Bulinus (Pyrgophysa) forskalii (Ehrenberg) as a Vector of *Schistosoma haematobium*

In a recent communication, McCullough[1] stated that although the snail *Bulinus (Pyrgophysa) forskalii* was known to be a vector of urinary bilharzia in the Gambia and in Mauritius, there was no direct evidence that it acted in a similar capacity in the Gold Coast; moreover, snails of that species collected in the Gold Coast were wholly resistant to experimental attempts to infect them with the miracidia of the causative organism, *Schistosoma haematobium*.

It seems appropriate to try to throw light on some aspects of this recurrent problem. First, no laboratory infection experiments can ever show beyond doubt that a species of snail is or is not a vector of a certain schistosome. Only by the finding of 'wild' snails shedding cercariæ and the infection of definitive hosts by those cercariæ, with the subsequent recovery and identification of the adult worms, can the role of a mollusc vector be established. Secondly, the apparent difference in receptivity to infection of a snail species in different countries can only be analysed when the identity of the snails is established beyond doubt. McCullough quotes his own work in collaboration with Duke[2] in the Gambia and that of Adams[3] and Cowper[4] in Mauritius to show that *B. forskalii* is a vector in those areas. In the first case, the evidence is largely epidemiological; but in the second, successful infection experiments were carried out. McCullough admits the possibility of separate and distinct species of snails being involved in the Gambia, Mauritius and the Gold Coast; but he maintains that if this is so, the differences between them have not been recognized.

So far as the Gambia is concerned, Smithers (in the press) has shown that the vector identified by McCullough and Duke as *B. forskalii* is in fact a different species which was identified by Mandahl-Barth as *B. senegalensis* Müller. My own observations (Wright, in the press) confirm the conclusion that the vector in the Gambia is a species distinct from *B. forskalii*; but I tentatively identify it with *B. ludovicianus* (Mittre). It is only by further taxonomic work, which is now in progress, that this difference of opinion can be resolved; but there can be no reasonable doubt that the important vector in the Gambia is not *B. forskalii* (which also occurs in that area) but another *Bulinus* which can be differentiated from it on both morphological and ecological grounds.

The evidence of Adams and Cowper from Mauritius rests also on an incorrect identification of the molluscan host. Specimens of Adams's material in the collection of the British Museum have been compared with the type series of *Bulinus cernicus* (Morelet), and there is no doubt that it is to this species that the Mauritian vector should be assigned. Adams states that his snails were identified by Connolly, who used the work of Germain[5], and it is this author who is responsible for the incorrect inclusion of Morelet's species in the synonymy of *B. forskalii*.

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Nov. 23.

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[4] Cowper, S. G., *Trans. Roy. Soc. Trop. Med. Hyg.*, **47**, 564 (1953).
[5] Germain, L., "Fauna Malacologique des Isles Mascareignes" (Angers, 1921).

Initial Absorption of Ions by Plant Tissue

Recent papers have stressed two aspects of the initial entry of ions into plant cells and tissue, namely, diffusion[1,2] and ion exchange[3,4]. It is important to realize that these processes are merely two aspects of the one system. Since the unity of the experimental facts may not be obvious, it is thought necessary to review some of the evidence, and to attempt to produce agreement amid apparent contradictions.

A proportion, depending on the medium concentration, *p*H, etc., of a piece of plant tissue is penetrated by both ions of a salt, such as potassium chloride, reversibly, in 20–40 min.[1,5]. The time depends on the geometry of the system[2,5]. The proportion of the tissue which appears to reach the external concentration in the initial uptake has been termed the 'apparent free space', a term originally due to G. E. Briggs. This varies from a few to more than 30 per cent[1,2,6]. Since the initial uptake and subsequent 'accumulation' are to a large extent independent, the vacuoles, which occupy a large proportion of the tissue volume, and into which the ions are finally accumulated, are thought not to be part of the apparent free space, which therefore includes intercellular spaces, cell-wall spaces and, very probably, some cytoplasm.

The dependence of the initial uptake and apparent free space on *p*H and concentration[2] of the medium is consistent with a Donnan equilibrium between the medium and a predominantly anionic phase in the tissue. The magnitude of the free space suggests that it includes some, if not all, of the cytoplasm as well as the aqueous phase associated with those cell-wall constituents which are anionic.

The mean concentration A of the Donnan (indiffusible) anions in the free spaces has been estimated[2] to be between $0{\cdot}006\,M$ and $0{\cdot}04\,M$ in maize and bean roots, depending on the age of the tissue. From measurements of the phase-boundary potential differences, Vervelde[7] estimated the surface of the roots of barley, oats, etc., to have the equivalent of $0{\cdot}02$–$0{\cdot}06\,M$ of immobile anions at *p*H 5·5.

At external concentrations C_0 (of a single salt) comparable with or higher than A, the equilibrium concentration of mobile anions and balancing cations (C_i) in the cytoplasm is appreciable: for example, if $A = 0{\cdot}01\,M$ and $C_0 = 0{\cdot}01\,M$, $C_i = 0{\cdot}0062\,M$. In addition to this diffusion of ions of both signs when $C_0 \geqslant A$, external cations will exchange with those initially paired with the immobile anions of the free space. This effect, as can be seen from Fig. 1, becomes increasingly important in comparison with the entry of ion pairs at external concentrations less than A: for example, if $A = 0{\cdot}01\,M$ and $C_0 = 0{\cdot}001\,M$, $C_i = 0{\cdot}0001\,M$. This accounts for the conclusion by Scott Russell and Ayland[4] that diffusion in their experiments was unimportant compared with ion exchange.

In the Donnan system envisaged for the cytoplasm of the free space, cation exchange will depend on the affinity of the immobile anions (proteins and others) and the exchanging cations[4]. The specificity of binding found by Epstein has lately been referred to the ion carriers of accumulation[8] and not to the initial uptake. Exchange between anions adsorbed to cytoplasmic indiffusible cations and anions from the medium is unlikely. At *p*H 7, dissociation of the acidic groups of the surface of the protoplast is complete and cationic groups are unlikely to exist, as shown by electrophoretic studies (McLean, personal