Charles Darwin and earthworms

from Clive A. Edwards

CHARLES DARWIN is most famous for his work on evolution and his controversial book *'The Origin of Species'*. Much less familiar is another book *'The Formation of Vegetable Mould through the Action of Worms'* (Murray) which appeared in 1881, the year before his death, and sold many copies. Correspondence concerning the book, preserved in Cambridge, has been reviewed by Otto Graff (Brauschweig, FRG) and shows that it was the culmination of more than 40 years of observations first inspired by Darwin's uncle Josiah Wedgwood. The book demonstrated for the first time the importance of earthworms in the breakdown of organic matter and in maintaining soil fertility, a conclusion very much at odds with the opinion of many of Darwin's contemporaries, who believed that earthworms were harmful to plants and produced a considerable literature describing methods of killing them.

The publication of Darwin's book in October 1881 was recently celebrated at an International Centennial Symposium*. Darwin's belief in the beneficial influences of earthworms stated so clearly 100 years ago was strongly supported by many of the contributions.

For example, it was shown that the production of grass in New Zealand, which is extremely important to sheep farming, could be influenced greatly by earthworm activity. New Zealand does not have native lumbricid earthworms, and experimental inoculation of earthworms of the species *Allolobophora caliginosa* has greatly increased yields of grass over that in pastures with no earthworms. Work by S. Stockdill (Department of Agriculture, New Zealand), J. Syers (Massey University) and J. Springett (Ministry of Agriculture and Fisheries, New Zealand) has shown that the well defined, undecomposed mat of organic matter at the base of the grass breaks down when earthworms are introduced and the available nutrients that are released greatly promote grass growth.

Many workers have claimed that when earthworms are inoculated into cultivated soils with poor natural populations, the growth of plants is increased. This role of earthworms has been shown to be much more important when crops are sown into soil after the use of a herbicide and with no mechanical cultivation (direct drilling). Workers at Rothamsted Experimental Station, UK have established that inoculating earthworms into soils that have been direct drilled for long periods, increases considerably the growth of roots and yield of crops. This was shown to be due to the provision of deep channels for root growth, lined with more available mineral nutrients than the surrounding soil. An earthworm management programme for direct drilled soils proposed by Rothamsted workers involves minimal ancillary cultivations, no straw burning, avoidance of harmful pesticides and addition of large doses of organic matter to soil.

The importance of earthworms in land reclamation was discussed by J.F. Curry and D.C.F. Cotton (University College, Dublin). There is a need for land reclamation after industrial activities such as strip mining and land fill, after inundation by the sea and after peat has been harvested from peat bogs. In all these situations, there is a gradual natural invasion by earthworms after the reclamation process begins, and there is little doubt that the worms have an important role in re-establishing soil structure. Earthworm activity can be promoted and reclamation accelerated by inoculation of earthworms, making soil conditions more favourable for them and by adding large amounts of suitable organic matter such as municipal sludge or animal wastes.

Few people consider earthworms to be a marketable commodity; but the large international traffic in earthworms was reviewed by A.D. Tomlin (Canada Agriculture, London, Ontario). He quoted figures that showed the retail value of earthworms exported from Canada to the US for fishing bait in 1980 was as much as 54 million Canadian dollars, and in addition large quantities were exported to

*The International Darwin Centenary Symposium on Earthworm Ecology was held at Grange-over-Sands, Cumbria (August 29 to September 4 1981) and attended by 142 scientists from 28 countries. The proceedings will be published by Chapman and Hall, London and in the journal *'Pedobiologia'*.

Clive A. Edwards is in the Entomology Department at Rothamsted Experimental Station, Harpenden, Hertfordshire.

100 years ago

MR. DARWIN ON THE WORK OF WORMS

If the world were not already accustomed to the unprecedented fertility of Mr. Darwin's genius, it might well be disposed to marvel at the appearance of yet another work, now added to the magnificent array of those which bear his name. But feelings of wonder at Mr. Darwin's activity have long ago been sated, and most of us have grown to regard his powers of research as belonging to a class *sui generis*, to which the ordinary measures of working capacity do not apply.

One of the most interesting chapters deals with the habit of dragging down leaves, &c., into the burrows; for here the experiments elicited some very remarkable evidence of action which is apparently intelligent.

Mr. Darwin "observed carefully how worms dragged leaves into their burrows whether by their tips or bases or middle parts. It seemed more especially desirable to do this in the case of plants not natives to our country; for although the habit of dragging leaves into their burrows is undoubtedly instinctive with worms, yet instinct could not tell them how to act in the case of leaves about which their progenitors knew nothing. If, moreover, worms acted solely through instinct or an unvarying inherited impulse, they would draw all kinds of leaves into their burrows in the same manner. If they have no such definite instinct, we might expect that chance would determine whether the tip, base or middle was seized. If both these alternatives are excluded, 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".

A large number of experiments were therefore tried with leaves of various shapes, and both of endemic and exotic species. The results showed unequivocally that the part of the leaf which the worm seized for the purpose of dragging the whole into the burrow was not a matter of chance, but in an overwhelming majority of cases that part of a leaf was seized by the dragging of which the leaf would offer least resistance to being drawn into the burrow. Thus, for instance, "the basal margin of the blade in many kinds of leaves forms a large angle with the foot-stalk; and if such a leaf were drawn in by the foot-stalk, the basal margin would come abruptly into contact with the ground on each side of the burrow, and would render the drawing in of the leaf very difficult. Nevertheless worms break through their habit of avoiding the foot-stalk, if this part offers them the most convenient means for drawing leaves into their burrows".

To test the hypothesis of chance, elongated triangles were cut out of paper and given to the worms instead of leaves. Here "it might certainly have been expected, supposing that worms seized hold of the triangles by chance, that a considerably larger proportion would have been dragged in by the basal than by the apical part"; while, inasmuch as the latter was in a literal sense the thin end of the wedge, it was the part which intelligent action would be most likely to choose. The results of many experiments with these paper triangles showed that "nearly three times as many were drawn in by the apex as by the base. . . . We may therefore conclude that the manner in which the triangles are drawn into the burrows is not a matter of chance, . . . and we may infer — improbable as is the inference — that worms are able by some means to judge which is the best end by which to draw triangles of paper into their burrows".

On the question of defining such action as intelligent or non-intelligent, Mr. Darwin refers to the criterion "that we can safely infer intelligence only when we see an individual profiting by its own individual experience"; and he adds that "if worms are able to judge, either before or after having drawn an object close to the mouths of their burrows, how best to drag it in, they must acquire some notion of its general shape", and thus guide their actions by the result of individual experience.

Assuredly these observations are most interesting, and it would seem well worth while to try whether, by a series of lessons with similar triangles of paper, an individual worm could be taught to lay hold of the apex in a greater and greater proportional number of cases; if so, there could no longer be any question as to the intelligent nature of the action.

GEORGE G. ROMANES

From *Nature* **24**, 13 October, 553, 1881.

0028-0836/81/410429-02$01.00