Science.

Darwin on the Action of Worms.*

Mr. Darwin's little volume on the habits and instincts of earth-worms is no less marked than the earlier or more elaborate efforts of his genius by freshness of observation, unfailing power of interpreting and correlating facts, and logical vigour in generalising upon them. The width of his sympathies with nature is not bounded by the limits which conventional taste or inherited prejudice too often assigns to the study of natural objects. It is not because such and such forms of life are rare or beautiful, complex or exotic, that they kindle his enthusiasm or keep his attention on the stretch by day and night. None has proved too humble or too repulsive in popular estimate to awaken his interest and concentrate his powers of observation. In the economy of life nothing is common or unclean to one who has learnt to view nature as a whole—various in function, but uniform in structure and design. In what is popularly thought the lowest grade of life it may be shown that there is a use, an adaptation to ends, and a resulting beauty which may reverse the verdict of vulgar prejudice. Animals even more lowly organised than the worm—namely, corals—have built up reefs, islands, and continents from the bed of the ocean, as Mr. Darwin was the first adequately to recognise and to explain. He now comes before us to do justice to an order of toilers far more despised, and even cast out as evil. In point of structure the worm, as he shows us, presents an interesting object of study. In its intelligence it holds no mean rank among living creatures, and in its labours are involved results which it behoves us to look upon with wonder and gratitude. The main purpose of Mr. Darwin's work is to point out the share which worms have taken in the formation of the layer of vegetable mould which covers the whole surface of the land in every moderately humid country. Though it may rest upon various subsoils, and differs but little in its general aspect—being for the most part blackish in colour and having but a few inches of thickness—one of its chief characteristics is the fineness of the particles of which this mould is composed, and this is to be seen whenever a field long undisturbed is freshly turned up by the plough. Now, although of the highest antiquity, viewed as a whole, yet, as regards permanence, the component particles of this superficial structure of earth have been all along in process of removal at a rate by no means tardy, being replaced by others due to the disintegration of the underlying materials. Nature's ploughman, the earthworm, has been for ages at his humble but beneficent work.

The anatomical structure of this wide-spread, familiar, yet rarely scrutinised order of annelids, shows the adaptation of the worm to its life-long task of burrowing. The lissom body is made up of from 100 to 200 almost cylindrical rings or segments, each furnished with minute bristles. Having a well-developed muscular system, worms can, by contact with the surrounding earth, crawl or work themselves backwards as well as forwards, and by the aid of their affixed tails can retreat with extraordinary rapidity into their burrows. At the anterior end of the body is seen the mouth, provided with a slight projection known as the lobe or lip, which is used for prehension. Internally behind the mouth there is a strong pharynx, which is pushed forward when the animal eats, corresponding, according to Perrier, with the protudable corresponding, according to Perrier, with the protudable trunk or proboscis of other annelids. The pharynx leads into the œsophagus, which has on each side of the lower part three pairs of large glands capable of secreting a surprising quantity of carbonate of lime. Nothing corresponding to these calciferous glands is known in any other animal. The œsophagus is enlarged in most species into a crop, behind which comes the gizzard, lined with a smooth, thick, chitinous membrane, and surrounded by muscles, weak lengthways, but powerful transversely. By the action of these muscles the food must be triturated, since the worm possesses no jaws or teeth of any kind. In the gizzard and intestines are to be found grains of sand and small stones from 0·1 to 0·05 inch in diameter, which serve, as is the case with fowls, like millstones for the trituration of food. From the gizzard the intestine runs in a straight course to the vent at the posterior end of the body, presenting the remarkable structure of the typhosolis, known to the old anatomists as *an intestine within the intestine*, consisting, as Claparède has shown, of a deep longitudinal involution of the walls of that organ, by means of which an extensive absorbent surface is gained. Worms breathe through their skin, having no special respiratory organs. Both the circulatory and nervous systems are well developed, and close to the anterior end of the body lie the two almost confluent cerebral ganglia. Although wholly without eyes, it has been found by Hoffmeister and other observers that worms are in general highly sensitive to light, and Mr. Darwin's experiments have strongly confirmed him in this view. The colour of light made no apparent difference, nor were the worms much affected by a sudden or moderate light, the effect being in proportion to its intensity and duration. It is only the anterior extremity of the body, the seat of the cerebral ganglia, which seems affected by it: no effect being produced, though the rest of the body be illuminated, if only this part is shaded. It is through the skin that we must suppose the light to pass and excite the cerebral ganglia; but by no particular difference in the transparency of the skin or in the incidence of the light could Mr. Darwin account for the various ways in which the worms were affected on different occasions. Their action in dashing rabbit-like into their burrows when suddenly illuminated might be looked upon as simply reflex or automatic, the irritation of the cerebral ganglia causing certain muscles to contract independently of the will or consciousness of the animal; but the insensibility of the worm on occasions when its attention seems absorbed in work would point to the possession of a mind comparable in kind, if not in degree, to that of animals higher in the scale of intelligence. Their sensitiveness to light certainly suffices for them to distinguish between day and night, enabling them to choose the night hours for burrowing to the surface, thus escaping many a danger from the diurnal animals that prey upon worms. They appear less sensitive to moderate radiant heat, judging from the effect of a poker heated to dull redness; but a low temperature immediately tells upon them, as may be inferred from their retiring into their burrows during frost. That they equally withdraw during heat may be more directly traceable to the effect of drought, humidity being the first condition of the worm's active work. They show not the slightest sense of hearing, yet are sensitive to vibrations in solid bodies, remaining perfectly unmoved when placed in their pots within a short distance while both high and low notes were loudly struck upon the piano, but rapidly burying themselves when the pots were set upon the vibrating frame of the instrument, or where sharply struck. The least current of air, as of the breath, shows how sensitive the worm's whole body is to contact.

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Carefully watching their habits by night and day, Mr. Darwin has set down a number of interesting particulars as to the way in which worms discriminate and seize their food, excavate their burrows, line and plug them with leaves, or pave them with little stones or seeds. Their instinct is shown in the way they grasp a leaf by its tip rather than by the base or foot-stalk, even in the case of exotic plants, of which neither they nor their progenitors could know anything. Small triangles of paper were found to act similarly as tests of intelligence, 62 per cent. being drawn in by the apex—which independent trials proved to be the way of least resistance—15 per cent. by the middle, and 23 per cent. by the base. When kept in a warm room they were found to work more carelessly, dropping or loosely dragging the triangles—a sad proof of demoralization. The rate at which worms burrow is too various to be easily reduced to measure, some burying themselves in a pot of loose mould in two or three minutes, others taking 15 or 40 minutes, without apparently swallowing any earth, whilst a large worm was 25 hours 40 minutes in burying itself in ferruginous sand, swallowing and evicting large quantities of it. That worms swallow earth more for the sake of nutriment than of making their burrows, though doubted by so high an authority as Claparède, Mr. Darwin considers to be proved by the analysis of castings. A tower-like casting from Nice, photographed life-size, 3½ inches high, voided probably by a species of Parichæta, hollow in the middle, through which the worm must have ascended to eject the earth it had swallowed, showed no signs of a leaf having been drawn in, the organic matter in the earth itself having supplied all necessary food. Similar results were obtained from castings from the Botanic Garden, Calcutta, and from the Nilgiris, one weighing over a quarter of a pound, the worms measuring 12 or 15 inches in length, and in thickness a man's little finger. With slight generic differences, worms are found at work over nearly all parts of the world alike, in Iceland and Tahiti, in the West Indies and New Caledonia, even in islands isolated and barren as Kerguelen Land, where not even a land bird is to be seen.

The interest of Mr. Darwin's researches culminates in the estimate he proceeds to make of the amount of work brought about by the continual labour of earth-worms, and the effects thereby produced upon the surface of the soil. From careful measurements of the weight of earth ejected from a single burrow and from a number of burrows within a given space, he has come to results which strikingly show the important part played by these seemingly insignificant agents in the economy of nature. In a field near Nice the castings within one square foot of surface were found to weigh 12oz. a year, equivalent to 14·58 tons per acre. Upon a chalk down in Kent 83·87lb. were accumulated in a square yard, equal to 18·12 tons per acre. Near Leith Hill, Surrey, the yield was calculated at 7·56 tons annually on one piece of land, and 16·1 tons on another. If uniformly spread out over the surface, the ejected castings would amount, Mr. Darwin estimates from a number of instances, to a thickness of about 1¼ inches in 10 years. The number of worms to be met with in an acre of garden land has been estimated by Hensen at 53,767; but, taking half this amount as the yield of average land, it may be inferred that each worm ejects some 20oz. a year in about the same number of castings. Considering that many a burrow extends to three, four, or even five feet in depth, it is easy to conceive the amount of change perpetually going on in the distribution of subsoil, fresh and virgin mould being brought up by these untiring miners to renew and fertilise the upper earth. At the same time they carry on the process of burying objects resting on the surface—stones, bricks, and other *débris* sinking to all appearance with the lapse of time :

burying objects resting on the surface—stones, bricks, and other *débris* sinking to all appearance with the lapse of time; the fact being that the worm-casts are heaped up alongside and over them till they become entirely hidden from view. Instances are given of great stones, the apparent sinking of which has been measured. One which had lain in a grass field for 35 years had been buried to the extent of 1½ inch below the original surface, another larger stone about 2 inches, the mould rising to several inches higher against the sides of the stone from the fact of the worms working under it having to eject their castings clear of the under surface, and thus piling them to a height above the average level. A sloping field near Mr. Darwin's house had been so thickly covered with flints great and small as to be called "the stony field." As his sons ran down the field the stones clattered together. In 30 years they had been so thoroughly buried that a horse could gallop from one end of the field to another and not strike with his shoes a single stone. A flagged path was similarly covered up in about the same space of time. A layer of coal ashes strewn upon the surface was found in a distinctly marked line, within 18 years, 7 inches under the soil.

Still more curious are the results indicated by remains of ancient buildings. The floors and walls of Roman villas at Abinger, Chedworth, Silchester, and Brading, penetrated and buried by worm casts, form an excellent index to the rate of accumulation. Pavements have been lowered by the gradual withdrawal of the underlying soil. At Silchester the centre tesseræ are found 5¾ inches below the line where those at the sides of the apartments join the wall, being thereby kept from subsiding. The ponderous trilithons of Stonehenge have undergone for ages the process of slow interment by the accumulation of mould around them, at the same time that they are in danger of tottering and falling from being undermined by these tiny assailants. On the other hand, we are often indebted to them for the preservation of coins, weapons and ornaments of metal and stone, and relics of all kinds. Archæologists are reminded by Mr. Darwin of what they owe to the despised earthworm. The agriculturist, the lover of the picturesque, the economical philosopher, the practical statesman, may join in grateful acknowledgment of services which have so largely helped to clothe the earth with richness and beauty. All lovers of nature, we may add, will unite in thanking Mr. Darwin for the new and interesting light he has thrown upon a subject so long overlooked, yet so full of interest and instruction, as the structure and the labours of the earth-worm.