The Taxonomy and Distribution of the Planorbidae in Relation to the Transmission of Schistosomiasis

BY

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INTRODUCTION

The identification of any organism at the species level very often is a matter of individual opinion. Under normal circumstances it would not matter very much if the same animal group was known under different names in, say, Africa and Australia. When, however, it concerns organisms of which the presence or absence in a given region might affect the well-being of millions of people, it becomes essential that those organisms should be recognised for what they are wherever they occur. The intermediate hosts of *Schistosoma* are such organisms.

TAXONOMY

In Africa the snails which transmit the disease have been tracked down to certain genera, subgenera and species all of which belong to the family Planorbidae. The taxonomy of this family and the species groups proved or suspected to be susceptible to *Schistosoma* indicates that we may restrict our present discussion to two genera, viz., *Biomphalaria* and *Bulinus*.

According to present views, the genus *Biomphalaria* in Africa comprises approximately 10 species and 15 subspecies. These are currently grouped into four groups listed in Table I.

Table I

SPECIES OF BIOMPHALARIA

pfeifferi group	*alexandrina* group
B. pf. pfeifferi +	*B. alexandrina alexandrina* +
B. p. bridouxiana +	*B. a. wansoni* ?
B. pf. rhodesiensis +	*B. angulosa* +
B. pf. nairobiensis +	*B. tchadiensis*
B. pf. rüppellii +	
B. pf. gaudi +	
B. germaini ?	
choanomphala group	*sudanica* group
B. ch. choanomphala +	*B. sudanica rugosa*
B. ch. elegans + expt.	*B. s. tanganyicensis* +
B. smithi + expt.	*B. camerunensis camerunensis* +
B. stanleyi + expt.	*B. c. manzadica* ?

+ — proved to be susceptible
? — susceptibility uncertain
expt. — experimentally susceptible

From the point of view of the epidemiology *Biomphalaria* does not present a very great taxonomic problem because, on experimental and epidemiological evidence, almost all its recognised species must be regarded as being actually or potentially susceptible to *S. mansoni*. Possible exceptions are *B. germaini*, *B. alexandrina wansoni*, *B. tchadiensis* and the two subspecies of *B. camerunensis viz. B. c. camerunensis* and *B. c manzadica*. Despite this general susceptibility of the species of *Biomphalaria* it should, however, be mentioned that the same species or different strains of the same species may be differentially susceptible to different strains of *S. mansoni*. It is not known whether this reflects species or strain differences in the snails or in the parasites.

An interesting problem is posed by a related planorbid, *Planorbis metidjensis* (=*P. dufouri*). In Southern Portugal this species apparently takes *S. haematobium* but not *S. mansoni* whereas in Africa north of the Atlas mountains the same species does not take *S. haematobium*.

As in the case of Biomphalaria the species of the genus *Bulinus* were, until very recently, also grouped into four groups (table II).

Table II

SPECIES OF BULINUS

africanus group	*truncatus* group
B. a. africanus ++ 4 spp.	*B. tr. truncatus* +++ 2 spp.
B. a. ovoideus + ?	*B. tr. trigonus* + ?
B. abyssinicus ++ ?	*B. tr. rohlfsi* + ?
B. nasutus nasutus ++ 2 spp.	*B. tr. sericinus* ?
	B. tr. rivularis (*S. bovis* +?)
B. n. productus ++	*B. contortus* ?
B. ugandae —	*B. guernei* + 2 spp.
B. globosus +++ 4 spp.	*B. coulboisi* + expt. 2spp.
B. jousseaumei ++	*B. nyassanus* ?
	B. transversalis
	B. mutandaensis —
tropicus group	*forskali* group
B. tr. tropicus —	*B. forskali* + ? 2spp.
B. tr. zanzibaricus ?	*B. reticulatus* ?
B. tr. toroensis	*B. cernicus* + in Mauritius
B. tr. alluaudi —	*B. camerunensis* ?
B. liratus + (*non B. obtusispira*) + ? Madagascar	*B. scalaris* ?
	B. senegalensis + 2 spp.
	B. beccarii + in Aden.
	B. bavayi + in Madagascar
natalensis group	
B. B. natalensis ?	

+, ++, +++ — different degrees of proven susceptibility
? — susceptibility not proved
— — not susceptible
2 spp., 4 spp. — susceptible to two or four species of *Schistosoma*

Of these the *africanus* and *forskali* groups are, in most cases, conchologically distinct forms. The *truncatus* and *tropicus* groups, however, are very

closely related both conchologically and anatomically and were, until recently, best separated by reference to the mesocone of the first lateral tooth of the radula. An arrow head shaped mesocone was taken to reflect *truncatus group* affinities and a triangular mesocone suggested relationships with the *tropicus* group. On the basis of this criterion the *truncatus* group which accommodates the intermediate host species of *S. haemotobium* in North Africa and which was thought to extend southward only as far as Tanzania and the Republic of the Congo, was found to be represented by populations also in South Africa and probably in Rhodesia as well. Recent cytological studies, however, revealed that, like the *tropicus* group, the South African *truncatus* populations have a haploid chromosome number n = 18. By contrast the northern species of the *truncatus* group invariably have a haploid chromosome complement n = 36 or 72. The present tendency, therefore, is to recognise a fifth group of bulinid species which has arrow head shaped mesocones like the *truncatus* group and a chromosome number n = 18 like the *tropicus* group. This is being referred to as the *natalensis* group. Of all the South African populations qualifying for inclusion under this group only one has thus far been proved to be susceptible to infection. A study just completed in my Unit, however, revealed that many (18 out of 83 population samples) eastern southern African populations in a certain "intermediate" area cannot be referred to either the *tropicus* or *natalensis* group because of the gradual intergradation of morphological characters. This might explain previous findings regarding the questionable susceptibility of *B. tropicus*.

Susceptibility

A glance at Table II makes it abundantly clear that our present basis of classification, apart from the taxonomic problems still inherent in it, has not yet led to a natural grouping of susceptible and non-susceptible species. This is so because no tell tale morphological feature has been discovered which can be linked with susceptibility and we therefore find susceptible, suspect and non-susceptible species in each group. Thus, in the Mediterranean and Sahara regions of Africa, in the Middle East and perhaps also in Madagascar all the known intermediate hosts of *S. haematobium* belong to the *truncatus* group. South of the Sahara and at the corresponding latitude on the eastern side of the continent the *africanus* group takes over this rôle, although the *truncatus* group is also represented in this region. In Mauritius *B. forskali* acts as intermediate host of *S. haematobium*. The same species (or *B. senegalensis*) from Gambia has been successfully infected with *S. haematobium* from both Gambia and Egypt but although this species is widespread in South Africa only 3 out of 37 specimens could be infected experimentally by de Meillon. In Aden another species of the *forskali* group viz. *B. beccarii* is viewed with suspicion.

In view of the apparent insufficiency of the morphology both as a taxonomic basis and as an index of susceptibility, attempts were in recent years made to supplement it with cytological and biochemical information. The polyploidy of the species of the *truncatus* group, however, reflects no correlation with susceptibility for all the species of *Biomphalaria* and *Bulinus* (*Physopsis*) as well as those of the *forskali* group have an haploid chrosome number n = 18. Chromatograms derived from tissue and body fluids seem to be influenced by diet, season, presence or absence of parasites and culture methods. It must therefore be regarded as an unsuitable taxonomic tool. The same criticism applies to the electrophoretic separation of blood proteins. One of the latest approaches is the electrophoretic separation of the egg proteins which has been applied to 80 populations which included representatives of the *truncatus, africanus* and *forskali* groups as well as of the genus *Biomphalaria*. It is to be hoped that refinement of the technique and of the analysis of the results will overcome the apparent limitations of the preliminary findings.

The great morphological similarity between the five species groups within the genus *Bulinus* might be taken to suggest a common ancestor. Should this be true then the capacity to become infected must either have evolved independently of each other in three of the five groups or it must have been independently lost in some of the species within each group. This is not at all impossible for the intraspecific variability as regards susceptibility to infection has been proved to have a genetic basis. It could therefore have arisen by mutation in more than one species on more than one occasion, and there is no reason why it could not happen again in future in species which, at present, are unsusceptible. We, in fact, have evidence pointing in this direction. Should this happen then the hermaphroditism of the snails coupled with their discontinuous distribution might facilitate genetic isolation and, thereby, perpetuation of the acquired susceptibility.

Geographical Distribution

Although it stands to reason that the geographic distribution of the disease must be correlated with that of the susceptible snails, a comparison of the data we have on these aspects reveals that

the snails are much more widespread than the disease. This might indicate that the disease has not yet reached all the areas into which, theoretically, it is capable of spreading. This phenomenon is by no means easy to explain and might be accounted for by any one or a combination of the following: (1) insufficient snail density, (2) insufficient density of the human population, (3) insufficient suitable slow flowing or standing waters, (4) unsuitable water quality, (5) inability of the parasite to complete its cycle in the snail under the prevailing climatic conditions and (6) other limiting factors which are not yet fully understood.

Theoretically some of these factors are subject to change in the course of time as a result of the activities of man which may either transform the ecological situation in a particular area into one more favourable to both the snail and the parasite or open up new territories for colonisation by these organisms. In South Africa this could be in the process of being brought about by the ambitious Orange River Development Programme. And yet the distribution pattern of *Biomphalaria* and *Bulinus* (*Physopsis*) in South Africa seems to have remained unchanged for at least 30 years, possibly indicating that they are no longer expanding their geographic range. If, moreover, this pattern be compared with the physiography of the country one feels justified to decide that both *Biomphalaria* and *Bulinus* (*Physopsis*) could be regarded as tropical to sub-tropical elements or at least lowveld dwellers and as such incapable of spreading beyond their present range. In fact, the altitudinal distribution seems to support this thesis.

A disturbing feature, however, is the circumstance that *Bulinus* (*Physopsis*) is capable of maintaining itself under South African highveld conditions although it can by no means be described as widespread in this area. The conflicting evidence concerning the correlation or lack of it between snail density and schistosome transmission to man, however, in my opinion justifies continued surveillance of the South African highveld.

A remarkable finding which has a bearing on the problem of the possible expanding distribution of the snails is the statistically significant degree of association between *Bulinus* (*Physopsis*) and *Lymnaea natalensis* reported by Van Eeden and Combrinck (1966). From these findings and from the fact that the geographic range of *L. natalensis* extends beyond that of *Bulinus* (*Physopsis*) we concluded that when assessing the suitability of a particular region for future colonization by *Physopsis*, *L. natalensis* may be used as an indicator species. Naturally it comes as a relief to us that, when applying this criterion to the Orange River catchment area, this region may, on present knowledge, be disregarded as potential future Bilharzia territory.

LITERATURE CITED

Van Eeden, J. A. & Combrink, C. (1966). *Zoologica Africana*, 2:95.

No Discussion was recorded