

THE REACTIONS OF EARTHWORMS TO DRY AND TO MOIST SURFACES

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The certainty with which an earthworm that is creeping over a partly moistened surface will avoid dry areas is well known to students of animal activities. It is the object of this paper to discuss briefly the character of this response, the location of the receptors concerned in it, and the nature of the stimulus. The work was carried out on the common dungworm, *Allolobophora foetida* (Sav.), but there is reason to believe that the results obtained apply equally well to most species of earth-worms.

If a normal worm is allowed to creep over a horizontal sheet of filter paper that is wet with tapwater excepting for a few spots and if it is directed by some such stimulus as light toward one of these dry spots, on reaching the spot, it will usually continue to creep over the dry surface for a distance varying from a few segments to half its length, stop, swing its head from side to side, then draw the anterior part of its body back to the moist region, and finally proceed to crawl in a new direction over the moist part of the paper. Of seventy worms put to this test only four failed to show the series of reactions just described. These four crept completely across an extensive dry area without showing the characteristic reaction, but a few days later three of these worms responded in a normal way, showing that their previous atypical condition was probably due to some unusual and temporary state. It is, therefore, fair to conclude that *Allolobophora* as a rule avoids dry areas.

To ascertain the part of the worm that is stimulated by a dry surface, several kinds of experiments were tried. To test the sensibility of the posterior end of the worm, individuals were made to creep backward by touching their anterior ends slightly

and, when thus creeping, were directed toward a dry surface. Thirteen worms tested in this way made considerable backward excursions over such surfaces showing, as was to have been expected, that the posterior end of the worm is not especially sensitive to dryness. Next, forty-five worms, all of which had been found to respond normally to a dry surface, were deprived of their prostomiums and in some instances of an adjacent segment or two, and were shortly afterwards tested on filter paper. All crept freely over a dry surface without showing the lateral movements and the retraction of the head characteristic of normal worms. The regeneration of the prostomium takes place in from one to two weeks according to the extent of the injury. This regeneration was found to restore to the worm its original sensitiveness to dry surfaces and enabled it to react again in a typical fashion. There is, therefore, every reason to believe that the region of the prostomium is the portion of the worm that is stimulated by dryness.

The terminal surface left after the removal of the prostomium offers more or less of an obstacle to the ordinary locomotor movements of the worm and to avoid this feature in the experiments, supplementary tests were made in which the prostomium, instead of being removed, was anaesthetized. After some preliminary trials, three anaesthetics satisfactory for this purpose were found; they were a weak solution of chlorotone, a 35 per cent solution of magnesium sulphate, and a 1 per cent solution of ether, all aqueous. If the anterior tip of a worm is bathed with one of these solutions for from one to five minutes, the prostomium is found to remain insensitive to a dry surface for one or more days. Such anaesthetized worms will creep persistently over a surface of dry filter paper on which, before anaesthetization, they could not be induced to advance more than a very short distance. Full recovery from the effects of the anaesthetic occurs in a day or two. It is, therefore, clear from this evidence also that the prostomium and possibly some of the adjacent parts of the worm are the receptive surfaces for this response.

It might be supposed that the greater harshness of dry filter paper as contrasted with moist filter paper, instead of the simple

absence of water, was the significant factor in these reactions, but such is not the case, for, if worms are allowed to creep on surfaces that remain equally rough whether they are wet or dry, the same reactions are observed as in the tests in which filter paper was used. Such surfaces as those of bricks, tiles, etc., present these conditions. In trials with the moist and dry surfaces of bricks results similar to those got on filter paper were obtained. Moreover worms drew back from a *dry smooth* brick to creep on a *wet rough* one, and from a *dry rough* brick to creep on a *wet smooth* one, showing that the presence or absence of moisture, and not roughness or smoothness were the significant elements in these reactions.

From these observations, it is quite evident that the prostomial region of an earthworm can be stimulated by dryness to such an extent as to call forth vigorous locomotor responses of a characteristic kind. A moist surface seems to be unstimulating and to afford merely a condition favorable for the locomotion of the animal. In this respect the earthworm is the reciprocal of the human being, for our skin is more receptive to the condition of wetness than to that of dryness. With us, however, the sensation of wetness is produced in all probability by a complex of pressure and temperature stimuli, whereas in the earthworm the response to dryness is dependent very likely upon a simpler stimulus. This is apparently the selective extraction of water from the peripheral protoplasm of the worm, a process which is favored by the capillarity of the dry surface over which the worm begins to creep and is probably dependent chiefly upon evaporation from the surface of the worm itself. Under such circumstances the materials in the peripheral protoplasm of the prostomium must become concentrated and probably initiate stimulation by undergoing some such change as partial coagulation. Processes of this kind are not well exemplified in the outer skin of man, but are more nearly comparable with what occur in our mouths when by excessive evaporation the oral surfaces become somewhat dry.