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EFFICIENCY IN COLLECTING FOSSILS

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ABSTRACT

Two hundred seventy-two kilograms of sediments and fossils were collected from 1 meter square plots on lake beach and river gravel bars to compare the efficiency of surface collecting with that of intensive laboratory processing. Collecting fossils by visual inspection of the outcrop required an average of 14 minutes 56 seconds per square meter and resulted in 319 vertebrate and 1320 invertebrate fossils. The ratio of time spent collecting and processing sediments to time spent in surface collecting fossils was 4.66:1. The ratio of invertebrates produced by the intensive laboratory process to invertebrates produced by surface collecting was 4.80:1. Vertebrate fossils produced by the intensive process amounted to only 0.91 of the amount collected on the surface. Surface collecting is, therefore, the more efficient collecting method, particularly for vertebrate fossils.

INTRODUCTION

Many sites along the South Sulphur River of Hunt County, Texas, needed to be sampled to attempt to locate the source of Pleistocene vertebrate remains which make up a minor fraction of a faunal assemblage otherwise dominated by Cretaceous Bivalvia and Chondrichthyes. Different collecting methods involved different costs and produced variable yields. A search of the paleontological literature since 1945 showed that the question of collecting efficiency had been ignored. Most investigators had been willing to invest whatever resources were required in order to collect all a locality had to offer, such as the heavy-liquid flotation treatment of one quarter ton of Cretaceous matrix to produce nine mammal teeth (Lees, Curator 7:300-306, 1964). This unlimited investment approach was deemed too expensive to use in the present study which compared 2 styles of collecting, quantified the results, and proved the superior efficiency of surface collecting over intensive laboratory processing.

METHODS AND MATERIALS

Two sites along the South Sulphur River were studied. The functional unit of this study was 1 meter squares laid out with meter sticks and string on gravel bars. The Neylandville site (Squares 1 through 4) was approximately 7.1 river miles and 6.5 airline miles upstream from the Commerce site which produced Squares 13-1 and 13-3 through 13-8. Three squares from a beach on Millwood Lake, Hempstead County, Arkansas, roughly 120 airlines miles to the east were used to represent a different environment.

The first technique of collection examined in this study required a minimum of processing: visual inspection of the surface for fossils. Time required for surface collecting was measured by electronic stopwatch, as were all time measurements in this study.

The second technique required intensive processing: bulk sampling, sifting, and picking. The top 0.5 inch of sediments in each square was collected by shovel, and the time spent collecting this layer was measured. In the laboratory, the fossils which had been collected on the surface were identified and counted. The fossils were then restored to the surface sediments before further processing. With screens made of hardware cloth with 0.5, 0.25, and 0.125 inch openings, the sediments were separated into 4 fractions: greater than 0.5 inch (coarse), 0.5 inch to 0.25 inch (medium), 0.25 inch to 0.125 inch (fine), and less than 0.125 inch (micro) sizes. The stages of the sifting process were timed.

The coarse (greater than 0.5 inch) and the medium (0.5 inch to 0.25 inch) sediments were then picked visually for fossils. This process was timed. The fossils recovered were then identified and counted. Pebbles, representing errors in picking, were also counted.

RESULTS

Two hundred seventy-two kilograms of sediments from the 14 squares were taken to the laboratory for processing. The collecting times, processing times, and specimens collected are presented in Tables 1-4. In computing processing times for the various sediment sizes, one quarter of the time spent collecting the surface layers and sifting the sediments into size fractions was assigned to each of the 4 fractions. None of the less than 0.125 inch size sediments were examined, and of the fine fraction (0.25 inch to 0.125 inch size), only the sediments from 3 squares

Table 1. Processing Times (in seconds) For Gravel Bar Squares

	1	2	3	4	5	6
Millwood Sq.-1	900	279	781	943	2102	4105
Millwood Sq.-2	901	190	398	940	2637	4165
Millwood Sq.-3	753	276	543	568	3255	4642
Neylandville 1	691	154	650	190	284	3843
Neylandville 2	720	121	1074	226	2486	3907
Neylandville 3	381	161	620	522	1838	3141
Neylandville 4	388	115	655	731	2178	3679
Commerce 13-1	856	211	834	282	2086	3415
Commerce 13-2	1082	183				
Commerce 13-3	1029	186	475	205	2008	2874
Commerce 13-4	821	160	558	552	3704	4974
Commerce 13-5	1334	152	446	284	5253	6135
Commerce 13-6	1448	226	591	347	3752	4916
Commerce 13-7	1207	207	658	245	3288	4398
Commerce 13-8	922	197	430	229	2468	3324

1 Time to surface collect.

2 Time to shovel surface.

3 Total sifting time.

4 Time spent picking sediments larger than 0.5 inch.

5 Time spent picking sediments between 0.5 and 0.25 inch.

6 Total processing time.

Table 2. Numbers of Fossils Found in Surface Collecting (M = Millwood Lake Site, N = Neylandville Site, C = Commerce Site)

	M-1	M-2	M-3	N-1	N-2	N-3	N-4	C-1	C-3	C-4	C-5	C-6	C-7	C-8
Bone	1		5					8	7	8	5	17	11	21
Shark Teeth				4	3	1		10	27	4	22	30	19	12
Barracuda Teeth							1	5	12	2	12	11	4	4
Ray Teeth		1						1	4		1	4	1	
Fish Bones	1	2						2				4		2
Tooth Enamel						1	1	1	3			3	3	4
Sawfish Rostrals						1						1	1	1
Shark Denticles												1		
Crushing Plates												1		
Reptile Teeth									2				2	1
Rodent Teeth											2		1	
Vert. Sum	2	3	5	4	3	3	2	27	55	14	42	72	42	45
Pelecyp. Molds		5	7				7	1	8	1	2	4		3
Pelecypod Shells	19	60	54	225	51	52	131	25	50	45	73	87	74	66
Gastropod Int. Molds		2	1				1	15	27	9	23	29	19	20
Gastropod Ext. Molds						1	1							
Belemnites		1												
Coiled Ammon.		1								1			1	
Straight Ammonites			1				1	3	4			4		
Echinoid Plates		1						1				1		2
Echinoid Spines	2	4	32											
Crinoids		5	9											
Worm Tubes	1	13	4	2				4	3	1	1	1		
Corals								1				1	2	
Crab Claws			1					1				2	1	1
Brachiopod?												2		
Unidentified		2									1			
Petrified Wood				2		1	1	2	1			2		2
Invertebrate Sum	22	93	102	229	51	54	142	53	93	57	100	133	97	94
Total Fossil Sum	24	96	107	233	54	57	144	80	148	71	142	205	139	139
Pebbles	6	8	15	17	1	4		24	14			22		11

Table 3. Numbers of Fossils with Diameter Greater Than ½ Inch (M = Millwood Lake Site, N = Neylandville Site, C = Commerce Site)

	M-1	M-2	M-3	N-1	N-2	N-3	N-4	C-1	C-3	C-4	C-5	C-6	C-7	C-8
Bone				1	5	1	1	1	5	5	2	7	5	6
Shark Teeth												1		
Ray Teeth		1												
Fish Bone		5	1							1				
Tooth Enamel									1				1	
Vert. Sum	0	6	1	1	5	1	1	1	6	6	2	8	6	6
Pelecypod Molds	1		2			6	8				2			
Pelecypod Shells	34	32	41	31	36	74	56	9	18	27	14	24	14	22
Gastropod Internal Molds							3		1		1			2
Coiled Ammonites						4	1							
Straight Ammonites		2				2	1		1	2				
Echinoid Plates		1	1											
Echinoid Spines	2	1	3											
Worm Tubes	1	2	4											
Corals	2													
Unident.	1													
Petrified Wood						2	2	2				2		
Invertebrate Sum	41	38	51	31	36	88	72	11	20	29	17	26	14	24
Total Fossil Sum	41	44	52	32	41	89	73	12	26	35	19	34	20	30
Pebbles	1	4	4	1	2	3		4	3			2		3

Table 4. Numbers of Fossils with Diameters From ½" to ¼" (M = Millwood Site, N = Neylandville Site, C = Commerce Site)

	M-1	M-2	M-3	N-1	N-2	N-3	N-4	C-1	C-3	C-4	C-5	C-6	C-7	C-8
Bone				8	7		2	17	16	10	11	16	7	11
Shark Teeth		2	4	2	2	1	3	11	9	1	11	11	4	7
Barracuda Teeth				1		4	1				4			
Ray Teeth		1	2					2	2	2	2	3		1
Fish Bone		5	3					2		1	2		1	1
Tooth Enamel				1		1	1	4	2		2	2	3	3
Sawfish Rostrals						1							1	1
Reptile Teeth							1		1				1	1
Rodent Teeth												1		
Armadillo Scute											1			
Vertebrate Sum	0	8	9	12	9	7	8	36	30	14	33	33	17	25
Pelecypod Molds	8	8	4	1		1	7	5	3	8	8	8	10	3
Pelecypod Shells	180	370	873	567	569	258	135	293	326	254	195	500	250	496
Gastropod Internal Molds	3	4	4	2	1	1	2	42	30	40	52	52	38	32
Belemnites	1	1												
Coiled Ammonites	1	1					2			4	6		9	
Straight Ammonites			1					4	3			13		3
Echinoid Plates		5	17											
Echinoid Spines	1	4	9											
Crinoids		1	2					1						
Worm Tubes	1	20	20	1				3	1		2	1		
Corals									1	1			1	
Crab Claws				1										
Brachiopod?						1						1		
Unidentified		3					2	2	2					
Petrified Wood	1				2	5	4	3		4	3	6	3	5
Invertebrate Sum	196	417	930	572	572	266	152	353	366	311	266	581	311	539
Total Fossil Sum	196	425	939	584	581	273	160	389	396	325	299	614	328	564
Pebbles	7	14	16	27	5	18	14	24	19	63		38	51	27

were examined. Although 2341 specimens were recovered with an efficiency of 21.1 seconds per fossil, the average time to pick the non-pelecypod fossils from each square was 4.58 hours. Therefore, complete processing of the fine and micro fractions was judged to be too time-consuming for the present study.

DISCUSSION

Overall, surface collecting of vertebrates is more efficient, as measured by number of seconds per fossil collected. Table 5 indicates it requires fewer seconds to collect each specimen of vertebrate fossil by visual inspection of the surface of a gravel bar (38.7 seconds per fossil) than by collecting, sieving, and picking sediments (178.2 seconds per fossil). Therefore, the rate of return from surface collecting averages 4.6 times the rate for fossils in laboratory processing.

Surface collecting of larger invertebrates is also more efficient than intensive processing. Surface collecting has a yield rate of 9.4 seconds per fossil as compared to 18.3 seconds per fossil in intensive processing of coarse sediments, those greater than 0.5 inch. Laboratory processing of medium sediments, on the other hand, had an efficiency of 7.5 seconds per fossil.

If the pelecypod shells are ignored in the samples, surface collecting becomes even more attractive. Many of the pelecypod shell fossils are fragmented and of little paleontological value although they remain identifiable. When they are removed from the total fossil counts, the surface collecting technique has a yield rate of 19.7 seconds per fossil, and the medium sediments produce at a rate of 53.0 seconds per fossil, only 37% the rate of surface collecting. Leaving out the pelecypod fossils drops the rate of return from the coarse sediment fraction to 78.5 seconds per fossil, the lowest return of all.

The number of non-fossiliferous pebbles that are mistakenly picked

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Table 5. Collecting Efficiency Ratios (seconds per fossil recovered).

	0.25"-0.5" (a)	> 0.5" (a)	Totals (b)	From Surface (c)
Vertebrates	177.4	182.0	178.2	38.7
All Invertebrates	7.3	18.3	8.2	9.4
Invertebrates Other Than Pelecypod Shells	75.5	137.9	82.0	40.1
Total Fossils	7.0	16.6	7.8	7.5
Total Fossils Other Than Pelecypod Shells	53.0	78.5	56.2	19.7

(a) computed by dividing the number of fossils into 0.25 of the surface shoveling time plus 0.25 of the sifting time plus the picking time for that particular fraction.

(b) computed by dividing the total number of fossils into 0.5 of the surface shoveling time plus 0.5 of the sifting time plus the total picking time for the greater than 0.5 inch and the 0.5 inch to 0.25 inch fractions.

(c) computed by dividing the total number of fossils recovered from the surface by the time spent surface collecting.

out would be an index of inefficiency. From among the surface collected sediments, 122 pebbles were retained. In the coarse sediments 0.29 pebbles per kilogram were retained in laboratory processing, and this index rose to 5.10 errors per kilogram of medium sediments, indicating this fraction presents problems when it is picked without some sort of magnification aid. For the 12,351 seconds of surface collecting, 122 pebbles were collected. This number indicates a span of 101 seconds between "errors," which could be caused by factors hard to control in the field such as poor illumination and a heterogeneous surface. For the 51,844 seconds of processing coarse and medium fractions in the laboratory, the 345 pebbles mistakenly collected indicate a span of 150 seconds between "errors," which is a 49% improvement in performance.

In terms of absolute numbers rather than rates of return, surface collecting produced only 25% (1639) as many total fossils (6621) as laboratory processing (Table 6). If the pelecypod shells are excluded,

Table 6. Numbers of Fossils Recovered.

	0.25"-0.5"	> 0.5"	Totals	From Surface
Vertebrates	241	50	291	319
All Invertebrates	5832	498	6330	1320
Invertebrates Other Than Pelecypod Shells	566	66	632	308
Total Fossils	6073	548	6621	1639
Total Fossils Other Than Pelecypod Shells	807	116	923	627

the surface collecting produced 68% as many fossils as laboratory processing. Of invertebrates, surface collecting produced 21% of the number that was recovered in laboratory processing or 49% of the laboratory-produced invertebrates if pelecypod shells are excluded. Of vertebrates, the 319 fossils recovered by surface collecting were 110% of the 291 found during laboratory processing. Therefore, it is among the vertebrate fossils that surface collecting is particularly effective, probably due in large part to the color contrast these phosphatic fossils make with their matrix. Only one taxon, Pleistocene armadillo scute, was not recovered during surface collecting, but just 1 specimen was recovered during intensive laboratory processing.

As might be expected, the correlation of collecting efficiency between the two Sulphur River localities is high in several respects. The average efficiencies for invertebrate, vertebrate, and total fossils taken in surface collecting, processed coarse sediments, processed medium sediments, and totals of all collections correlated at a level of 0.94. When the average collecting efficiencies for just the vertebrate and invertebrate categories are correlated, a value of 0.92 is obtained, and the correlation for invertebrate categories is at 0.87. Correlation for vertebrates falls to 0.79 since the Neylandville site produced an average of 3.0 vertebrates per surface-collected square meter (Observed Range 2 to 4) and the Commerce site produced an average of 42.4 vertebrates per surface-collected square meter (O. R. 14 to 72). Some of the correlations of collecting efficiencies between Millwood Lake and the Sulphur River localities were high. In the average efficiency for invertebrate, vertebrate, and total fossils taken in surface collecting, processed coarse sediments, processed medium sediments, and totals of all collections, the correlation of Millwood Lake with the Neylandville squares was 0.91, and the correlation of Millwood Lake with Commerce was 0.82. The correlation between average efficiencies for just the vertebrate and invertebrate categories between Millwood Lake and Neylandville was 0.87 and between Millwood Lake and Commerce, 0.72. These lowered correlations probably reflect basic differences due to different stratigraphic levels acting as the source of the fossils and to different depositional environments (lake beach gravels vs. stream gravels). For example, among the surface-collected fossils, Millwood Lake produced 39 echinoid plates and spines, no shark teeth, and no barracuda teeth compared to 4, 132, and 51 for the same categories from the Sulphur River sediments.

There is a correlation of 0.80 between amount of time spent surface collecting and number of vertebrates recovered throughout this study. There was much less correlation between time spent surface collecting to invertebrates produced (0.02) or to total fossils produced (0.35). On the other hand, correlation was low between total times for processing sediments from the individual squares and vertebrates recovered (0.17), invertebrates found (0.04), and total fossils found (0.05). In some circumstances a square would have an efficient yield by intensive processing, but one can not rely on high yields in any given square.

The range in richness of fossils in sediments observed in this study was considerable (2 to 72 vertebrates per square meter) but exceeded, for example, that of the Kansas Great Plains Pleistocene deposits. There, the standard procedure has been to search out sediments in which gastropod shells are readily visible (indicating past depositional conditions have not been so severe as to destroy delicate fossils) and then to collect the material in bulk, measured in fractions of tons, for concentration by water screening. In those circumstances, where stratigraphic considerations are of paramount importance, a quarry producing three mammalian teeth per 80-100 pound lot of sediment is regarded as a paying proposition. But in sediments as rich as were collected in this study, surface collecting is preferable over more intensive styles of processing.

SUMMARY

1. Surface collecting had 4.6 times the efficiency of intensive processing of sediments in terms of seconds per vertebrate fossil recovered.
2. More vertebrate fossils were found by surface collecting (319) than were recovered by laboratory processing (291).
3. Even from the standpoint of total fossils recovered, surface collecting produced 25% of the yield of laboratory processing or 68% of the lab yield if pelecypod shells are excluded.
4. Twenty-seven of the 28 taxa recognized in this study were recovered during surface collecting. The missing taxon is represented by only 1 specimen in the 6621 found in the laboratory.
5. Collecting efficiencies at all three sites had a correlation of 0.94, but in several aspects correlation between the South Sulphur River sites was higher than between either of them and the Millwood Lake locality.
6. There was a low correlation (0.05) between total processing time and total fossils found, but a high correlation (0.80) between time spent surface collecting and number of vertebrates recovered.

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