

Intermediate Hosts of *Schistosoma* in Africa

Some Recent Information

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Dr Mandahl-Barth's monograph on the intermediate hosts of Schistosoma in Africa, published by the World Health Organization in 1958, attempted to clarify the complicated subject of the taxonomy of Biomphalaria and Bulinus—the snail vectors of bilharziasis in Africa. The classification of these vectors, however, is still far from being cut-and-dried, and each fresh fact unearthed must be regarded as a potential challenge to its validity. Since the publication of the monograph a great deal of further material has been submitted to the WHO Snail Identification Centre at Charlottenlund, Denmark. The additional information collected, together with some amendments to the earlier data, is presented in this supplementary contribution to the monograph.

Since the publication in 1958 of the author's monograph on intermediate hosts of *Schistosoma* in Africa,¹ much material has been sent to the WHO Snail Identification Centre at Charlottenlund, Denmark, from various parts of Africa.

Considerable collections were submitted by Dr Gillet from the Belgian Congo and Ruanda-Urundi and by Dr McCullough from the northern part of Northern Rhodesia. Other collections, smaller in respect of the number of samples but nevertheless of the greatest interest, were sent by Mr Cridland from Uganda, Dr McMahon, Dr Teesdale and Dr Verd-court from Kenya Colony, Dr Maffi from Somalia, Dr Najjar from Ethiopia, Dr van Eeden from the Union of South Africa, and Mr Webbe from the Tanga, Bagamoyo and Mwanza districts of Tanganyika Territory. In all, these new collections comprise 369 populations of *Biomphalaria* and *Bulinus*, and of these some 1500 specimens have been dissected. Added to the specimens examined earlier, the new collections bring the total to about 7000 dissected specimens from 1163 different populations.

This new material has not only added much to our knowledge of the taxonomy and distribution of several species and subspecies, but has also revealed

some new subspecies and even a new species, so that some additions and corrections to the monograph are needed. Without the kind help of the gentlemen mentioned above, this progress would have been impossible, and the author takes great pleasure in expressing his most cordial thanks to all of them.

Although the *Biomphalaria* and *Bulinus* of some countries of Africa—for instance, Gambia, Egypt, Somalia, Uganda, Kenya Colony, Belgian Congo, Northern Rhodesia, and the Union of South Africa—are fairly well known, it must be emphasized that the snail fauna of the remaining countries, which together form about two-thirds of Africa south of the Sahara, is incompletely known or practically unknown, very little reliable information or material being available. It is highly desirable, indeed essential, that snail-collecting activities should increase in the near future, otherwise it will be a very long time before the complicated taxonomy of the intermediate hosts of *Schistosoma* in Africa reaches a satisfactory stage. Nor should it be forgotten that even when such a stage has been reached the work will not be finished, because a number of taxonomic problems within the African Planorbidae will never be solved satisfactorily without recourse to laboratory research.

The additions and corrections presented below are listed by species and subspecies in the same order as these are dealt with in the monograph. To facilitate reference, the numbering in the monograph is indicated in parentheses after the name of the species or subspecies.

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¹ Mandahl-Barth, G. (1958) *Intermediate hosts of Schistosoma: African Biomphalaria and Bulinus*, Geneva (World Health Organization: Monograph Series, No. 37). Originally published in *Bull. Wld Hlth Org.*, 1957, 16, 1103; 17, 1.

BIOMPHALARIA

B. pfeifferi subsp.

A very large collection from the eastern part of the Belgian Congo and Ruanda-Urundi has shown that it is almost impossible to separate the various forms of *B. pfeifferi* in these areas, where the subspecies *bridouxiana*, *nairobiensis*, and *rüppellii* merge into each other. New material from the northern part of Tanganyika Territory presents the same difficulty of separating *bridouxiana* and *nairobiensis*. It seems most likely that the areas around lakes Kivu and Tanganyika are the centre from which the various forms of *B. pfeifferi* have spread. As *B. pfeifferi gaudi* is inseparable from *nairobiensis* except in its distribution, and *nairobiensis* is most likely merely a transitional stage between *bridouxiana* and *rüppellii*, it seems wiser not to divide *B. pfeifferi* into subspecies. This solution will probably be the best from a medical point of view, especially as all forms act as intermediate hosts of *Schistosoma mansoni*, although it is far from being satisfactory for malacologists, since the subspecies, when typically developed, seem to be a reality. The difficulties arise from the many intermediate forms and from our insufficient knowledge of the ecophenotypical variation. Laboratory experiments must be carried out to determine which characters are due to genetic factors and which are caused by the conditions of the habitat.

New material examined: *Transvaal*: Gudzani River, Orami River Dam. *Angola*: Nova Lisboa. *Northern Rhodesia*: Namwandwe, Lupuma Dam (Fort Rosebery district). *Belgian Congo*: Kisenyi, Sake, Kirinye, Ruburale, Muringa, Nyabidahina, Lungutu, Lubarika, Kalambo, Nyakabere, Rusabagi, Kiliba, Runingo, Kitumbili, Sandoa, Stanleyville, Kirotshe, Katana, Kalambare, Kibangula, Butembo, Sange, Lemera, Mugarura, Bwegera, Kawezi. *Ruanda-Urundi*: Kigali, Lake Tshohoha, Mutongo, Shangugu. *Tanganyika Territory*: Arusha, Moshi, Endagikot. *Kenya Colony*: Taveta, Mwea, Kitui, Kabarnet. *Sudan*: Kosti.

B. pfeifferi rhodesiensis Mandahl-Barth (3)

This form—designated "*B. pfeifferi rhodesiensis* n. subsp." in the monograph—differs so much from all the other forms of *B. pfeifferi* that it would probably be better to regard it as a distinct species; experimental evidence must be awaited, however, before a final decision can be made.

New material examined: *Northern Rhodesia*: Matanda.

B. choanomphala choanomphala (Martens) (8)

An empty shell from Lake Naivasha (Kenya) looks very much like the nominate form. More material is desirable.

B. smithi Preston (10)

New material examined: *Ruanda-Urundi*: Kigali, Lake Tshohoha.

The few specimens from these localities were immature and the identification is not quite certain. More material is desirable.

B. angulosa Mandahl-Barth (14)

Designated "*B. angulosa* n. sp." in the monograph, this species has been found in Johannesburg, Transvaal, as well as in the places mentioned in the paragraph "Distribution". The specimens from Johannesburg are quite typical apart from being smaller. With just over four whorls they have the following measurements—diameter of shell (D): 9.5 mm; height of last whorl (H): 3.5 mm; and diameter of umbilicus (U): 3 mm. Probably they are not full-grown.

B. sudanica sudanica (Martens) (18)

The original material examined also included specimens from Kosti in the Sudan.

B. sudanica tanganyicensis (Smith) (19)

New material examined: *Belgian Congo*: Kalambo, Lubarika, Nyakabera, Mugurura, Kilomony, Kiliba. *Ruanda-Urundi*: Kigali, Lake Murago, Lake Mugesera, Lake Rugwero.

B. sudanica rugosa n. subsp. (see Plate IA and Fig. 2a)

The shape and dimensions of the shell are as in the nominate form, but the growth lines are coarser. The type-specimen has the following measurements—D: 14.8 mm; H: 3.7 mm; and U: 6.5 mm. The mean measurements of five paratypes are as follows—D: 13.3 mm; H: 3.7 mm; and U: 5.7 mm.

The radula has the same small teeth as the two other subspecies of *B. sudanicus*, but in the genital organs it differs from both of them by the much longer vergic sheath, which is almost twice as long as the preputium. The verge itself is a little shorter than the sheath (see Fig. 2a).

Distribution: known only from the type-locality, Luimbe near Kapalala, Northern Rhodesia, where it was collected by Dr McCullough. *B. sudanica* has never been found so far south before.

BULINUS

B. (Ph.) africanus africanus (Krauss) (1)

The paragraph "Distribution" in the monograph should be amended to read: Natal, Transvaal, Southern and Northern Rhodesia, Mozambique, and probably also Tanganyika.

New material examined: *Northern Rhodesia*: Fort Rosebery, Ndola Lagoon. *Nyasaland*: Blantyre.

B. (Ph.) africanus ovoideus (Bourguignat) (2)

New material examined: *Belgian Congo*: Lusangi, Wapinda, Kibangula. *Ruanda-Urundi*: Shangugu.

B. (Ph.) abyssinicus (Martens) (3)

New material examined: *Somalia*: Lac Anole and Lac Busbusc-Burgao, which are both near the Kenya border and thus outside the drainage of the Juba River.

B. (Ph.) nasutus (Martens) (4)

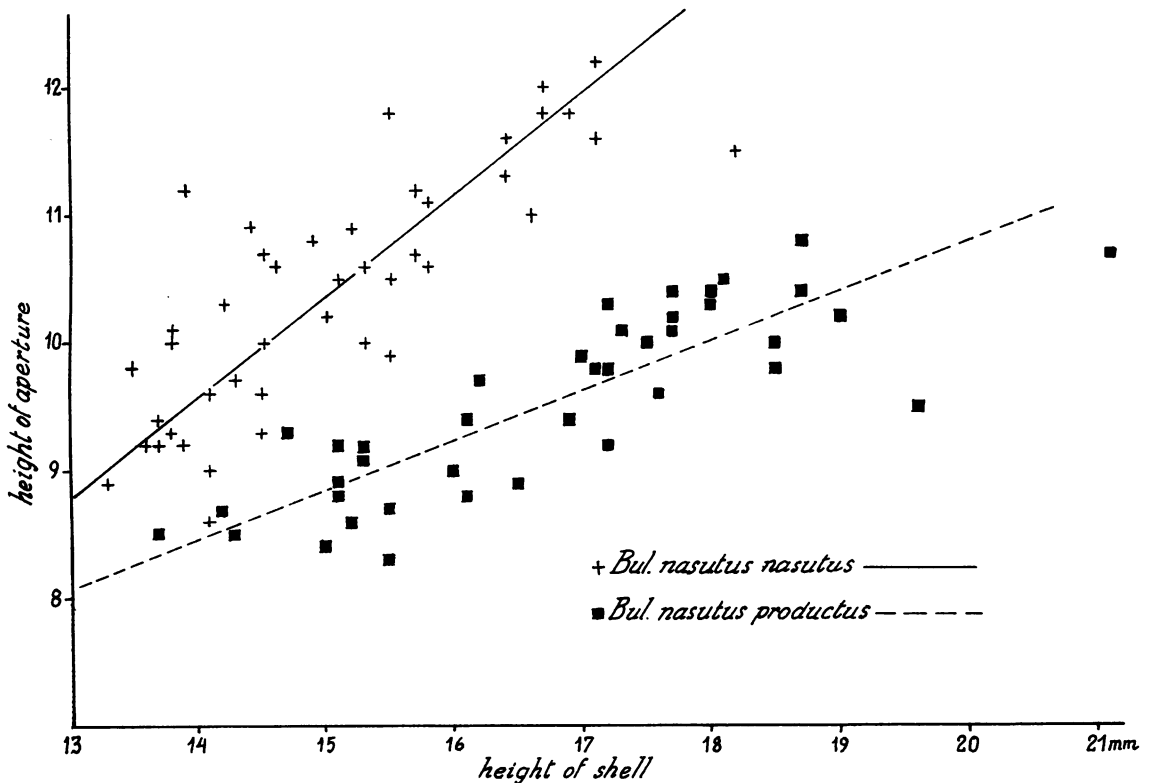
The examination of a large collection from the type-locality, Bagamoyo in north-eastern Tanganyika, has shown that there is a remarkable difference in the shape of the shell between this and the form occurring in Uganda. The difference is best expressed as the ratio height of aperture to height of shell. Fig. 1 shows this ratio for 42 specimens from

the Bagamoyo and Tanga districts and for 40 specimens from Uganda and western Kenya, all measuring more than 13.0 mm in height. It will be seen that the way of growing is different in the two lots, and that very few intermediates occur, so that it is justifiable to regard them as distinct subspecies. The Tanganyika form is the typical *B. nasutus nasutus*, while the Uganda form must be described as a new subspecies, *B. nasutus productus*.

B. (Ph.) nasutus nasutus (Martens) (see Plate II A, B)

The full-grown shell consists of five-and-a-half whorls, which means at least half a whorl more than any other *Physopsis* and one whorl more than *B. globosus*, the only one with which it could be confused. The spire is pointed, broadly conical and rather prominent, constituting about 33% of the height. The basal margin of the aperture is groove-like and more or less drawn out in the shape of a

FIG. 1
RATIO OF HEIGHT OF SHELL TO HEIGHT OF APERTURE IN *BULINUS NASUTUS NASUTUS*
AND *BULINUS NASUTUS PRODUCTUS*



spout. The columella is straight and more or less truncate. The microsculpture consists of spirally arranged rows of minute nodules or sometimes punctures, as a rule more coarse on the upper whorls and becoming finer on the lower, but usually covering the entire shell. In other species of *Physopsis* the microsculpture is restricted to the spire. The colour is usually a yellowish or reddish brown. At each pause in the growth the outer lip becomes slightly thickened by a reddish brown lip, and in most specimens two or more such lips may be seen inside as darker, and outside as lighter, transverse bands.

The mean measurements of ten specimens from Bagamoyo are as follows—height of shell (H): 14.7 mm; diameter of shell (D): 9.1 mm; and height of aperture (A): 10.2 mm. The biggest specimen (from Pongwe) has the following dimensions—H: 18.2 mm; D: 10.5 mm; and A: 11.5 mm.

The radula teeth are equal in size to those of *B. africanus*. The vergic sheath is as long as, or a little longer than, the preputium.

Distribution: Zanzibar, Eastern Tanganyika and Kenya.

Material examined: *Tanganyika Territory*: Tanga, Bagamoyo, Morogoro. *Zanzibar*. *Kenya Colony*: Kitui.

B. (Ph.) nasutus productus n. subsp. (see Plate II C, D)

This subspecies differs from the nominate form by the longer and more slender shell and the higher spire, which on the average constitutes about 43% of the height of the shell. Otherwise it agrees with the typical form.

The type-specimen (see Plate XIXc in the monograph) has the following dimensions—H: 17.5 mm; D: 9.5 mm; and A: 10.0 mm. The mean measurements of five paratypes are as follows—H: 17.2 mm; D: 9.2 mm; and A: 10.0 mm. The biggest specimen (from Asembo, Kenya) has the following dimensions—H: 21.1 mm; D: 10.7 mm; and A: 10.7 mm.

Distribution: Western Kenya and Uganda. Type-locality: Lake Kyoga at Bugondo.

Material examined: *Kenya Colony*: Asembo. *Uganda*: Iganga, Bugungu, Nyenga, Nkondo Dam, Bugondo, Akoli. *Tanganyika Territory*: Mwanza, Usagara, Magu, Tinde.

B. (Ph.) globosus (Morelet) (6)

Unfortunately some localities in Mozambique were listed erroneously under Angola in the monograph. The part of "Material examined" concerning

these countries should be amended to read: *Mozambique*: Boboli, Limpopo, Zambesi, Mogovolas, Nam-pula, Ribane, Malema, Vila Cabral, Maniamba, Marrupa, Montepwezi, Mocimboa da Praia, Palma, Porto Amelia, Erati, Nakala, Mosuril, Imala, Moginkwal, Antonio Enes. *Angola*: Sassa River, Morine, Lufinda, Dando, Cangombe, Chibia.

New material examined: *Natal*: Ndumu Game Reserve, Port Shepstone. *Northern Rhodesia*: Samfya, Mwewa, Shikamushile, Matanda, Kalaba, Ndola. *Kapalala*. *Belgian Congo*: Bukama, Katana, Kainama.

B. (B.) tropicus tropicus (Krauss) (8)

New material examined: *Orange Free State*: Steynsrust, Sasolburg, Vredefort, Kroonstad, Odendaalsrus, Marquard, Ventersburg. *Basutoland*: Roma. *Bechuanaland*: Palapye, Lobatsi. *Transvaal*: Claremont, Carolina, Ermelo, Mosane River, Bronkhorstspuit, Bethal, Rustenburg. *Northern Rhodesia*: Fort Rosebery, Samfya, Ndola Lagoon, Shikamushile, Matanda, Nsalushi Island, Lule Dambo, Mwewa.

B. (B.) tropicus toroensis nom. n. (see Plate XXVIIIa, c in the monograph)

This subspecies was designated "*B. (B.) tropicus mutandaensis* (Preston)" in the monograph, but examination of preserved material of Preston's "*Physa*" *mutandaensis* has shown that this is a distinct species belonging to the *truncatus* group and different from the other populations united under the name "*B. (B.) tropicus mutandaensis*". It is therefore necessary to give these other populations a new name.

The subspecies *B. tropicus toroensis* has a rather large, inflated shell with a low or very low spire and a large and wide aperture. The columella is usually straight and broadly reflexed. As a rule no particular sculpture is present, but in some localities the shells are more or less distinctly costulate. The shell is of a dull light or dark brownish colour.

As type the specimen shown in Plate XXVIIIa is selected and the type-locality is the crater lake 13 miles (21 km) south of Fort Portal, Toro, Uganda. It has the following measurements—H: 11.6 mm (not 12.1 mm as stated on Plate XXVIII); D: 9.2 mm; and A: 9.6 mm. The mean measurements of ten paratypes are as follows—H: 11.7 mm; D: 8.7 mm; and A: 9.4 mm. The biggest specimen seen (from Isunga) has the following dimensions—H: 17.6 mm; D: 11.7 mm; and A: 12.1 mm.

The radula teeth have the same shape, but are slightly larger than those of *B. tropicus tropicus*. Otherwise there are no differences in the soft parts.

Distribution: Lakes (mainly crater lakes) in the western province of Uganda, in Ruanda-Urundi, and in the adjacent part of the Belgian Congo and Tanganyika Territory.

Material examined: *Uganda*: Fort Portal, Isunga, Kichwamba. *Ruanda-Urundi*: Lake Luhondo, Lake Mohasi and Lake Rugwero. *Tanganyika Territory*: Usagara. *Belgian Congo*: Kibati, Mongbwalu, Djungu, Lake Gandu (erroneously listed under "*B. sericinus*").¹

"*B. (B.) sericinus* (Jickeli)" (14)

Hitherto the systematic position of Jickeli's "*Isidora sericina*" has not been known with certainty, because no preserved material from Ethiopia has been available. Owing to the kindness of Dr Najjar it has now been possible to examine the soft parts of true *sericinus* from Lake Tana. Anatomically these specimens agree with *B. truncatus* in having the same arrowhead-shaped mesocones on the lateral teeth and genital organs of the same type. It is thus beyond doubt that *sericinus* is a form of *truncatus*, and owing to the costulate shell it is justifiable to regard it as a distinct subspecies, *B. (B.) truncatus sericinus*, characteristic for the Ethiopian highland. The Nubian specimens from El 'Alaqi, Abu Simbel and Ballana represent true intermediates between the typical *truncatus truncatus* and *truncatus sericinus*. The correct taxonomic position is between *B. truncatus truncatus* and *B. truncatus trigonus*, numbered 17 and 18, respectively, in the monograph.

The specimens from Lake Gandu in the north-eastern part of the Belgian Congo do not belong to *sericinus*, but are a deviating form of *B. tropicus toroensis*. Unfortunately the radula of this form was incorrectly shown as the radula of *sericinus* in the monograph (Fig. 19 m). A drawing of the true *sericinus* radula is given here (see Fig. 2 b).

New material examined: *Ethiopia*: Lake Tana.

B. (B.) truncatus truncatus (Audouin) (17) (see Plate I B, C)

Since the monograph was written, two new forms of *B. truncatus* have come to the author's knowledge. As both of them come from areas well outside the known range of *truncatus* in Africa, thus indicating that the distribution of the species is much wider than hitherto supposed, it is reasonable to mention them, especially because they must be regarded as

potential vectors of the Egyptian *Schistosoma haematobium*.

One of these new forms comes from the Ruzizi plains around Kalambo and Bwegera. Both in the shell and in the anatomy the specimens resemble very closely the typical form from Egypt, apart from the relatively higher aperture in most specimens. The mean measurements of ten specimens from Kalambo are as follows—H: 11.6 mm; D: 8.4 mm; and A: 9.7 mm. A few specimens look very much like Bourguignat's "*Physa*" *randabeli* from Lake Tanganyika and have similar measurements. It is therefore possible that "*Physa*" *randabeli* should be included in the list of synonyms of *B. truncatus* rather than of *B. coulboisi*, unless the form from the Ruzizi plains can be regarded as a distinct subspecies, in which case it should be designated *B. truncatus randabeli* (Bourguignat). It is, however, better to defer the final classification until material from Lake Tanganyika is available.

Material examined: *Belgian Congo*: Kalambo, Bwegera.

As mentioned in the footnote on page 60 of the monograph, the author received from Dr van Eeden a few specimens of a hitherto unknown form of the *truncatus* group from Ovamboland. These specimens do not differ in the soft parts from the typical form of *truncatus*, but the shells are rather different, being much more globose and inflated and having a very low spire. Further, the lower part of the columella is somewhat oblique, thus calling to mind the much smaller *B. transversalis* from Lake Victoria. The colour is a light yellowish grey. The mean measurements of five shells are as follows—H: 11.8 mm; D: 10.2 mm; and A: 10.2 mm. The material, consisting of only five specimens from two localities, is too small for a definite assessment of the taxonomic position to be made.

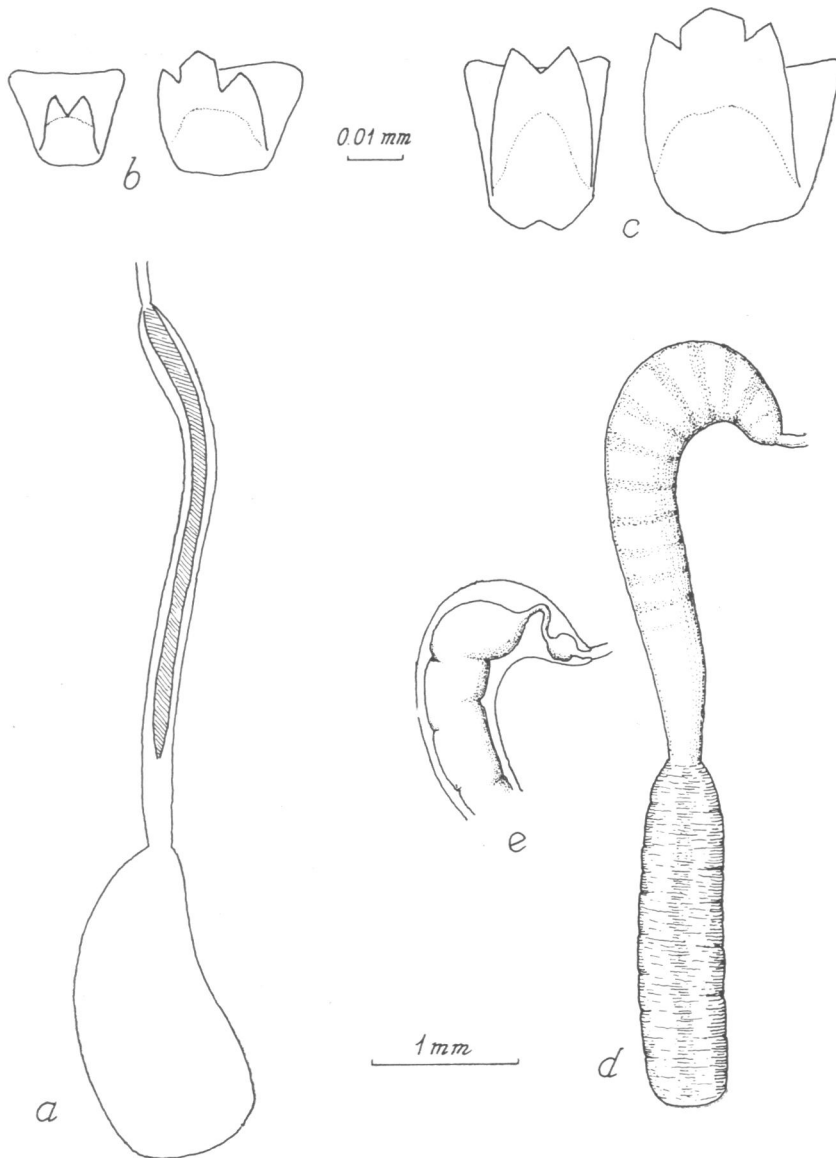
Material examined: *South-West Africa*: Okwambi, Ondangua.

B. (B.) nyassanus (Smith) (20)

New material has shown that the first lateral tooth does not always have a bifid mesocone and ectocone and, further, that the shell in some localities is not more solid than in other *Bulinus*. It is questionable whether *nyassanus* is really a distinct species or is only a subspecies of *B. truncatus*, with which it is closely allied. As all the specimens in hand are considerably smaller than the type-specimen, the author prefers to leave the decision until better material is available.

¹Two other localities—Lake Bunyoni and Bukama—were listed erroneously in the monograph. An anatomical examination of specimens from Lake Bunyoni has shown that they belong to *B. coulboisi*. Those from Bukama are *B. (Ph.) globosus*.

FIG. 2

ANATOMY OF SOME *BIOMPHALARIA* AND *BULINUS* SPECIMENS

a=*Biomphalaria sudanica rugosa*, copulatory organ

b=*Bulinus truncatus sericinus*, central tooth and first lateral tooth

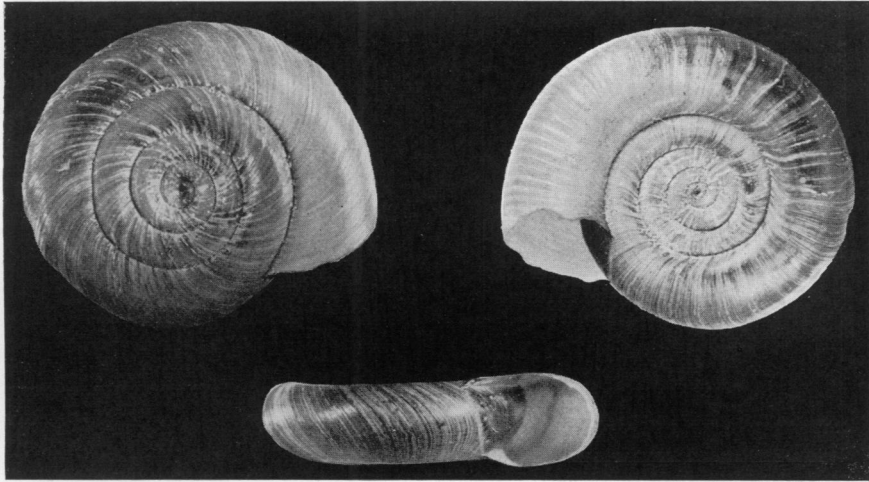
c-e=*Bulinus mutandaensis*: c. central tooth and first lateral tooth;

d. copulatory organ;

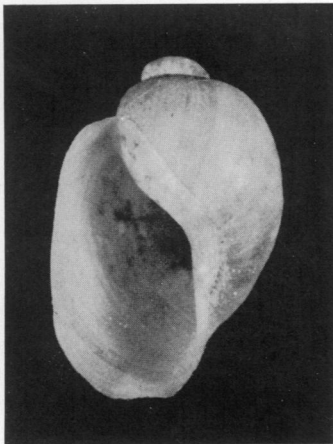
e. vergic sheath opened to show swollen basal part of epiphallus.

PLATE I

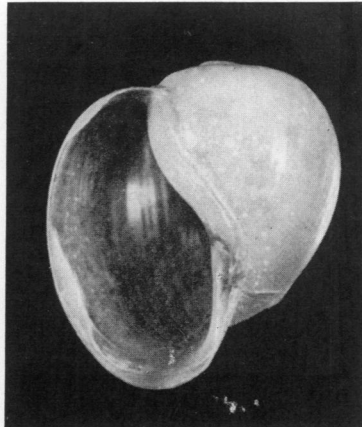
A



B



C

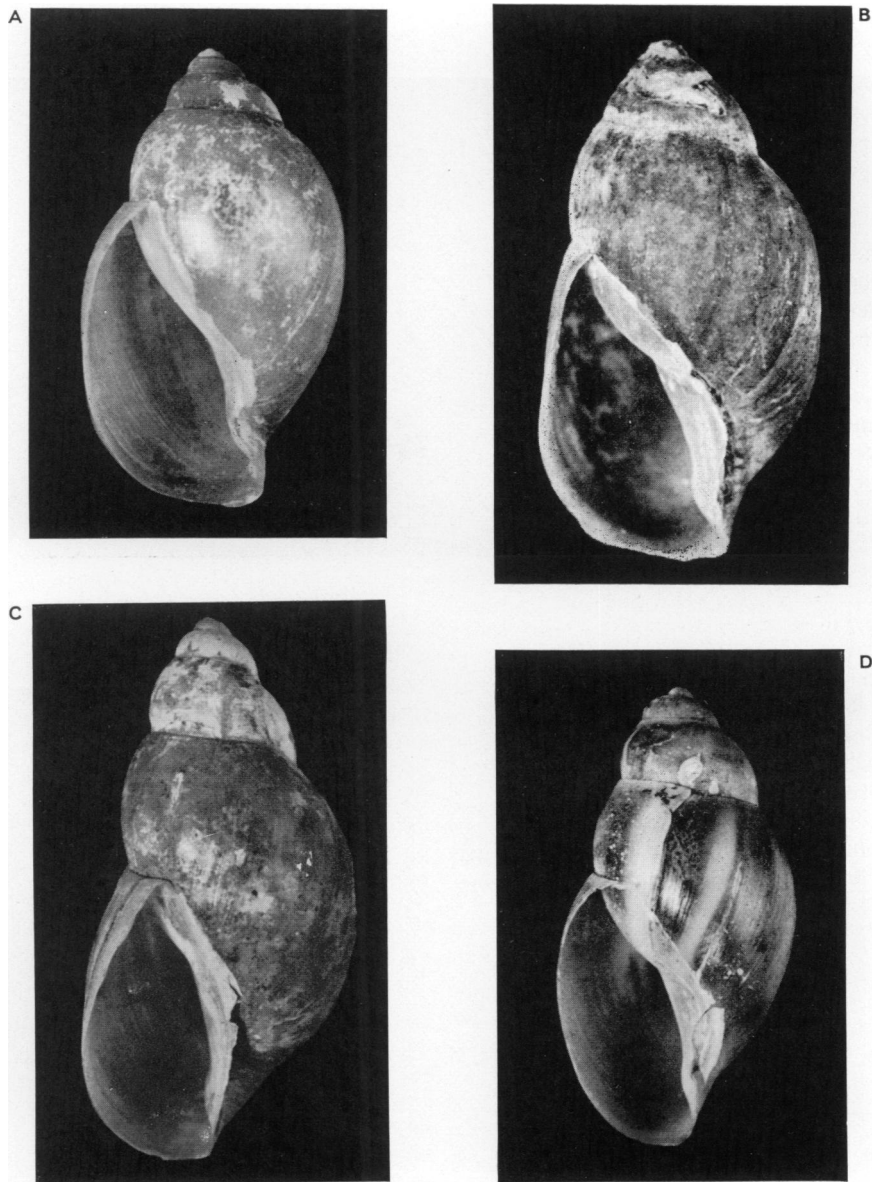


A. *Biomphalaria sudanica rugosa*, Luimbe, Northern Rhodesia,
D: 14.8 mm (type-specimen)

B. *Bulinus truncatus*, Kalambo, Belgian Congo, H: 11.5 mm

C. *Bulinus truncatus* subsp.?, Okwambi, South-West Africa,
H: 10.7 mm

PLATE II



A. *Bulinus nasutus nasutus*, Bagamoyo, Tanganyika, H: 15.5 mm
B. *Bulinus nasutus nasutus*, Pongwe, Tanganyika, H: 17.5 mm
C. *Bulinus nasutus productus*, Asembo, Kenya, H: 18.0 mm
D. *Bulinus nasutus productus*, Akoli, Uganda, H: 15.2 mm
The light transverse bands indicate earlier lips.

New material examined: *Tanganyika Territory*: Lake Nyasa at Tukuyu. *Nyasaland*: Domira Bay, Fort Johnston.

B. (B.) mutandaensis (Preston) (see Plate XXVIIIb in the monograph)

As explained under *B. tropicus toroensis* it has been necessary to separate the true *mutandaensis* from the *tropicus* form occurring in the lakes of western Uganda, Ruanda-Urundi and eastern Belgian Congo.

The shell is rather narrow, somewhat cylindrical, and consists of four whorls of which the last one is only very slightly convex. The aperture is high and narrow, wider in the basal part and with a distinctly twisted columella. The sculpture consists of fine, but distinct and somewhat raised, closely set, transverse striae. The colour is a yellowish grey. The mean measurements of ten shells are as follows—H: 10.8 mm; D: 7.8 mm; and A: 8.4 mm. The biggest specimen seen is only 11.9 mm high.

In the internal organs *B. mutandaensis* differs from all other *Bulinus* by the very large radula teeth, which are almost twice as large as those of *B. truncatus* (see Fig. 2 c). Of the four specimens available for dissection, three were aphyllid. The copulatory organ of the fourth is rather large and of almost the same width throughout the length. The vergic sheath is distinctly longer than the preputium. The epiphallus is unusually short and its basal part is swollen (possibly an abnormality) (see Fig. 2 d, e). The other organs agree with those of the typical *truncatus*.

Distribution: Lake Mutanda in the extreme south-western part of Uganda, where it seems to be endemic.

Material examined: *Uganda*: Lake Mutanda.

B. (B.) coulboisi (Bourguignat) (21)

To the description given in the monograph it should be added that some specimens from Lake Kivu have lateral teeth with slightly arrowhead-shaped mesocones which, perhaps, indicates a closer relation to *B. truncatus* than hitherto assumed. The problem can be solved only by experimentation.

New material examined: *Uganda*: Lake Bunyoni. *Ruanda-Urundi*: Lake Tshohoha, Lake Rugwero, Shanguu. *Tanganyika Territory*: Mwanza.

B. (B.) reticulatus Mandahl-Barth (23)

A few specimens from Rae near Kisumu are unusually large. The dimensions of the biggest specimen are as follows—H: 6.9 mm; D: 4.1 mm; and A: 3.6 mm.

B. (B.) forskalii (Ehrenberg) (25)

New material examined: *Tanganyika Territory*: Bagamoyo, Morogoro, Usagara. *Belgian Congo*: Kiliba, Kalambo, Runingo, Kibangula, Kasongo, Lubutu, Walikale. *Somalia*: Lac Curni, Lac Anole.

B. (B.) scalaris (Dunker) (26)

It is noteworthy that the vagina is frequently everted and protrudes to such an extent that it is visible below the mantle border and almost reaches the sole of the foot. Nothing like this has been observed in other *Bulinus*. In a specimen from Kiliba both the verge and the vagina were everted. The verge is very long and slender, and is not much wider than the vas deferens.

New material examined: *Northern Rhodesia*: Abercorn. *Belgian Congo*: Kiliba, Jadotville.