

ANALYSES OF BOOKS.

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*The Formation of Vegetable Mould through the Action of Earth-Worms, with Observations on their Habits.* By CHARLES DARWIN, LL.D., F.R.S. London: John Murray.

MANY persons will probably consider the work before us un-Darwinian. It contains, indeed, no reference to the origin or the transformation of organic species, or to the theory with which the name of our great English naturalist will be for ever connected. But it is characteristically Darwinian as summing up the effects of a continually recurrent cause, each of whose manifestations may be feeble, whilst their total result is mighty. The ability thus to trace the working of agencies is one of the most prominent features of the author's mind. Another characteristic of the writer is the patience and perseverance with which, in this as well as in his other researches, his ideas are elaborated and tested prior to final publication. More than forty years ago Mr. Darwin read before the Geological Society a short paper on the formation of the so-called vegetable mould. He referred to the fact that ashes, burnt marl, &c., which have been spread over the surface of meadows, gradually disappear from view, and in the course of a few years may be found in a layer at the depth of some inches beneath the turf. This phenomenon, which farmers often ascribe to some "kind of alacrity in sinking" possessed by bones, marl, lime, and other materials spread upon the land, was traced by the author, at the suggestion of his friend Mr. Wedgwood, to the agency of earth-worms. The theory was opposed by M. d'Archiac, Mr. Fish, and others; but Mr. Darwin has not merely fully proved it by a series of prolonged and careful measurements, in which his sons and several of his friends have taken a part, but he has further shown that these humble creatures are geological agents of no small importance, aiding in the disintegration of rocks, in the denudation of the land, as well as in the preparation of the soil for the growth of plants.

The inquiry necessarily involved a careful examination of the habits, powers, and faculties of the earth-worm. Everyone knows that this little animal lives in tubular burrows in the earth, which it rarely leaves except before evening; that it travels in the night, especially in damp, rainy weather, leaving long tracks in the mud and sand. Everyone must also have noticed their so-called "castings,"—small heaps of earth which they bring up to the surface of lawns, meadows, &c. The worm in making its burrows pushes the soil partly aside, and eats the

rest. All animal and vegetable matter which is in a suitable condition is digested and assimilated, whilst the residue, very finely divided, is ejected in the form of little globular pellets. With this matter they line the walls of their burrows, but much of it they bring to the surface. The weight of each casting is not very great; but in order to estimate rightly what worms can do, we must, following Mr. Darwin, consider their number per acre, and form an idea of their work over a long series of years. Prof. Hensen, in a treatise on the habits of worms, calculates, from the number which he found in a measured plot of land, that there must be upwards of 53,000 worms per acre, or, taking their average weight at 15 grains each, about 356 lbs. Mr. Darwin found in a single cake of earth, of the size of two open hands, seven worm-burrows, of the diameter of goose-quills.

A gentleman, mentioned by Mr. Dancer in the "Proceedings of the Manchester Philosophical Society," having upset some barrels of sour ale on his land, was amazed at the heaps of worms which lay dead on the surface. We have often noticed the multitudes of worms which fall into small water-courses cut in grass-lands for irrigatory purposes. If we also remember to what extent they are devoured by moles, birds, hedgehogs, slugs, and other enemies, without growing scarce, we must admit that their numbers are very great. The weight of the castings found at the mouth of each burrow varies greatly. In the case of our common British worm it is found, by actual collection and weighing, to range from  $\frac{3}{4}$  oz. to close upon 4 ozs. But the author is prepared to give more exact data. A lady friend undertook to collect and preserve for a whole year the total worm-casts thrown up on two separate square yards of ground, near Leith Hill, Surrey. From one of the plots—a place unfavourable for the life of worms—the year's castings, when dry, weighed  $3\frac{1}{2}$  lbs. The other plot gave  $7\frac{1}{4}$  lbs. The former consequently would show  $7\frac{1}{2}$  tons of dry earth per acre, raised to the surface by the activity of worms, whilst in the latter it would reach 16 tons. At the latter rate the deposit, if uniformly spread over the surface of an acre, would measure in the course of a single year 0.1429 inch, or in round numbers nearly  $1\frac{1}{2}$  inches. This quantity is somewhat smaller than the rate at which mould accumulates over objects left on the surface of the ground in a similar time. But Mr. Darwin points out that earth is also raised to the surface by moles, ants, dung-beetles, &c., and that a part of the worm-castings is blown away in dry weather, and washed down in time of rain. Thus we see that in the course of years every particle of the upper soil of a field or garden must have been finely comminuted and passed through the intestines of worms. It is doubtful whether their burrows contribute much to the drainage of the land, as worms generally stop up the opening with leaves, or in default with small stones. But that they admit air, and thus aid in the chemical changes going on in the sub-

soil, there is no doubt. From this point of view it is to be remarked that the contents of the intestines of worms and the castings themselves are always acid. A considerable quantity of dead leaves, &c., are also drawn into the burrows to the depth of 3 to 4 inches, and thus the organic matter in the soil is increased. As regards the acid secreted by worms, or otherwise produced in their systems, we would suggest that it is not improbably the oxalic, a solvent well adapted for effecting the chemical disintegration of many kinds of rocks. Numbers of minute stones are also swallowed, and by the mechanical action of the gizzard and their friction against each other they are in part pulverised.

It will easily be seen that any agency which raises small quantities of earth from beneath to the surface, and deposits them there, must aid in the process known to geologists as denudation. If the surface has a slope, the fine soil thus deposited will gradually be washed down by rains, and must then find its way to the nearest water-course, and ultimately to the sea. In dry weather the castings must be dispersed by the wind, and carried to leeward. Hence the difficulty of believing that "any appreciable quantity of earth can be removed from a gently inclined surface, covered with vegetation and matted with roots," is removed. It may even be suggested that worms play a part in causing large boulders and fragments of rock to travel down gentle declivities. They like the shelter of stones, and by gradually excavating and removing the soil from beneath the margins of the block they may cause it gradually to slide downwards.

It is also by the action of worms that ancient pavements, coins, weapons, &c., left upon the surface of the earth, gradually disappear from view. Mr. Darwin mentions that a footway leading across his lawn, and constructed of flagstones set edgewise, had become covered with an inch of mould between the years 1843 and 1877.

The interesting account of the habits of the earth-worm can be but very briefly noticed. From careful observations and experiments it appears that worms do not possess eyes, but can nevertheless distinguish light from darkness. If brightly illuminated they withdraw, not by a reflex action, but voluntarily. They have no power of hearing, but are very sensitive to vibrations and to changes of temperature. They appear to possess the senses of smell and taste, though very imperfectly developed. Though omnivorous, and even given to cannibalism, they prefer some kinds of food to others. From the experiments of Mr. Darwin, on the manner in which they drag into their burrows leaves of different shapes, they may even be considered as not entirely without intelligence.

We must here close our survey of this work, with which naturalists will do well to make themselves acquainted, both for the facts which it makes known and as a model how researches of this nature ought to be conducted.