

This report contains the collective views of an international group of experts and does not necessarily represent the decisions or the stated policy of the World Health Organization.

**WORLD HEALTH ORGANIZATION
TECHNICAL REPORT SERIES**

No. 90

**BILHARZIA SNAIL VECTOR
IDENTIFICATION AND CLASSIFICATION
(Equatorial and South Africa)**

Report of a Study-Group

	Page
1. Introduction	3
2. Nature of the problem	4
3. Identification and classification of snails	5
4. Collection and preservation of material	14
5. Future research	17
6. International co-ordination	19
Annex 1. Minimum particulars required in labelling snail collections	21
Annex 2. Full particulars required concerning snail collections	21

WORLD HEALTH ORGANIZATION

PALAIS DES NATIONS

GENEVA

NOVEMBER 1954

**STUDY-GROUP ON
BILHARZIA SNAIL VECTOR IDENTIFICATION AND CLASSIFICATION
(Equatorial and South Africa)**

Paris, 22-27 February 1954

Members :

William Alves, Ph.D., Director, Bilharzia and Malaria Research Laboratory,
Salisbury, Southern Rhodesia

E. G. Berry, Ph.D., Laboratory of Tropical Diseases, National Microbiological
Institute, National Institutes of Health (Public Health Service), Bethesda,
Md., USA (*Rapporteur*)

Bengt Hubendick, Dr.Sc., Evertbratavdelningen, Naturhistoriska Riks-
museum, Stockholm, Sweden

P. L. LeRoux, D.Sc., Senior Lecturer in Helminthology, Department of
Parasitology, London School of Hygiene and Tropical Medicine, London,
England

G. Mandahl-Barth, Dr.Sc., Danmarks Akvarium, Charlottenlund, Denmark

Gilbert Ranson, Docteur ès Sciences, Sous-Directeur du Laboratoire de
Malacologie, Muséum national d'Histoire naturelle, Paris, France
(*Chairman*)

Secretary :

Dr. W. M. Bonne, Director, Division of Communicable Disease Services,
WHO

The report of this study-group was originally issued in mimeographed form
as document WHO/Bilharz/11, 12 May 1954.

PRINTED IN SWITZERLAND

BILHARZIA SNAIL VECTOR
IDENTIFICATION AND CLASSIFICATION
(Equatorial and South Africa)

Report of a Study-Group

The meeting of the Study-Group on Bilharzia Snail Vector Identification and Classification took place at the Muséum national d'Histoire naturelle, Paris, from 22 to 27 February 1954.

Mr. Gilbert Ranson was elected Chairman and Mr. E. G. Berry, Rapporteur.

1. Introduction

In October 1949 the Joint OIHP/WHO Study Group on Bilharziasis in Africa, which met in Cairo, Egypt, recommended that a uniform classification and nomenclature of the snail vectors of bilharziasis should be established and that this study should be based on the internal morphology of the snails and on their ecological characters, rather than on the mere external characters of the shells. This group also recommended that WHO should make arrangements for competent specialists to undertake this work.¹

The Expert Committee on Bilharziasis of the World Health Organization, which held its first session in San Juan, Puerto Rico, in October 1952, emphasized the continuing confusion regarding the status of many species of snail vectors, particularly those concerned in the transmission of bilharziasis in Africa, and advised that further malacological studies should be undertaken, indicating regional priority for Africa. The committee also asked for suitable recommendations on the collection and preservation of the material, and on the type of pertinent data that should accompany the specimens sent in for identification.²

During the present meeting, principles of classification and criteria for identification, particularly of African Planorbidae, were considered and

¹ *Wld Hlth Org. techn. Rep. Ser.* 1950, 17, 5 (section 1.2)

² *Wld Hlth Org. techn. Rep. Ser.* 1953, 65, 18 (section 3.1.1)

suggestions on essential data to accompany all collections sent for identification, and acceptable methods to be used for the preservation of the vector molluscs, were submitted. A tentative list of various African species of *Biomphalaria* likely to be helpful to field workers was compiled, but the classification should not be regarded as final. Future research needed, and international co-ordination desired were also discussed.

2. Nature of the Problem

The public-health worker finds in nature certain snails which are shedding cercariae of mammalian schistosomes. He also discovers that certain snails can be experimentally infected with mammalian schistosome miracidia. He needs to know which snails are vectors, and if he has an infected snail he wants to be sure which species it is. Identification of the snail host is, therefore, essential to him. The difficulty is, however, that snail species are not easily identified. Within a given species of snail there exists a large variation of forms. When identification is based only on the shell, much confusion may arise because forms of the same species have been given different names or because the different forms are confusable with other species. It is necessary, therefore, that not only the shell, but the anatomy as well, be studied, and many criteria may have to be applied for the final zoological identification. For the field worker, simpler criteria are needed.

One purpose of the meeting was to find those criteria which will enable the field worker to make a primary identification. A second goal was to guide the malacologist towards a definite identification and classification of the intermediate hosts and related species.

The molluscan family Planorbidae, to which the snail vectors of bilharziasis belong, is large, and a number of species have evolved that are represented throughout the world. The majority of these species are lacking in easily recognizable characters or ornamentation that would be helpful for identification. Another difficulty has been the poor description of species on the sole basis of shell characters, with no reference to the anatomy of the animal which would be a help in determining relationships. Malacologists therefore encounter great difficulty in the identification of these species, and it is realized that a serious problem confronts the parasitologist or public-health worker in attempting to classify intermediate hosts of bilharziasis.

This report will deal only with the molluscan fauna which is, zoogeographically, strictly African. It will not, therefore, include the palaeo-arctic element which appears along the northern fringe of the continent.

3. Identification and Classification of Snails

Words used in zoological terminology have a precise meaning. The following definitions should therefore be understood :

Family. A natural taxonomic unit composed of related genera. As it is the oldest natural category considered in this report, the characters are basic and embrace its lesser components, the genera.

Subfamily. A subdivision of the family composed of two or more natural groups of related genera. In category it is younger than the family to which it belongs but older than its genera.

Genus. A natural taxonomic unit composed of closely related species. Groups of related species which show trends of becoming genera are regarded as *subgenera*.

Species. A group of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups. The species is the basic taxonomic unit.

Subspecies, race, or geographical race. A geographically more or less isolated group of populations of a species. These populations have common genotypical differences to the remaining populations of the species.

Form. A neutral term for a specimen or a group of specimens with common features, which can be genotypical or ecophenotypical (environmentally induced). "Form" may mean specimen, ecophenotype, the genotype of a population, subspecies, or species.

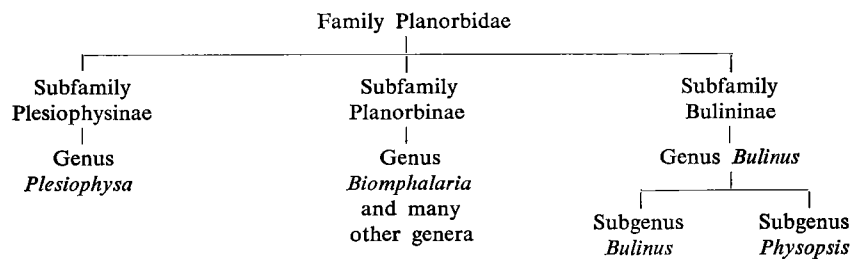
Confusion was found to exist not only in the nomenclature of the species, but even in the delimitation of the genera and the family to which the snails belong. It was therefore unanimously agreed that the family name should be "Planorbidae" and that the intermediate hosts should be placed in the two subfamilies "Planorbinae" and "Bulininae".

The known species which serve as intermediate hosts for *Schistosoma mansoni* have, heretofore, been placed in five genera, namely, *Planorbis* Geoffroy, 1767; *Biomphalaria* Preston, 1910; *Afroplanorbis* Thiele, 1931; *Australorbis* Pilsbry, 1934; and *Tropicorbis* Pilsbry & Brown, 1914. It has long been recognized that the known species which serve as the intermediate hosts for *S. mansoni* are generically the same and that all have probably been derived from a common stock. It was therefore agreed that these and their related species should be united into a single genus

Biomphalaria, and that the genera *Australorbis*, *Afroplanorbis*, and *Tropi-corbis* should be considered synonyms. The name *Planorbis* should no longer be used in reference to the intermediate hosts of bilharziasis. Members of this genus have anatomical features distinct from species assigned to the genus *Biomphalaria*. Species belonging to the genus *Planorbis* are regarded as palaeo-arctic.

The known species which serve as intermediate hosts for *S. haematobium* (with the exception of *Planorbarius metidjensis* Forbes, which has been reported as the host of the schistosome responsible for urinary bilharziasis in Portugal) all belong to the subfamily *Bulininae*, and it is the consensus of opinion that *Pyrgophysa* Crosse, 1879 and *Isidora* Ehrenberg, 1831 are synonyms of *Bulinus* Müller, 1781, and that *Physopsis* Krauss, 1848 is a subgenus of *Bulinus*.

The following is a schematic chart showing relationships of *Biomphalaria* and *Bulinus* :



A classification of the genera of molluscan hosts of bilharziasis found in Africa is given below (not applicable for other parts of the world):

Family Planorbidae

Aquatic snails, discoidal, globose, turreted; male and female genital openings on left side, presence of a secondary gill (pseudobranch); radula with central teeth bearing two cusps.

Subfamily Planorbinae

Shell flat, discoidal, or lens-shaped; prostate gland elongate; male copulatory organ with normal verge; pseudobranch not folded.

Genus Biomphalaria

Shell discoidal, diameter 8 mm or more; pseudobranch not lobular; prostate duct absent; male copulatory organ with a normal verge; flagella and stiletto absent.

Subfamily Bulininae

Shell turreted or globose; pseudobranch lobular, prostate gland fan-shaped; male copulatory organ with ultrapenis. One genus, *Bulinus*.³

Genus Bulinus

Same characters as subfamily.

Subgenus Bulinus

Ridge absent on ventral side of kidney; columella usually continuous, not truncate; striae usually present on nuclear whorls.

Subgenus Physopsis

Ridge present on ventral side of kidney; columella usually truncate; nuclear whorls usually not ribbed or striated, and usually with small dots arranged spirally.

The classification up to this point is satisfactory. Species classification, however, is much more involved and further research is required before a reliable taxonomy can be presented.

From time to time field workers find planorbids of differing appearance, and it is essential that a name should be applied to such specimens. An attempt has therefore been made to fill this need (see Lists 1 and 2, pages 8 and 12). It should be understood, however, that these lists are merely provisional; they should not be regarded as in any way final. Owing to the lack of material from many parts of Africa it is in some cases impossible to decide whether the names given represent a definite species or a geographical race or merely an ecological form. It is to be expected that as more material becomes available alterations will be made, and until that time a reliable classification of the African vectors and non-vectors must be postponed.

The descriptions given below are incomplete; the purpose is only to give the main characters of the shells and of the soft parts by which it is possible to identify the specimens. The arrangement is strictly practical and does not indicate relationships. Where such relationships are known or assumed they are given in each case. The geographical distributions are likewise provisional.

³ Hubendick, B. (1948) *Arkiv Zool.* 40, A, No. 16, p. 48

List 1. Biomphalaria*Sudanica* (von Martens, 1870)

Shell : About 6 whorls, flat on the upper side and separated by a shallow suture. Diameter of umbilicus $1\frac{1}{2}$ times the height of the shell. Diameter of the shell $3\frac{1}{2}$ times the height; diameter up to 20 mm. Maximum height 4.5 mm.

Anatomy : Marginal teeth of the radula with a single or bicuspid ectocone. In the copulatory organ, penis sheath equal in length to the preputium. Verge not longer than the sheath.

Distribution : Ethiopia, Somaliland, Sudan, Ubangi-Shari, north-eastern part of the Belgian Congo, Uganda, and Tanganyika.

Remarks : To the south, it is replaced by a geographical race (*tanganikana*, Bourguignat, 1858), differing from the typical form by a slightly higher shell and narrower umbilicus. This form is known in Tanganyika, the Belgian Congo, and possibly Northern Rhodesia.

Boissyi (Potiez & Michaud, 1838)

Shell : Differing from *sudanica* by having only $5\frac{1}{2}$ whorls, more convex and separated by a deeper suture. Diameter of the shell slightly less than 3 times the height; that of the umbilicus slightly greater than the height. Diameter 15 mm, height 4.7 mm.

Anatomy : Single ectocone on the marginal teeth. Penis sheath almost twice as long as the preputium.

Distribution : Egypt.

Remarks : In Ubangi-Shari a new subspecies has been found differing from the typical form by having only 5 whorls, with a diameter of 15 mm and a still longer penis sheath.

Camerunensis (Boettger, 1941)

Shell : Differing from other bigger forms by the angular whorls and the height. $5\frac{1}{2}$ whorls, having a distinct angle both on the upper and the under side. Umbilicus slightly less than the height. Diameter 20 mm, height 7.5 mm.

Anatomy : Still unknown.

Distribution : Cameroons.

New species

Shell : Very similar to *camerunensis*, but the angle on the upper side still more pronounced. Diameter 15 mm, height 5.5 mm.

Anatomy : Copulatory organ resembling that of *boissyi*, with the penis sheath much longer than the preputium. Ectocone of the marginal teeth divided into 3 cusps.

Distribution : Hitherto only known by two specimens from the southern parts of Tanganyika and one from Natal. More material is wanted.

Salinarum (Morelet, 1868)

Shell : Resembling that of *boissyi*, but width of whorls increasing more rapidly. $5\frac{1}{2}$ whorls, slightly convex on both sides and on the lower side with a very obtuse angle near the aperture. Diameter of the umbilicus slightly greater than the height of the shell. Diameter 15-16 mm, height 4.5 mm.

Anatomy : Ectocones of the marginal teeth usually bicuspid. Penis sheath shorter than the preputium. Verge almost twice as long as the sheath.

Distribution : Angola and southern part of the Belgian Congo ; possibly northern Rhodesia.

Remarks : It is possible that *salinarum* will turn out to be a subspecies of *pfeifferi*, but more material from Central Africa must be examined before a final decision can be made.

Ruppellii (Dunker, 1848)

Shell : $4\frac{1}{2}$ to 5 whorls, regularly increasing, convex on the upper side, angular on the under. Diameter of umbilicus equal to the height of the shell or slightly less. Diameter up to 17 mm but mostly not more than 14 mm ; height 5.5 mm.

Anatomy : Ectocones of the marginal teeth divided into 4 cusps. Penis sheath slightly shorter than the preputium. Verge slightly longer than the sheath.

Distribution : From Eritrea and Somaliland south-westward to Angola ; possibly also in Egypt. In Fezzan a somewhat aberrant form is known.

Remarks : No specimens from the type locality in Ethiopia have been dissected ; therefore it is not quite certain that *ruppellii* is the proper name, although shells from Ethiopia make this identification probable.

Adowensis (Bourguignat, 1879)

Shell : Resembling that of *ruppellii*, but increasing more rapidly in width, with only 4-4½ whorls and a narrower umbilicus (at most, three-quarters of the height). Diameter 10-13 mm, height 4.5-5 mm.

Anatomy : Ectocones of marginal teeth divided into 4 cusps. Length of penis sheath only half that of the preputium. Verge twice the length of the preputium.

Distribution : From Eritrea southward to Kenya, Uganda and the eastern part of the Belgian Congo.

Remarks : As *ruppellii* and *adowensis* occur in the same districts and same kinds of localities, but have never been found together, it is possible that they are merely two ecological forms.

Nairobiensis (Dautzenberg, 1908)

Shell : Very similar to that of a small *ruppellii*. 4 whorls. Diameter about 9 mm, height 3.5 mm.

Anatomy : Ectocones of the marginal teeth single or bicuspid. Copulatory organ as in *adowensis*.

Distribution : Only known from few localities in Kenya, northern Tanganyika, Ruanda, and the eastern part of the Belgian Congo.

Remarks : This is a doubtful form, showing relation to *ruppellii*, *adowensis*, and *pfeifferi*. An apparently related form from Senegal has been described by Ranson (1953), as *Planorbis gaudi*.⁴ Until more material has been examined it is impossible to draw further conclusions.

Pfeifferi (Krauss, 1848)

Shell : Closely resembles the shells of *ruppellii* and *adowensis*. 4½ whorls rapidly increasing in width. Diameter of umbilicus about three-quarters of the height of the shell. Diameter 11 mm, height 4.5 mm.

Anatomy : Ectocones single. Penis sheath half the length of the preputium. Verge not longer than the sheath.

Distribution : South Africa.

Remarks : In the northern parts of the range, *pfeifferi* is rather variable, and in order to clarify the situation it is essential that more material (especially from Northern Rhodesia) be made available for examination.

⁴ Ranson, G. (1953) *Bull. Soc. Path. exot.* 46, 783 (804)

Kivuensis (Schwetz, 1950)

Shell : Relatively high, 5 whorls. Diameter of the shell only a little more than twice the height. Diameter of umbilicus about two-thirds of the height. Diameter 13.5 mm, height 5.8 mm.

Anatomy : Ectocones of the marginal teeth single. Copulatory organ as in *pfeifferi*.

Distribution : Lake Kivu (Belgian Congo and Ruanda-Urundi).

Remarks : Probably a local form of *pfeifferi*. The high and strong shell is due to the type of water peculiar to Lake Kivu.

Choanomphala (von Martens, 1879)

Shell : $3\frac{1}{2}$ -4 whorls, angular on both sides. In the concavity of the upper side, ridge-like projection of whorls. Angle on the lower side placed medially. Diameter of the shell slightly more than twice the height. Height almost twice the diameter of the umbilicus. Diameter 8-10 mm, height 3.3-4.3 mm.

Anatomy : Ectocones of the marginal teeth bicuspid. Penis sheath equal in length to the preputium. Verges with a dilatation at the base and equal in length to the sheath.

Distribution : Lake Victoria, Victoria Nile, and Lake Kyoga (Kenya, Uganda, and Tanganyika).

Elegans (Mandahl-Barth, 1954)

Shell : Resembling that of *choanomphala*, but with the angle on the lower side placed near the suture and the concavities smooth on both sides. Diameter 8 mm, height 3.5 mm.

Anatomy : As in *choanomphala*.

Distribution : Lake Albert (Belgian Congo and Uganda); possibly also in some other of the Central African lakes.

Remarks : Possibly a subspecies of *choanomphala*.

Stanleyi (Smith, 1888)

Shell : In relation to the size, the highest of the African *Biomphalariae*. $3\frac{1}{2}$ -4 whorls, more convex than in *choanomphala*. Diameter of the shell less than twice its height. Diameter of the umbilicus only half the height. Diameter 10.5 mm, height 5.8 mm.

Anatomy : Ectocones of the marginal teeth usually undivided, or in a single row with 2 cusps. Copulatory organ as in *choanomphala*, but with both the penis sheath and the preputium relatively longer.

Distribution : Lake Albert (Belgian Congo and Uganda).

Smithi (Preston, 1910)

Shell : Differing from all other *Biomphalariae* by the last whorl descending obliquely towards the aperture. $4\frac{1}{2}$ whorls. Diameter 12 mm, height (of the last whorl) 4.7 mm.

Anatomy : As in *stanleyi*.

Distribution : Lake Edward (Belgian Congo and Uganda).

Remarks : In some specimens the last whorl is not descending, so that it is almost impossible to distinguish *smithi* from *stanleyi*. It is therefore probable that they represent two forms of a possible subspecies.

Germaini (Ranson, 1953)

Shell : Closely resembles the shell of *stanleyi*, but not quite so high and with the umbilicus slightly wider. Diameter 10.5 mm, height 4.3 mm.

Anatomy : Ectocones of the marginal teeth single. Penis sheath equal in length to the preputium. Verge distinctly shorter than the sheath.

Distribution : Lake Chad and French West Africa.

Remarks : Seems to be closely related to the fossil *Biomphalaria duveyrieri* (Deshayes) from the Sahara.

List 2. *Bulinus*, subg. *Physopsis*

Africanus (Krauss, 1848)

Shell : Usually with a short conical, rather pointed spire; columella strongly truncated and normally with a lamella along the truncation. Spiral microsculpture on the upper portion of the shell pronounced. Height of shell up to 20 mm.

Anatomy : Penis sheath longer and in its upper part wider than the preputium.

Distribution : Not exactly known because it has been confused with *globosus*. Typical *africanus* are known from South Africa and Rhodesia. In East Africa closely related forms (subspecies) occur, such as *ovoides* (Bourguignat, 1879).

Globosus (Morelet, 1866)

Shell : Differing from that of *africanus* by the more obtuse apex ; less pronounced truncation of columella, with no lamella. Spiral microsculpture usually much finer. Height of shell up to 25 mm, but usually smaller.

Anatomy : Penis sheath short and narrower than the preputium.

Distribution : Seems to occur in most parts of Africa south of the Sahara.

Remarks : It is probable that local focuses have developed in various parts of Africa, but more material must be examined before definite conclusions can be drawn. Sometimes *globosus* has no truncation on columella and then closely resembles *Bulinus tropicus*, from which it may be distinguished by the microsculpture and by the ridge on the kidney.

Nasutus (von Martens, 1879)

Shell : Conical spire equal in length to the aperture, consisting of rather flat whorls separated by shallow sutures. Columella with a weak truncation. Basal margin forming groove-like spout. Height up to 20 mm.

Anatomy : Penis sheath of equal length and width to preputium.

Distribution : British East Africa.

Abyssinicus ([von Martens] Jickeli, 1874)

Shell : Spire with convex whorls separated by deep sutures. Porcelain-like gloss. Truncation of columella usually feeble.

Anatomy : As in *nasutus*.

Distribution : Ethiopia and Somaliland.

The following list shows the *Biomphalariae* which have already been found and those which probably occur in various parts of Africa, the latter being marked with an asterisk (*).

Egypt, Libya :	<i>boissyi</i> , <i>ruppellii</i> *
Sudan :	<i>sudanica</i> , <i>ruppellii</i> , <i>boissyi</i> n. subsp.*
Ethiopia, Eritrea, Somaliland :	<i>sudanica</i> , <i>ruppellii</i> , <i>adowensis</i>
French West Africa :	<i>germaini</i> , <i>gaudi</i>
Nigeria, Cameroons :	<i>camerunensis</i> , <i>sudanica</i> , <i>germaini</i> , <i>gaudi</i>

French Equatorial Africa :	<i>sudanica</i> , <i>boissyi</i> n. subsp., <i>germaini</i> , <i>camerunensis</i> *
Belgian Congo, Ruanda-Urundi :	<i>sudanica</i> (including <i>tanganikana</i>), <i>ruppellii</i> , <i>adowensis</i> , <i>nairobiensis</i> , <i>salinarum</i>
British East Africa (Uganda, Kenya, Tanganyika) :	<i>sudanica</i> (including <i>tanganikana</i>), <i>ruppellii</i> , <i>adowensis</i> , <i>nairobiensis</i> , <i>Biomphalaria</i> n. sp.
Angola, Northern Rhodesia, Nyasaland, Mozambique :	<i>salinarum</i> , <i>pfeifferi</i> , <i>ruppellii</i> , <i>suda-</i> <i>nica (tanganikana)</i> *, <i>Biompha-</i> <i>laria</i> n. sp.*
South Africa :	<i>pfeifferi</i> , <i>Biomphalaria</i> n. sp.
Central African lakes :	<i>sudanica</i> (including <i>tanganikana</i>), <i>choanomphala</i> , <i>elegans</i> , <i>stanleyi</i> , <i>smithi</i> , <i>kivuensis</i>

It is felt that most valuable assistance could be afforded to field workers by providing them, through WHO aid, with photographs (prepared by technical experts) of typical "average" members of the genera that have been described here, along with this list of geographical distribution. These photographs, accompanied by good and detailed descriptions of the mollusc, would not only be very useful local keys, but would, it is hoped, provide a further stimulus to the collection and submission of specimens to malacologists.

4. Collection and preservation of material

The species-discriminating shell characters in the planorbids are often hidden by the vast range of intraspecific variation. The following procedure has to be used to define characters which are useful in practice.

A large amount of material of the forms concerned has to be collected and studied in regard to the whole anatomy. Some reliable species-discriminating features may be found. The true species can thus be determined and the shells of all specimens at hand compared. Definite and easily recognizable shell characters may be found.

After the first step—the connexion of anatomical characters with shell characters—the second step is to relate the shell of the species in question to type specimens of already described species. It is preferable for this

purpose to use material from the type locality. This will generally permit of a direct comparison of anatomy, shell, and type specimen, and it is of particular importance as the soft parts of the types are almost never retained. The result will lead to the definite naming of the species, which is thus not only conchologically but also anatomically defined. The naming, of course, has to follow the International Rules of Zoological Nomenclature.

This whole type of work has to be based on a vast amount of material which must be analysed by comparative and statistical methods. For comparative purposes it is important to have homogeneous material, which can be obtained only if certain standard techniques are applied. For statistical purposes, population samples, and not just a few specimens, have to be collected from every locality. It is of special importance to get samples from localities where more than one species of *Biomphalaria* or *Bulinus* seem to occur.

The results obtained can possibly be confirmed by means of breeding experiments and serological tests.

The first step in the procedure mentioned above—the connexion of anatomical characters with shell characters—is dependent on properly collected, labelled, and preserved material.

It is appreciated, however, that ideal techniques of collection and preparation may not always be possible for workers who have few facilities, and methods which, it is hoped, are practicable in almost any situation are therefore detailed below. It is emphasized that these methods are to be regarded as fulfilling *minimum* requirements for satisfactory studies.

1. The snails, preferably more than a few, from a given uniform locality, are put into 75% ethylalcohol. The volume of the snails should not exceed one-third of the volume of the alcohol. Place and date of collecting must be given.

2. A more refined method of preserving and labelling is, however, desirable. A better, but still simple, method is that of killing the snails in hot water. The collected snails are dipped into boiling water for not more than four to five seconds and then placed in about 75% alcohol in the same way as above. It is desirable that a few of the snails should be cautiously extracted from their shells before being put into the alcohol.

If ethylalcohol is not available, then 75% industrial methylated spirits may be used.

The minimum particulars required in labelling these collections are given in Annex 1 (see page 21).

It is emphasized, however, that the fullest scientific value from field collecting can be attained only when the methods detailed below are followed and the required data given.

Snails can be picked up with forceps but more practically collected with the help of a screen of about 1-mm mesh size. A round screen which can be drawn through submerged vegetation, or with which the surface layer of a soft bottom can be scaled, is useful. Another type of screen (designed at the British Museum of Natural History) with a sharp angle and perpendicular edges is particularly useful in rocky pools or on hard bottoms in general. It should be possible to fasten a pole to the screen in order to reach deeper water.

It is important to collect many specimens from a locality. Up to 300 is desirable. In each case all the snails must be collected from one delimited and reasonably uniform habitat. It is desirable to get different growth stages represented in the material. Collections from the same habitat at different times of the year would be useful. Snails from different habitats should not be placed together in the same container.

Every collection must be carefully labelled. The location of the habitat should be given in such a way that anybody can find the spot again. Country, province, county; nearest place named on small-scale maps; nearest place named on commonly used large-scale maps; nearest place on a main road; name of the stream, river, lake, or pool; exact location in relation to nearest place named on the label should be given. The collector should also record the date, the estimated size of the relevant body of water, and as many characteristics of the habitat as possible. This procedure might be facilitated by the use of a specially prepared form (see Annex 2, page 21).

The ideal preservation is as follows: 20-30 specimens, representing different growth stages, are placed in a jar with some water. When the snails begin to crawl, one or two drops of a menthol solution (24 g menthol dissolved in 10 ml of 95% ethylalcohol), or a few menthol crystals, are applied on the water surface. Immediately, a cover should be placed on the jar. After 10-24 hours—the time varies according to the size of the snails and the environmental conditions—the animals are relaxed and anaesthetized. When the snails are completely anaesthetized, they can be put into a fixative consisting of 2 parts of 75%-80% alcohol and 1 part of commercial formalin. This has given good results. An alternative is 4 parts of 75% alcohol, 1 part of water, and 1 part of commercial formalin. After 24 hours the specimens have to be transferred into ethylalcohol of about 75%. The shells of a few specimens should be carefully cracked with a small vice or some other tool, before fixing, in order to facilitate the penetration of the fixative. This method will result in well-extended animals on which the external morphology of the soft parts can be studied. The rest of the population sample should be put in 75% alcohol, which should be changed at least once, after about

24 hours. Preservation by this procedure is of particular importance because it allows the external morphology of the soft parts to be compared with external species-distinguishing characters on the living animal, easily recognizable in the field.

The possibility of substituting other alcohols for ethylalcohol, such as secondary butylalcohol, should be examined.

Institutions requesting living molluscs will forward complete instructions to field workers on methods of packing and shipment.

5. Future Research

A vast amount of research remains to be done in the field of medical and veterinary malacology and, unfortunately, the number of trained malacologists in the world is not large. It is now clear that assistance from other fields is necessary to help to supply the knowledge which is lacking in this specialized branch of zoology.

It was agreed that there can be no relinquishing of the research work already undertaken in the study of the systematics of the various families, genera, and species which are of medical and veterinary importance in their role as vectors of trematode diseases. Considerable advances have been made within the last few years in knowledge of the intermediate hosts of human bilharziasis and their distribution. A number of gaps still remain, however, which must be filled. This can be achieved more rapidly through the co-operation of field workers sending their material to malacologists for study. A large collection from many localities will give an insight not only into the range of variation present within a species but also into relationships with other members of the genus.

There exists at present a definite handicap which impedes the progress of malacology. The malacologist must not only be familiar with the large number of snails which have been proven to serve as intermediate hosts of human or other animal trematode diseases, but he should be equally capable of advising the field worker if a particular specimen is closely related to a known intermediate host, so that it might even be a possible intermediate host. He should therefore have access to a large bibliography containing descriptions of the various species of snail which he is required to identify. He should also have access to authenticated specimens with which to compare those that are submitted for identification. Since the majority of the works containing descriptions of the species are out of print and since type specimens are to be found only in widely separated museums throughout the world, it is difficult for the malacologist to determine certain species, and the establishment of a stable nomenclature—which is requested, for example, by workers in the field—is retarded.

It is therefore requested that assistance be given for the compilation of a file of the original descriptions of molluscs which are intermediate hosts and of their close relatives. These descriptions should be accompanied by photographs of the type species. Certain groups of snails should have a priority in this study, but it is equally important that a geographical selectivity should be exercised where the need seems to be the greatest. At present the Planorbidae (*Biomphalaria* and *Bulinus*) from Africa, the Mediterranean Region, and South America appear to deserve priority treatment in that order.

There are many other problems which can be investigated by the field worker. Examples of these are : (1) the discovery of infected snails which should be submitted to the malacologist for species identification and to the helminthologist for determination of the helminth ; (2) the exposure of certain snails to miracidia of human bilharziasis, and the sending of the exposed snails to laboratories where specialized research work on the snails and the disease is being conducted, and to the malacologist for final identification. Information regarding the seasonal infection of snail hosts is important. Control programmes of bilharziasis can be more successful when knowledge concerning the optimum breeding season of molluscan hosts in a particular area is available.

It is known that animal bilharziasis develops in snails at temperatures which are below those essential for the development of the related human parasite. In Corsica, Sardinia and Sicily, for example, *Schistosoma bovis* occurs although no indigenous human infection with *S. haematobium* has yet been reported.

In other areas, as, for instance, Egypt, it is found that while heavy infection of humans with *S. haematobium* is manifest, animal bilharziasis transmissible by the same species of snail appears to be absent, although optimum conditions for transmission are present. It is possible in this situation that the intense infestation of snails by human schistosomes precludes by competition the establishment of the animal form.

Infection rates and susceptibility of the snail hosts appear to have an important bearing on the snail population.

Field workers attempting to control bilharziasis are aware of the scarcity of information regarding the bionomics and ecology of aquatic snails, namely : length of life ; breeding season ; preference of aquatic vegetation ; chemistry of water ; temperature requirements for minimum, optimum, and maximum existence ; aestivation of snails in infected areas ; length of time they can exist in certain temperatures ; natural enemies and predators which might be useful in control measures ; resistance to certain molluscocides. All these subjects require research, and when the problems are

solved, it will be of substantial help in adding to the knowledge of medical malacology.

6. International Co-ordination

From the discussions it became clear that different aspects have to be further examined, such as the bionomics, the ecology and the physiology of snails. Malacologists, parasitologists, ecologists, and limnologists will have to co-operate.

The few universities and institutes engaged in malacological studies will have to be asked to co-ordinate efforts, in co-operation with field workers, to fill the gaps in our knowledge of freshwater molluscs. They should be encouraged to train more specialists in the different disciplines mentioned above.

It is realized that, since training as a malacologist means approximately four years' study for a graduate zoologist, only a few countries will be willing and able to give such highly qualified training. Accordingly, the results of malacological studies will have to be brought to the field workers; the specialists will have to advise them on the spot. It is quite possible to impart certain malacological techniques to field workers.

In terms of assisting governments in Africa, it would be difficult to visualize training fully qualified malacologists for all the territories where bilharziasis is a problem; but a team of experts could readily advise those concerned with bilharzia control on problems which still remain to be solved, and how best to deal with them.

Such a team might consist of:

- (a) a public-health officer epidemiologist;
- (b) a parasitologist;
- (c) a malacologist;
- (d) a sanitary engineer.

Knowledge of ecology and of limnology should be represented in the team. Such a highly qualified team could serve several countries and would be the best practical solution under the present circumstances. It could also indicate what is still to be done to assemble the material for a final evaluation of all African snail vectors of bilharziasis, and indicate further efforts to come to a definite species identification and classification.

Such a team has to work in close collaboration with other interested workers such as veterinarians and agriculture experts of the country concerned.

The importance of fellowships for key workers in bilharziasis control, for the purpose of learning malacological techniques, was stressed.

Exchange of workers is particularly useful, because methods and techniques in use vary according to the ecological conditions in the different endemic areas; it would therefore provide these workers with valuable new information. International courses for postgraduate key workers in bilharziasis control are highly recommended; such courses should last 2-3 months.

To solve the many problems referred to in this report, close co-operation between field workers, national research institutes, and international reference institutes is essential.

Annex 1**MINIMUM PARTICULARS REQUIRED
IN LABELLING SNAIL COLLECTIONS**

Date :
 Number :
 Name of collector :
 Country :
 Province :
 District :
 Nearest village :
 Name of lake, river, stream or pool :

Annex 2**FULL PARTICULARS REQUIRED
CONCERNING SNAIL COLLECTIONS**

Date :
 Number :
 Name of collector :
 Country :
 Province :
 District :
 Nearest village :
 Name of lake, river, stream or pool :
 Location in relation to nearest village :

 Altitude :
 Incidence of bilharziasis (*S. haematobium*) :
 Incidence of bilharziasis (*S. mansoni*) :
 (To be expressed in terms such as heavy, medium, light)
 Density of snails :
 (To be expressed in terms such as many, few)
 Presence or absence of egg-masses :
 Surface area of water body :
 Permanent or seasonal water :
 Stagnant or running water :

Indicate whether the water is clear or muddy, or contains much vegetation, etc. :

.....

Colour of water :

Hardness of water (expressed in terms of lime [CaCO₃] content) :

* pH :

* Temperature of surface water, expressed in degrees centigrade (give time of day) : ..

.....

Sun exposure of habitat :

Substratum, expressed in terms such as rocks, sand, clay, humus, decaying matter : ..

.....

Quantity of aquatic vegetation, expressed in terms such as dense, light, etc. :

.....

Type of water vegetation :

Type of vegetation around the habitat :

Presence or absence of aquatic birds and mammals :

Describe contact with and use of waterbody by local population :

.....

.....

.....

Any further remarks :

.....

.....

.....

* Information on these items is desirable, wherever possible.

**WORLD HEALTH ORGANIZATION
TECHNICAL REPORT SERIES**

Selected Titles :

	Number	Price		
		s. d.	\$	Sw. fr.
Adoption , Joint UN/WHO Meeting of Experts on the Mental-Health Aspects of Final report	70	1/3	0.15	0.60
Alcohol , Expert Committee on First report.	84	1/9	0.25	1.—
Alcoholism Subcommittee See under Mental Health				
Antibiotics , Expert Committee on Report on the first session.	26	9d.	0.10	0.40
Bilharzia snail vector identification and classification Report of a study-group	90	1/9	0.25	1.—
Bilharziasis , Expert Committee on First report.	65	2/3	0.30	1.20
Bilharziasis in Africa , Joint OIHP/WHO Study-Group on Report on the first session.	17			<i>Out of print</i>
Brucellosis , Joint FAO/WHO Expert Committee on Report on the first session.	37	2/-	0.25	1.—
Second report.	67	2/-	0.25	1.—
Cholera , Expert Committee on First report.	52	1/3	0.15	0.60
Cholera , Joint OIHP/WHO Study-Group on Report on the third session	18	1/3	0.15	0.60
Diphtheria and Pertussis Vaccination Report of a conference of heads of laboratories producing diphtheria and pertussis vaccines	61	4/3	0.55	2.20
Environmental Sanitation , Expert Committee on Report on the first session.	10			<i>Out of print</i>
Second report.	47	1/3	0.15	0.60
Third report	77	1/9	0.25	1.—
Health Education of the Public , Expert Committee on First report	89	1/9	0.25	1.—
Hepatitis , Expert Committee on First report.	62	1/6	0.20	0.80
Hygiene of Seafarers , Joint ILO/WHO Committee on Report on the first session.	20	9d.	0.10	0.40
Influenza , Expert Committee on First report.	64	1/6	0.20	0.80
Insecticides , Expert Committee on Report on the first session.	4	2/3	0.30	1.20
Report on the second session	34			<i>out of print</i>
Third report	46	2/-	0.25	1.—
Fourth report.	54	5/-	0.65	2.60

	Number	Price		
		s. d.	\$	Sw. fr.
International Sanitary Regulations				
World Health Organization Regulations No. 2	41	5/-	0.65	2.60
Leprosy, Expert Committee on				
First report	71	1/6	0.20	0.80
Malaria, Expert Committee on				
Report on the third session	8	2/3	0.30	1.20
Report on the fourth session	39	1/6	0.20	0.80
Fifth report	80	1/9	0.25	1.—
Malaria Conference in Equatorial Africa				
Report	38	3/6	0.45	1.80
Malnutrition, Prevention and treatment of severe, in times of disaster				
Report of a group of consultants	45	2/9	0.35	1.40
Maternity Care, Expert Committee on				
First report: a preliminary survey	51	1/3	0.15	0.60
Mental Health, Expert Committee on				
Report on the first session	9	2/3	0.30	1.20
Report on the second session	31	2/9	0.35	1.40
Third report ("The community mental hospital")	73	2/-	0.25	1.—
Alcoholism Subcommittee				
Report on the first session	42	1/3	0.15	0.60
Second report	48	2/-	0.25	1.—
Mentally Subnormal Child (The)				
Report of a Joint Expert Committee convened by WHO with the participation of United Nations, ILO, and UNESCO	75	1/9	0.25	1.—
Nursing, Expert Committee on				
Report on the first session	24	1/6	0.20	0.80
Second report	49	1/3	0.15	0.60
Third report	91		<i>In preparation</i>	
Nursing Education, Working Conference on				
Report	60	1/6	0.20	0.80
Nutrition, Joint FAO/WHO Expert Committee on				
Report on the first session	16		<i>Out of print</i>	
Report on the second session	44		<i>Out of print</i>	
Third report	72	1/6	0.20	0.80
Occupational Health, Joint ILO/WHO Committee on				
Second report	66	1/6	0.20	0.80
Onchocerciasis, Expert Committee on				
First report	87	1/9	0.25	1.—
Physically Handicapped Child, Joint Expert Committee on the (WHO, United Nations, ILO, and UNESCO)				
First report	58	1/6	0.20	0.80
Plague, Expert Committee on				
Report on the first session	11	1/6	0.20	0.80
Second report	74	9d.	0.10	0.40