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GROWTH OF ANT MOUNDS.

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It is well known that many sorts of ants dig into the ground and carrying out mouthfuls of earth soon make conspicuous ant hills above their subterranean dwellings. In some, these mounds are of considerable size and of long duration and serve as nests or places for rearing the young.

The best known mound builder in America is the rather large red and black *Formica exsectoides*, the mound builder of the Alleghanies, whose mounds are seen here and there in Nova Scotia, Ontario, Maine, New Hampshire, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, North Carolina, Georgia, Wisconsin, Illinois, and Colorado. As one of these mounds may contain more than a ton of earth it becomes of interest to find out how long the ants must labor to accumulate so relatively vast masses of material. One of these ants, alive, weighed 10 milligrams.

When the Rev. H. McCook in 1876 studied the "ant city" of local fame near Holidaysburg in Pennsylvania where this ant, which he called the wood or fallow ant (locally called pismires) had built up as many as 1700 mounds, he soon decided, from the occurrence of the very largest mounds on old charcoal hearths, that even the mounds that might contain 300 cu. ft. of earth were not of any very great age. He also recorded that a field plowed in September 1875 showed new mounds in February 1877; one ten inches high and 35 in diameter; a second 14 by 48. As the work of the ants stops in November these mounds were made, he thinks, in a little over one season of work. Again in a corn field in July 1876 were two new mounds, each made in two months, or one third of a working year, and each measured 8 inches in height and 18 in diameter. The first hill was, he

points out, built up at the rate of $1\frac{1}{4}$ cu. ft. per annum, the second at the rate of 3, and the other two at the rate of 1. The second hill arrived in about one year to above the average size of the mounds of that region, and its very great rapidity of growth may have been due, McCook supposes, to the fact that it was not a new colony but was reconstruction work built up on the ruins of an old mound.

McCook inferred that mounds might require five to seven years to be built up to average size and that once full grown they do but hold their own. He says there were good reasons to suppose that some of the large mounds might be thirty years old but no evidence that any of them last through great periods of time. McCook states that the two small mounds in the corn field were probably new communities and it is evident that only such new communities should be considered in reckoning the initial rate of construction. Each mound is the communal work of a family and grows as the family prospers and multiplies year by year since its individuals escape death in the winter by withdrawing deep under ground in subterranean tunnels and are known to be able to live in captivity as much as seven years. The very rapidly rebuilt mounds on the other hand are the reconstruction work of prosperous communities that are able to repair even great amounts of destruction and removal of old mound materials.

As these estimates of McCook on the rate of building mounds by *Formica exsectoides* seem to be the only ones printed, the following data collected near Baltimore, Md., may be worthy of record.

Near Lutherville and Timonium in Baltimore County there is a settlement of these ants embracing some two hundred mounds and measurements made at irregular intervals from 1905-1924 furnish added means for judging of the rate of growth and the age of the mounds of these ants. During this period some of the mounds have remained in existence; either growing or remaining stationary in size; others have disintegrated; and others have sprung up anew. Parts of the entire area have been largely abandoned and other parts have been invaded by new mounds. In one of these newly populated areas measurements have been

made of a certain new mound and incipient community which has grown to maturity along with many others established during this period in the same area, which was a very sterile flat of several acres covered with reddish-iron-ore earth: refuse removed formerly from large adjacent bog-iron-ore pits.

When first seen July 7, 1906, this new nest was conspicuous amidst the sparse grass as being a few handfuls of light yellow and white pellets of irregular size brought up from the subsoil and piled up amidst the grass in an irregular mass three inches high and nine inches wide. There were no holes into the middle of the nest, but large irregular entrances about the base on the N. W. S. and E. sides. It was about 150 feet from an old nest, No. 59 of a survey in 1905, that has remained there since despite the encroaching Japanese honeysuckle and has grown from five, to six by eight feet in diameter, and from 2 to nearly three feet in height, with a circumference of 22 feet. Possibly from this large nest came the female that started the incipient nest. When disturbed the ants in this incipient nest swarmed out and made a rustling sound running over the dead leaves near the nest, but they were but few in number though so rapidly covering all the surroundings.

When next measured, November 13, 1906, this incipient nest had grown to be a considerable mass fifteen inches across and four to five in height. This, then, was the maximum of the first year's building.

After another year, October 24, 1907, this incipient nest measured 6 by 18 inches. The ground on which it was placed was an artificial ridge falling off to the East as a shallow depression and from now on it became evident that the earth placed by the ants tended to spread unequally and the measurements from the ground level were greater on the east and less on the west. Thus June 12, 1908, the mass of earth was 21 inches from NW-SE, 18 inches wide from NE-SW, while the height was 8 inches from the ground on the west and 12 from the level on the east. More ants were now busy over the mound, but grass blades and small shoots of honeysuckle were growing up in the midst of the nest. In the fall of that year, October 18, the mound measured 9 by 26 inches and was quite conspicuous and

well covered with small sticks and minute pebbles as well as several snail shells, flat and several millimeters in diameter; thus showing that much material had been added to the mound from surface collections, while originally all the material had come from subterranean excavations. At that date, though there had been frosts, the temperature was 70° F. and yet only one or two ants were to be seen on the mound. No more measurements were made till August 7, 1914. It had then become a noticeable mound arising abruptly on the west where bordering an obscure path apparently used by dogs, and sloping gradually on the east down to the lower level. The top of the mound was bald, covered with small sticks and stones, but about the middle height was a tonsure of straggling grass stems. The "stones" were such as ants collect; some may be 7 x 5 mm. and weigh 200 milligrams. Many ants were active about the base, but none up on the mound. A similar nest stood some 80 feet to the North. The measurements taken were: height 12 on west; 19.5 on east; diameters 42 east and west, 38.5 north and south.

September 19 of the following year, 1915, it measured 16 on west, 24 on the east, 47 north and south, and 52 east and west. It seemed well cared for with large fragments of stick and stone recently added to the dome to build up after heavy rains and was covered with very active ants. Both base and summit were bare with the sparse grass growing out from the sides of the mound in a zone.

After more than a week of rain in a cold wet season, the nest, June 18, 1916, was still in good form with much fine sand newly applied and swarming with actively working ants. The measurements were: west 16, east 21 in height; north and south 50, east and west 53 in width. Thus the mound had not gained, but apparently lost somewhat of its greatest height since the previous autumn, though its increased diameters suggested winter denudation had spread the material and as yet the loss of height had not been made good.

No measurements followed till the spring of 1919, April 13, when on account of cold few ants were working, though in the immediate neighborhood some dozen fine new nests of this same general age all showed much recent activity by presence of

fresh earth over the domes. Then as in 1916, the incipient nest remained very much steeper on the north slope and still had an irregular band of green grass in tufts from half way up the slopes to near the base. The surface was covered about an inch deep with fine pellets and dried earth apparently brought out this spring to replace denudation and a series of partly open tunnels and pits across the apex of the mound showed that the interior had been exposed by destruction and removal of the roof in that part. The measurements were: west 15, east 24, north-south 58, east-west 54. Later, October 18, the grass around the middle zone had grown tall but the honeysuckle that surrounded the nest stopped abruptly, leaving a bare narrow yard all about the base of the mound, no spray or stem of the honeysuckle reaching over this dead space to the base of the mound. The bald top with bits of stick and gravel extended down farther on the southerly exposure. The measurements were: west 18, east 28, east-west 60, north-south 63. Thus in this single season of building the ant's mound had risen three to four inches and spread out five to six in diameter.

July 25, 1920 the mound swarmed with ants but some other mounds near by were more populous. The bald top of the mound was in sharp contrast to the sides grown up with tall grass amidst which the ants had accumulated heaps of earth pellets that formed a spongy mass with irregular cavities. The grass holds the sides in very steep slopes. The moat-like encircling dead space on the level without the base of the mound was strewn with dead leaves but the honeysuckle stopped short at its outer edge. The mound had grown so that the North-west-South-east diameter much exceeded the shortest diameter. The measurements were then: West 18-20, East 24-30, North-South 57, East-west 54. By the 19th of September the mound had increased somewhat; the height being West 21, East 28, the width North-south 60, East-west 57. Very few ants were to be seen at this time of year and the nest had been got into fine condition for the winter, being covered with fresh roofing of whitish clay pellets as if from deep subsoil, along with many bits of grass stems, one to one and a half inches long, dispersed through with scattered black, dried, excreta of some large caterpillar. At the

end of its fifteenth year the mound was rather imposing, being 16 feet about the base, with abrupt slope on the north 30 inches up the steep to the summit, and 48 from the summit down to the ground to the South, while the west slope was 33 and the east 44 inches from summit to ground level.

August 21, 1921, the mound was in fine condition with newly capped dome, but owing to cool weather and time of day, 6.30 p. m., but few ants were slowly going over the dome and about the neighborhood of the nest. The measurements were: West 21, East 30, North-south 72, and East-west 72. The greatest North-west-South-east diameter was 76 inches. The surface distances over the top were: East-west 82, North-south 85 and greatest North-west, South-east 88. The circumference of base was 18 feet. In general appearance the mound presented a high state of differentiation. The surrounding bare space or moat strewn with dead leaves and twigs of vine that stops in growth at its outer edge, makes more striking the sudden rise of the mound from the level of the ground. The lower parts of the slopes of the mound are covered with talus of loose mouthfuls of earth rolled down from upper levels. Higher up is a faint zone of scattered grass, and still higher up a higher zone of still more sparse grass. The rounded dome is free from grass and covered with fresh light-colored subsoil and bits of dead twigs deposited to form a sort of rudely thatched roof. Near the summit of the north a minute crater seemed possibly still open to the interior. The north face remains much the steepest and the summit is nearer the north and far from the southerly limits of the mound. At this period of great development of the mound a new incipient nest was being constructed 42 inches to the North-west from the adult mound and if this may be regarded as an offspring from the large community, it may indicate its maturity and a successful effort at colonization of the neighborhood.

July 20, 1922, with temperature of 93, after many rains, the mound was swarming with very active ants that also spread many feet from the nest amidst the honeysuckle and grass. The mound presented several open holes of exit near the top but no ants were working near the top. The growth of grass on the sides of the mound was sparse and sickly, the honeysuckle dead

in a broad band of a foot width about the base. The elongation of the mound to the South-east was very evident as well as the great steepness of the north slope. The measurements were: West 23, East 30, North-south 81, East-west 79, as computed from surface measurements of East-west $91\frac{1}{2}$ and North-west, South-east 99. Measured again in the fall, September 10, 1922, it was: West $20\frac{1}{2}$, East 32, width North-south 87, East-west 73. The distance around the base of this seventeen year old mound was 20 ft. 6 in., the distance up the north slope 3 feet and up the long south slope 5 ft. 22 in. The tape over the surface showed a distance of 8 feet 4 in. in the North-south direction and 7 ft. 4 in. East-west. This being a clear warm day ants were abundant upon the mound carrying up and dragging earth pellets toward the summit which was conical and closed, in spite of heavy recent showers. The mound was recently covered with fresh light earth with very many light fluffy cast-off pupa cases lying about as if brought up by ants from within the nest. In some parts of the circumference of the base there was more than a foot in width of dead honeysuckle. Large streams of ants ran to and from a tulip tree about twenty feet distant and many up and down the tree. Fifty feet to the east were evident several new young nests.

In the next year, 1923, measurements were made July 8, when the height had fallen, west 19, east 29, east-west 76, north-south 84 corresponding to surface distances of 89 and 98 inches. Apparently the lessened height might have come from denudation which added to the diameters. The mound was in fine state of preservation, not injured at the top and the ants were bringing out earth through holes near the top. The sparse grass still present about the upper reaches of the mound did not prevent much fine clean earth from rolling down and spreading to the south-east.

The next measurements, January 27, 1924, showed a greater depression of the summit, west 16, east 27, north-west-south-east 86, north-east-south-west 75. For the first time the angles of slope were measured as follows: North 45° , West 45° , East 40° - 38° , longest South-east slope 35° . Other measurements were: circumference 20 ft. 2 in., distance over top North-west-

south-east 98, northeast-south-west 89. An evident cause for the diminished height was the crushed in state of the top of the dome which was flattened and marked as if by human footprints partly filled in by the ant's work. No actual break into the interior remained. A large human footprint on the north-east slope near the top indicated disturbance with the normal surface. The entire mound was frozen stiff, smooth on the surface with some of the small tufts of grass still green about the lower parts of the slopes.

July 20, 1924, after several days clear and dry, in a very rainy season, the ants were very active over the surface of the mound at four to five p. m. Mound in a fine state of repair with four holes near the top on the north and one at the summit nearly, from which ants emerged; other holes concealed by talus except on the base of the north where talus was absent and old holes of egress show plainly, so that the north side seemed inactive and dead in comparison with the very long talus of fresh mouthfuls running far down to the south-east. Grass about eight inches high but not very flourishing made a ring about the bare summit. The moat or bare space about the base of the mound was very conspicuous from dead defoliated honeysuckle and stone or gravel made clean by the ants having removed the earth. Two dead branches projected from south-east part of east side near the base. Measurements as made with the aid of a level and angle, tape and yard-stick were: height, west $19\frac{3}{4}$ inches, east 33 inches, diameter east-west 88 inches, north-south 85 inches, north-west-south-east 96 inches, width of moat: north 12, west 19, south 16, east 14, circumference at base: 22 ft. 6 in., circumference of moat 29 ft. 8 in. Angle of slope: north 35° , but at base 45° where dead and full of holes; south-east, 28° , west 35° , east 35° . Distance by tape up west side: 3 ft. 4 in., up north 3 ft. 4 in., up east 4 ft. 4 in., up south-east 5 ft. 11 in.

The final measurements made at the end of the year 1924, December 20, showed the mound as it then appeared at the height of its recovered maximum, after the previous period of depression but they are not added to the following table since

Dates	MEASUREMENTS							CALCULATIONS					
	Height	W.	E.	Width	N. S.	E. W.	Circumference in inches	Contents cu. ft.	Increment cu. ft.	Duration months.	Increment per month.	Increment per working month.	Increment per working day in cu. in.
1906-7-7	3			9				.012	.012	7	.001	.006	.345
1906-11-13	4-5			15				.151	.139	4	.034	.046	2.699
1907-10-24	6			18				.291	.013	11	.001	.028	1.636
1908-6-12		8	12		18	21		.564	.273	7	.039	.136	7.733
1908-10-18	9			26				.912	.348	4	.087	.087	5.011
1909-12-31									.518	14	.037	.103	5.922
1910-12-31									.444	12	.037	.088	5.068
1911-12-31									.444	12	.037	.088	5.068
1912-12-31									.444	12	.037	.088	5.068
1913-12-31									.444	12	.037	.088	5.068
1914-8-7		12	19		38	42		3.72	.296	8	.037	.095	5.472
1915-9-19		16	24		47	52		7.35	3.63	13	.279	.726	41.817
1916-6-18		16	21		50	53		7.359	.009	9	.001	.004	.230
1917-12-31									.874	18	.048	.006	.345
1918-12-31									.586	12	.048	.009	.518
1919-4-13		15	24		58	54		9.012	.193	4	.048	.193	11.116
1919-10-18		18	28		63	60		13.048	4.036	6	.672	.800	46.08
1920-7-25		18 20	24 30		57	54		10.029	-3.019	9	-.35	-.115	-6.624
1920-9-19		21	28		60	57	192	12.009	1.980	2	.990	.990	57.024
1921-8-21		21	30		76	72	216	20.945	8.936	11	.512	1.789	102.846
1922-7-20		23	30		81	79		25.44	4.495	11	.408	1.124	64.742
1922-9-10		20½	32		87	73	246	25.44	0.000	2	.000	0.000	00.000
1923-7-8		19	29		84	76		23.04	-2.40	10	-.240	-.800	-46.08
1924-1-27		16	27		86	75	242	20.988	-2.042	6	-.340	-1.021	-58.809
1924-7-20		19¾	33		85	88	270	29.813	8.825	6	1.470	2.941	169.401

they so closely agree with those of July, some slight falling off being due to a defect near the north summit caused by human feet. This table shows all the measurements taken in the years 1906-1924 inclusive, as well as some calculations of bulk reckoned on the assumption that the mound may be a conical figure. Graphs have been made to illustrate the main facts of the table. They show that the growth in height and in diameter taken from the measurements of the last part of each year, rises steadily for a few years as two nearly parallel curves and then the height curve becomes more flat and with indented summit while the width curve continues to a much greater height and with no

flattening, yet with depressions and recoveries. In a drawing showing the projections of the circumference of the mound as measured or calculated each year the circles enlarge concentrically and rather uniformly at first and then, in this special case of the mound being erected upon unlevel base, the north-west-south-east diameter elongates and the outlines become more elliptical with the axis shifted to west of north.

The curve of the bulk, as plotted from the calculated bulks at ends of years, shows steady rise for the first years; a depression in 1920 followed by greatly increased acceleration with a second set back in 1923 followed by a sharp rise above all previous heights. All these plotted results show irregularities which suggest complex factors acting upon the growth of the mound. The very slow growth the first years is striking as well as the very rapid growth in some later years correlated with the small numbers of ants in the incipient colony at first and the immense numbers in the old successful community. The ants work but half of the year at most, lying dormant in November to March inclusive.

It is to be emphasized that the growth is very irregular, the only constant numbers in the table are the interpolated figures in the seven years when measurements were not actually made. While some of these irregularities are due to crude measurements many seem to be the results of complex factors and they actually may express the resultant of causes of success or failure in the community. Thus in the years of no progress and of actual diminution, the loss of height is sometimes compensated by increase in width since the materials are spread out laterally in place of being accumulated at the apex; but there is sometimes an actual diminution in bulk. As the interior of the mound is spongy and readily compressed by large animals walking on the mound it sometimes happens that the measured bulk may diminish when the mass is the same or greater. Possibly some storms may actually carry material in some quantities away from the nest so far that it is not soon returned by the ants and thus the mound may be washed away if the ants are not very successful some seasons in combatting this constant denudation. When a mound is deserted it slowly dwindles

through some years but eventually is all washed away. This particular colony of ants had a very difficult soil to deal with and the progress made at first was much behind that reported by McCook in a region of sandy wood soil. Like all loosely piled earth, the nest must suffer shrinking and condensation from settling when this is not actively counteracted by ant work.

During the years that this mound had been forming others were made in the same soil nearby and these had grown to about the same dimensions. Two little mounds were started near the above mound and may well have been colonial offspring from it. As far as measured they have the same very slow rate of starting and are in the same soil. The following table shows these young mounds starting on their long period of trial, at the same cautious pace:

	Nest No. 2	Width	Contents cu. ft.	Material
1921-8-26	4-5	8-10	.054	Subsoil, clay
1922-7-22	3	11	.054	Subsoil, clay
1922-9-10	3	11 x 14	.070	Earth
1923-7-8	4	14 x 14	.117	Earth and sticks
1924-1-27	3	15 x 15	.101	Earth and sticks
1924-7-20	4-5	29 x 17	.421	Subsoil
1924-12-20	5.5	18 x 18	.267	Coarse particles and sticks
	Nest No. 3			
1921-9-9	2	13 x 7	.030	Subsoil, Sandy
1922				
1923-7-8	2	11 x 5	.019	Subsoil, sandy
1924-7-20	6.5	19 x 16	.045	Clay, subsoil, sticks
1924-12-20	6	20 x 18	.328	Very coarse particles and sticks

The rate of growth under the natural conditions prevailing is but slow, yet when injury is done to the mound the repair work and reconstruction results in very rapid new formation. Thus the little mound No. 2 was cut into two with a saw when frozen, January 27, 1924, and the half carried away, yet by the following July the ants had made good the loss and added to the former height, width and bulk as shown in the table. In the same way a full grown or adult mound cut into two when frozen

at the same date and one-half removed for study, was found in July completely regenerated and perfect. The ants can thus accomplish much more work in a given time than they would without the stimulus of destructive injury to the mound.

The actual bulk of the mound at the end of nineteen years of work by the ants of this community is about 30 cu. ft., and was thus accumulated at the average rate of about 2 cu. ft. per year. The table shows the actual slow growth of the first years and the rapid growth of some of the later years. The number of ants is unfortunately not known, but they were very few in the first years and very many indeed in the later years. The nascent community accumulated but few cubic inches per day, the mature colony fifty to one hundred or more. As the single ant is but 1-630 part of a cubic inch the labor done is relatively very great and all the work seemed to be done by individuals without aid of fellows. Such facts led McCook to the estimation that considering the bulk and the speed of construction of the ant mound as compared with the bulk and supposed speed of construction of the pyramids of Egypt, the ant may be much more efficient than man, in fact nearly 700 times as powerful a laborer.

In the building of the mound the first two or three years seem to be exclusively years of mining operations, bringing up the earth from the shafts below ground; but after that period the ants begin to construct the mound from two classes of materials. Not only is the excavation process continued and the removed material added to the pile, but there is more and more bringing in of surface material, both surface soil and bits of organic matter such as sticks, straws, leaves and other light particles. In the early stages of mound growth the cast up mouthfuls of subsoil merely accumulate in a loose pile, but the weather compacts them and a denser mass results within which the ants begin to excavate their tunnels above the natural surface of the ground. Thus mound No. 2 had, when four years old, but few internal tunnels merely suggesting the complex labyrinth of the mature mound.

Incidentally it may be noted that in this region no trees seem to be killed by the ants, though that has been described in New England; but the ants keep the Japanese ivy from growing

over the mound and even climb up and kill branches of this vine and of catbriar that may project over the mound though some feet above its surface.

Summary.

In a mound of *Formica excestoides* measured at intervals during nineteen years the growth was not constant but fluctuating in rate. In the earlier years increase was very slow, in the later years very fast. Interruptions in growth and diminution in proportions may to some extent be referred to external interferences, but probably in part to lack of steady success of the community. Other small incipient mounds start at the same slow rate. Mature mounds require many years for completion to full size.

In the first two or three years the material of the mound is mined from the subsoil, but later more surface soil and collected fragments of vegetable matter are added to the pile.

The rate of growth in reconstruction after injury to, or removal of part of, the mound is much greater than the usual rate of growth. Comparison with other mounds suggests the rate of growth to be strongly an individual character of each community under its own complex environment.



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