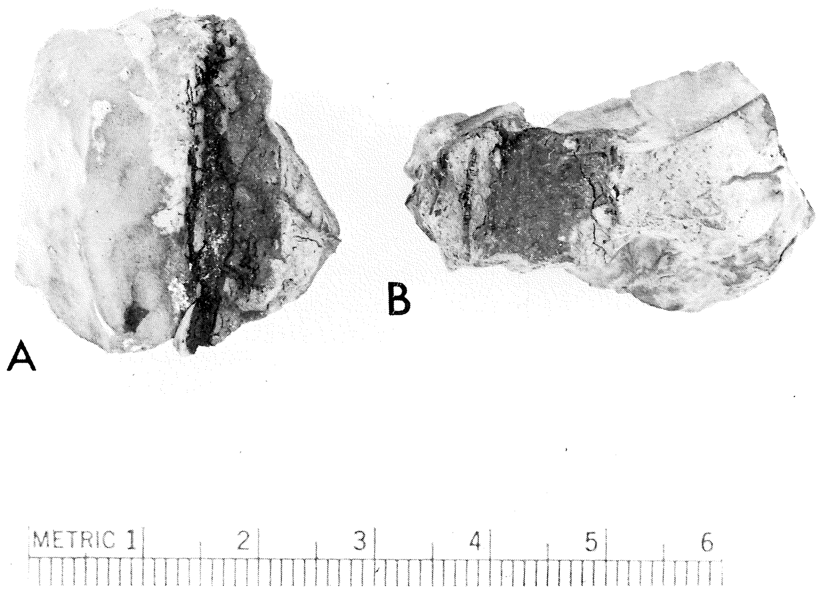

Figure 7. Coprolite fragments with surface impressions. A, SMM P79.6.111. B, SMM P79.6.113.

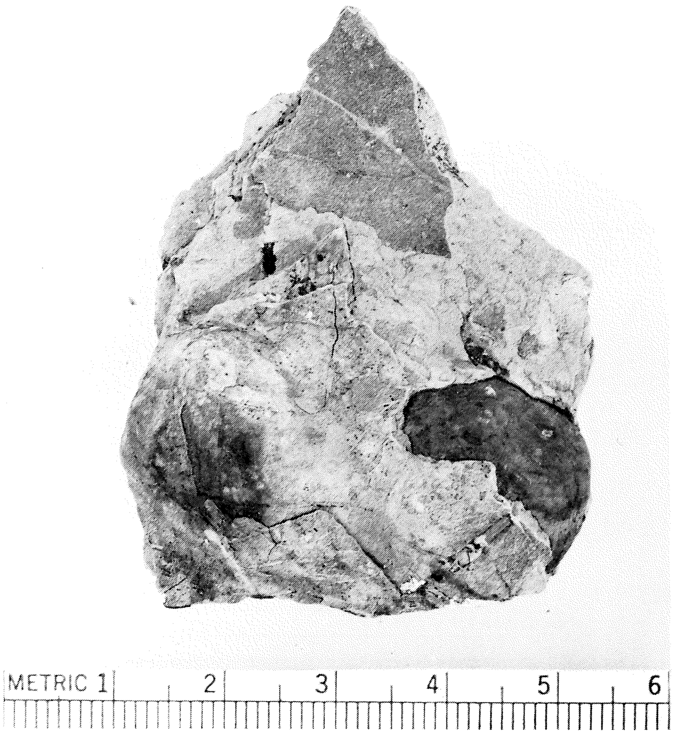

Figure 8. Coprolite enveloped in leaves, SMM P79.6.105.

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