

THE FORMATION OF VEGETABLE MOULD, THROUGH THE ACTION OF WORMS, WITH OBSERVATIONS ON THEIR HABITS. By Charles Darwin, LL.D., F.R.S. London: John Murray.

To the naturalist, nothing that lives or that ever has lived is "common or unclean," the study of the lowest organisms being as fitted as that of the highest to throw light upon the problems of life. This valuation of the lowly has been largely due to the labours of Charles Darwin, and to the wide acceptance of that doctrine which would unite all life by the ties of kinship. It is not alone by his theory of what they are that these veteran naturalists have given dignity to the lowliest creatures; he has further contributed to the same end by his accounts of what they do. In an early work he thus showed how the formation of coral reefs and islands was mainly due to the labours of individually insignificant zoophytes; and now in his latest work he seeks to prove that the despised earth worm has played and is playing an equally important part in the history of the world. The part played he believes to be that of Nature's ploughman. "The plough," he says, "is one of the most ancient and most valuable of man's inventions; but long before he existed the land was in fact regularly ploughed, and still continues to be thus ploughed, by earthworms." The entire mass of so-called vegetable mould covering the earth's surface passes, he says, every few years through the bodies of worms, and is thus exposed to the air, sifted of all stones, and even manured. Worms are, further, the sakers of the world, and as this material is being continually wasted away by rains, were the loss not made good by the unremitting labours of these subterranean workers, the vegetable mould would in time disappear, and plant growth become impossible. The work thus said to be accomplished by earthworms seems at first sight stupendous in view of the insignificance of the individual workers; the evidence led by Mr Darwin in favour of his conclusion is, however, overwhelming, and affords a further proof, if such were needed, of the vast results flowing from the accumulated effects of small agencies. Few people are aware of the vast numbers of worms that live beneath their feet; but it has been calculated, and the author thinks it credible, that they abound, in garden ground at least, to the number of 53,767 per acre.

Little is popularly known regarding the habits of earthworms, and Mr Darwin devotes two chapters to this subject, giving in these the results, for the most part, of his own observations. Earthworms are nocturnal animals, coming out of their holes at night and wandering about in search of food, which may either consist of animal or vegetable matters. They are quite deaf and have no eyes, yet they can distinguish light from darkness, for if a strong light be suddenly turned upon them they dart into their burrows like rabbits. Should they, however, be busily engaged at the time collecting or devouring food, they disregard the light. This obliviousness to one set of impressions during the predominance of another, when it occurs among the higher animals, is usually attributed to their attention being absorbed, and Mr Darwin is inclined to regard it as evidence of the same in worms, although attention implies the presence of a mind. It might have been supposed that a chapter on the intelligence of worms would have resembled the famous one on the snakes of Iceland in disposing of the subject in the single sentence, "Worms have no intelligence." Much of Mr Darwin's success as a naturalist, however, is due to the power he possesses of disabbing his mind of preconceived ideas, and of being simply content to look and learn. This he has done in the case of worms, and as the result of his observations, he thinks "we can hardly escape from the conclusion that worms show some degree of intelligence." Evidence of this he finds in their manner of plugging up their burrows. The worm makes its burrow by pushing aside the earth in all directions, and when the soil is too compact to be thus dealt with, by swallowing it. Their burrows sometimes reach to a depth of over six feet, and throughout their course they are lined with a layer of viscid earth voided by the worms themselves, while the deeper burrows generally terminate in a chamber, the bottom of which is frequently lined with small stones or tiny seeds. In this

chamber the worm has coiled up in a dormant state during winter. It likewise lines the upper part of its burrow with leaves, and here it lies motionless, with its head near the surface, during the day—a habit which leads to its destruction in great numbers by thrushes and blackbirds. One of the strongest instincts of worms is that which leads them to plug up the mouths of their burrows with leaves, and, in default of those, with twigs and other small objects. If man had the filling up of a small cylindrical hole with such objects as leaves, he would probably drag or push them in by their pointed ends, as being the easiest method. Intelligence in his case would be the guide. Mr Darwin therefore thought it worth while "to observe carefully how earthworms dragged leaves into their burrows—whether by their tips or bases, or middle parts." If they acted in this matter solely through instinct, they would, he argued, draw all kinds of leaves into their burrows in the same manner. If, on the other hand, they had no definite instinct, chance might be expected to determine their mode of action. "If both these alternatives are excluded," he says, "intelligence alone is left, unless the worm in each case first tries many different methods and follows that alone which proves possible, or the most easy; but to act in this manner and to try different methods makes a near approach to intelligence." As the result of numerous experiments made with leaves and with triangles of paper, he found that the part of the leaf seized upon was not a matter of chance, but that in the great majority of cases the worm dragged the leaf into its burrow by that part which offered least resistance to its entrance. This in most cases was the apex, but he also found that they made use of the foot-stalk whenever that end offered the most convenient means for attaining their purpose. He further adduces evidence to show that worms do not habitually try to draw objects into their burrows in many different ways. "One alternative alone," he says, "is left—namely, that worms, although standing low in the scale of organization, possess some degree of intelligence. This will strike every one as very improbable; but it may be doubted whether we know enough about the nervous system of the lower animals to justify our natural distrust of such a conclusion. With respect to the small size of the cerebral ganglia, we should remember what a mass of inherited knowledge, with some power of adapting means to an end, is crowded into the minute brain of a worker ant."

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emptying their bodies, form those "castings" with which every one is familiar. The effect on the superficial mould of the earth's surface of this alternate filling and emptying of the bodies of earthworms, forms the main topic of the present work. In order to discover how much mould is thus annually brought to the surface from beneath, Mr Darwin adopted the simple but effectual method of collecting the year's castings from a square yard of soil in two different localities, when he found that the one yielded 7½ tons weight per acre, and the other 16 tons. Were the latter spread equally over an acre of ground it would form in ten years a layer 1½ inch in thickness. Of the fact that such layers are being formed wherever the earthworm is at work the author supplies the most conclusive evidence. He relates numerous cases that have come under his own observation during the past fifty years of fields which have had a layer of cinders, marl, or chalk laid upon them, and how after the lapse of a few years these have all got buried to varying depths beneath the accumulation of vegetable mould heaped over them by earthworms. "A quantity of broken chalk," he says, "was spread on December 23, 1842, over a part of a field near my house, which had existed as pasture certainly for thirty years. The chalk was laid on the land for the sake of observing at some future period to what depth it would become buried. At the end of November 1871—that is, after an interval of twenty-nine years—a trench was dug across this part of the field, and a line of white nodules could be traced on both sides of the trench, at a depth of seven inches from the surface. The chalk had thus had an additional inch of mould placed over it in the course of every

four years. This disappearance of stones from the surface of pasture land is well known to farmers, but it is explained by them on the theory that the stones work themselves down! In this turning over the soil the worm performs a subsidiary service to man in preserving valuable relics of the past; and the archaeologist can scarcely read the chapter dealing with the part which worms have played in the burial of ancient cities without feeling that the earthworm has been his most valuable ally. Prehistoric remains, ancient coins, the relics of former battles, have thus been preserved to a time when their value in elucidating the history of the past is fully recognized. The fossilized pavements and the remains of Roman villas, and the sites of ancient Roman cities that have from time to time been discovered in Britain have been buried, and so preserved to us, by the action of earthworms. Mr Darwin or his sons have personally examined most of these sites, and have obtained abundant evidence of the fact. They found these penny workings as busy as ever throbbing on their earth works, and if these now swept and garnished pavements were only let alone for a few years, the "castings" thrown up between the fissures would soon oust them to a second oblivion. The work of burial was also found to be hastened in the case of large stones by the undermining of the earth beneath them by worms, and their consequent gradual sinking. The land surface, as every one knows, is being slowly wasted away through the action of atmospheric and other causes, and its materials deposited on the floor of the ocean. As worms bring to the surface fine mould which is readily washed away by rain, it might safely be inferred that those creatures play a part, however humble, in the denudation of the land. Mr Darwin, however, is not content with inferences, and he has therefore made exact observations of the weight of ejected earth which is thus borne along the surface seawards in a given time, with the result of establishing the worm as an important denudating agent. It is this substitution of quantitative results in place of mere inferences as to the action of worms on the vegetable mould of the earth's surface that forms the special feature of this research. The present work shows no diminution in these remarkable features of observation, and of generalization in the skillful marshalling of facts and clearness of statement, which have raised Mr Darwin to the foremost place among living biologists.

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