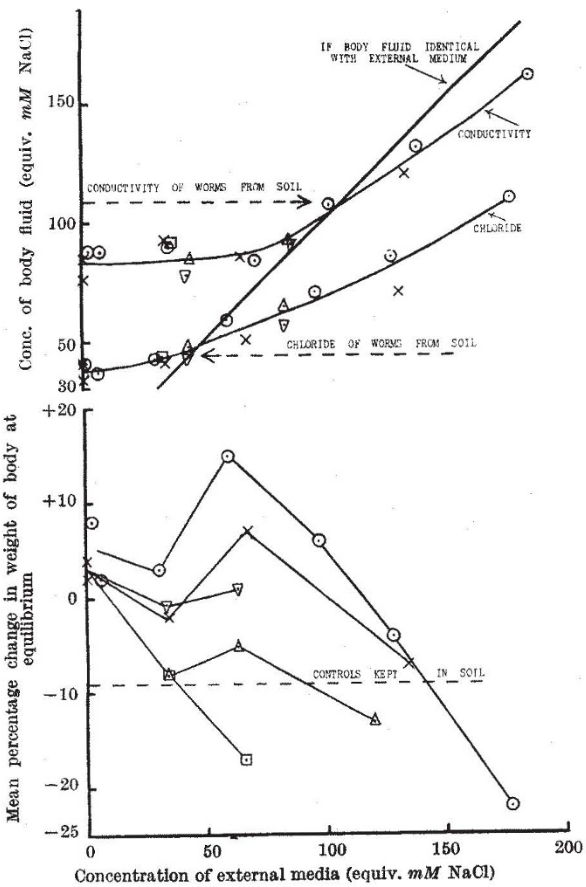
Concentration Regulation and Volume Control in *Lumbricus terrestris* L.

PREVIOUS work on these topics (Adolph and Adolph[1], Adolph[2], Maluf[3], Wolf[4], Maluf[5], Wolf[6]) has assumed that the earthworm is a freshwater animal, and that volume changes are inversely proportional to changes in the concentration of the body fluids. Soil analyses (Russell[7]) show that the osmotic pressure of soil is higher than the above workers have assumed. Moreover, in the case of another annelid, *Nereis diversicolor*, Beadle[8] has shown that the body volume can remain constant while the body fluid is diluted. Both assumptions may therefore prove unsound.

Earthworms were kept in filter paper moistened with saline solutions, and the concentration of the body fluid was determined. The body fluid used for each determination consisted of a mixture of the cœlomic fluid and blood of four worms. This was analysed for chloride, and the conductivity of a warmed diluted sample was measured. Changes in weight were also followed, the worms being weighed in air after gentle rolling on filter paper. Equilibrium body fluid concentrations are given in the upper graph, and equilibrium changes in weight in the lower graph.

The upper graph shows that the animal possesses well-developed powers of concentration regulation, which are equally effective in media of widely different cation compositions. It can maintain a hypertonic body fluid in 'dilute' media, and a hypotonic body fluid in 'concentrated' media. Few animals so far investigated are able to maintain hypotonic body fluids, and in each case it has been supposed that they have evolved from fresh water (see Beadle[9]). It is possible to argue in a similar manner that *Lumbricus* has evolved from a freshwater to a semi-terrestrial habitat. The earthworm is certainly no longer a freshwater animal in so far as its osmotic relationships with the environment are concerned.

The lower graph shows that body weight (that is, body volume) depends on the nature and concentration of the medium. Comparison with the other graph shows that in many media, volumes and concentrations both increase. Volume control and concentration regulation are apparently not intimately correlated, at least under the present experimental conditions. Almost all the previous work is based upon an inverse relationship between concentrations and volumes, and therefore some revision of past conclusions may be necessary.



○, Sea-water dilutions; ×, sol. of sodium chloride; □, sol. of potassium chloride; △, sol. of calcium chloride; ▽, sol. of magnesium chloride.

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[1] *J. Exp. Zool.*, **43**, 105 (1925).
[2] *J. Exp. Zool.*, **47**, 31 (1927).
[3] *Zool. Jahrb.*, **59**, 535 (1939).
[4] *Anat. Rec.*, **75** (suppl.), 139 (1939).
[5] *J. Cell. Comp. Physiol.*, **16**, 175 (1940).
[6] *Physiol. Zool.*, **13**, 294 (1940).
[7] "Soil Conditions and Plant Growth" (7th edit., 1937); see p. 532.
[8] *J. Exp. Biol.*, **14**, 56 (1937).
[9] *Biol. Rev.*, **18**, 172 (1943).

Pigmentation of Orthoptera

THE wings and skin of the green *Mantis religiosa* L. contain not a green but a yellow and a blue pigment. The yellow pigment is of a carotenoid character, soluble in alcohol, ether, chloroform, acetone, benzene, etc. It is insoluble in water. The parts treated with the ether leave their blue pigment in the water. This pigment is precipitated from the aqueous solution by ammonium sulphate to saturation. It is very probably a chromo-protein (*ortho*pterocyane). It is immediately decomposed by a few drops of cold concentrated acetic acid.

The blue colouring matter (*ortho*pterocyanobiline) passes into chloroform, ethyl acetate or amylic alcohol. These solutions give the Gmelin reaction of biliary pigments (violet rings, then green) with strong nitric acid. The aqueous solutions show a strong biuret reaction.

The phytophagous Orthoptera, such as *Acrida turrita* L. and *Phaneroptera quadripunctata*, have the yellow and blue components, while in the hind wings of *Oedipoda caerulescens* and *Oed. schochii* there is only water-soluble pigment.

The green hæmolymph also contains the blue and yellow components. A green drop, absorbed by filter paper, turns blue in an organic solvent. A blue drop is in turn dissolved in water.

The bright red hind wings of *Oedipoda miniata* Pall., as well as an orange-yellow carotenoid, contain also a red pigment soluble in water. It is probably a chromo-protein (*ortho*pteroerythrine). It is decomposed by acetic acid, like the blue pigment. The red colouring matter (*ortho*pteroerythrobiline) gives the Gmelin reaction, while the aqueous solution shows a strong biuret reaction.

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