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The generic position of Planorbis (Gyraulus) intermixtus Mousson, 1874, and Planorbis presbensis Sturany, 1894 (Gastropoda, Basommatophora)

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INTRODUCTION

Since the planorbid species *intermixtus* was described (Mousson, 1874) as a member of the subgenus *Gyraulus* of the genus *Planorbis* it has been regarded as an *Anisus* or *Gyraulus* species by most subsequent authors (e.g., Baker, 1945; Starmühlner & Edlauer, 1957; Chu, Massoud & Arfaa, 1968). Similarly a planorbid species, described as *presbensis* from Lake Presba (Makedonia) by Sturany (1894), has generally been dealt with as a *Gyraulus* species (e.g., Jaeckel, Klemm & Meise, 1957), though originally described as a *Planorbis* without giving a "subgenus" name. It must be borne in mind, however, that in the last century, and in some countries yet today, all members of the family Planorbidae were united in a single genus, viz. *Planorbis*, and that the taxa, now generally accepted as genera, at that time were conferred at most subgeneric rank.

In the course of taxonomical studies on Eurasiatic *Gyraulus* species anatomical examination has revealed that placing *Planorbis intermixtus* and *presbensis* in the genus *Gyraulus* cannot be sustained. The characters supporting the decision to place these species in the genus *Planorbis* s.s. are described here.

MATERIAL AND METHODS

Preserved and living snails of *Planorbis intermixtus* were kindly provided by Dr. J. Massoud, who maintains a stock from North Iran (Caspian Sea area) for parasitological studies in his laboratory at the Institute of Public Health Research, University of Teheran[1]. Snails were reared in Tübingen, relaxed with pentobarbital for 1 to 1½ days, fixed in formalin (4%) and preserved in 70% alcohol (according to Meier-Brook, 1976a). Dissecting and drawing was done under a Wild Stereomicroscope M 7 with a camera lucida. Measuring of organs was performed on drawings with the aid of a cartographic distance meter. The extent of narrow and inconspicuous lumina was made visible by allowing air to enter them during the transfer from xylene to the mounting medium (Eukitt^{R}), as described by Meier-Brook (1975: fig. 1). For terminology see fig. 1. Chromosome numbers were determined in acetic orcein squash preparations of early embryonic stages and ovotestes under a Zeiss interference contrast microscope.

RESULTS

Redescription of *Planorbis intermixtus* Mousson, 1874.

Material examined: North Iran (Caspian Sea area), 67 individuals bred from a stock collected by J. Massoud; Shiraz (South Iran): pool near Maharlu salt lake, two individuals collected by S. Bauer and R. Carle, Tübingen, 18 July 1975; Samava/Euphrates: shells of the original series after which Mousson described his species (Zoologisches Museum Zürich, ZMZ 521254). This lot contains 18 specimens of this species in addition to 11 shells of *Gyraulus euphraticus* Mousson described from the same locality. A lectotype is designated here (fig. 2).

The shell is very similar to that of *Planorbis planorbis* (L.), from which it differs only by its smaller size. The lectotype is 6.6 mm in maximum diameter and 1.8 mm high and has 4¼ whorls. The biggest shell from Samava kept apart by Mousson in a separate tube (ZMZ 521255) is 8.6 by 2.2 mm. In laboratory cultures the most frequent sizes of adult snails were 6 to 7 mm diameter, but under low

[1] According to Yousif & Lämmler (1975) snails of the same stock have recently proved in experiments to be suitable hosts of the nematode *Angiostrongylus cantonensis*, pathogenic to man.

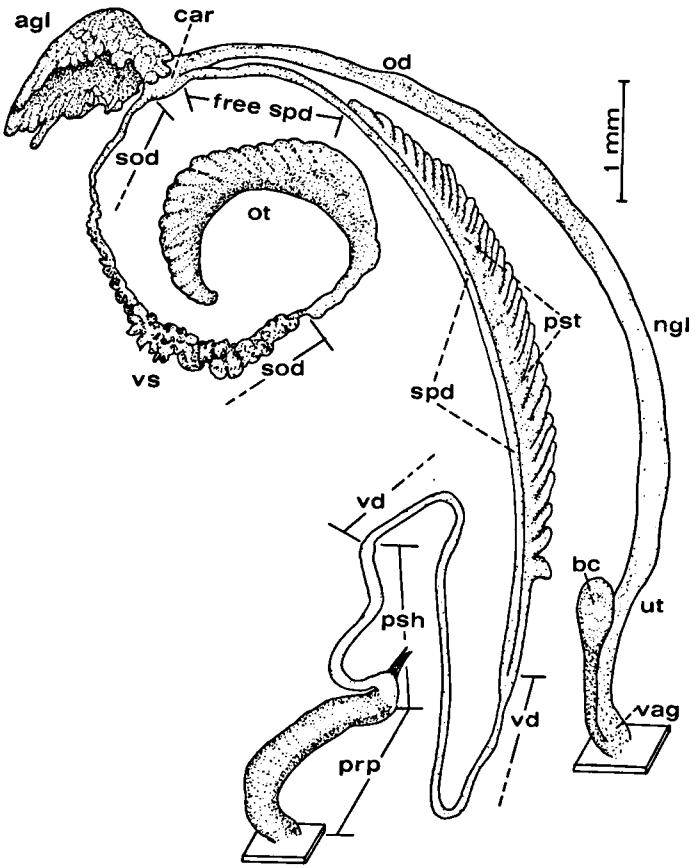

Fig. 1. Reproductive system of *Planorbis intermixtus*, N. Iran, maximum shell diameter 6.3 mm. Arrows and bars indicate the extension of organs used for comparison (tables 1 and 2). Key to lettering: agl – albumen gland; bc – bursa copulatrix; car – carrefour; free spd – free sperm duct; mrp – penis retractor muscle; ngl – nidamental gland; od – oviduct; ot – ovotestis; prp – preputium; pst – prostate gland; sod – spermoviduct; spd – sperm duct; ut – uterus; vag – vagina; vd – vas deferens; vs – vesicula seminalis.

density conditions giant forms of up to 11.5 mm diameter could be obtained. A more or less distinct obtuse angle on the left side of the shell, which was already noticed by Mousson, clearly places the shell in

species	locality	maxim. shell diam. n*	maxim. shell diam. $\bar{x}$ ±s.d.	no. of wh. $\bar{x}$	number of prostate diverticula n*	number of prostate diverticula range	number of prostate diverticula $\bar{x}$ ±s.d.
a) *planorbis*	Fehmarn	18	9.8±1.9	4.9	16	35–52	43.0±4.6
b) *planorbis*	Neusiedler See	18	9.6±1.4	4.8	17	42–57	48.8±4.1
c) *planorbis*	Öland	2			2	45+45	
d) *intermixtus*	N-Iran	19	7.0±1.7	4.4	45	21–36	30.0±2.8
e) *intermixtus*	S-Iran[2]	2			1	20	
f) *atticus*	Mykonos[2]	2	5.2+5.2	3.5	2	30+27	
g) *atticus*	Crete[2]	1	3.6	3	1	19	
h) *carinatus*	Allgäu	11	12.1±0.8	5	11	23–30	28.6±3.8
i) *carinatus*	Bodensee	5	14.6±0.7	5	5	21–32	28

[1] sph – tadpole spherical, el – tadpole elongate, clb – club, tpr – tapering.
[2] Killed in alcohol without relaxation.
* Not each parameter was determined in all individuals due to occasional breaking of organs during dissection or to other reasons.

Table 1. Lengths (in mm) and other characters of reproductive organs in *Planorbis*, fixed in extended state, unless indicated otherwise.

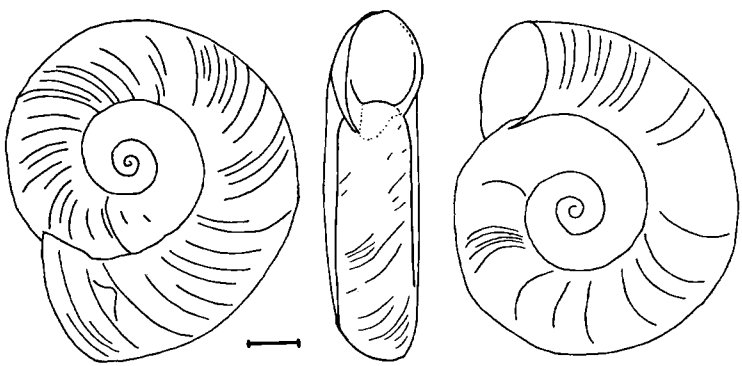

Fig. 2. Lectotype of *Planorbis intermixtus* Mousson, 1874. Scale 1 mm.

the genus *Planorbis* O.F. Müller. There is no resemblance to shells of *Gyraulus* to which group it had been referred by Mousson.

The animal has a lead- to anthracite-coloured cephalopedal mass, a

free sperm duct	vas deferens	penis sheath	pre-putium	shape types[1] of bursa copulatrix a. ductus b.c.			
$\bar{x}$ ±s.d.	$\bar{x}$ ±s.d.	$\bar{x}$ ±s.d.	$\bar{x}$ ±s.d.	sph	el	clb	tpr
3.7±0.9	7.7±1.8	1.0±0.2	2.3±0.4	21%	63%	16%	–
2.6±0.5	6.8±1.3	1.3±0.2	2.3±0.6	36%	57%	7%	–
		0.9+1.3	1.9+1.5	–	x	x	–
1.7±0.6	4.9±1.1	1.6±0.2	2.3±0.9	–	31%	53%	16%
				–	–	x	–
1.4+ ?	4.7+4.7	1.2+1.4	1.2+1.2	–	–	x	–
?	2.4	1.2	0.9	–	–	x	–
3.9±0.5	6.6±0.7	1.7±0.4	2.1±0.3	75%	–	25%	–
4.7±0.6	7.3±0.7	1.9±0.4	2.9±0.5	x	–	–	–

(Table 1 ctd.)

dark grey to black mantle which is a little lighter and of a more scattered pigmentation in the kidney-region. The albumen and digestive glands have a very slight pigmentation, the ovotestis is moderately grey. The kidney has straight margins. The reproductive organs are of the *Planorbis*-type: the preputium is voluminous, its lumen being narrowed by two pilasters which carry transversal folds. The penis sheath, harbouring the penis, shows two distinctly separated portions: a short bulbous terminal part which passes into the preputium from which it is separated by the (internal) velum. The penis retractor muscle inserts at this part of the penis sheath. The more apical part is considerably longer and so slender that it is scarcely distinguished from the vas deferens which is only slightly thinner. This is obviously the reason that Baker (1945: 46, 52, pl. I fig. 2) overlooked its true nature and, thus, mistook this part as the distal part of the vas deferens. The preputium is well distinguished from the unpigmented penis sheath by its strong pigmentation. In well extended animals the penis sheath is about $\frac{3}{4}$ the length of the preputium (cf. table 2). The penis itself, which is nearly the same length as the penis sheath, has a terminal opening and does not carry a stylet which would have justified placing the species in the genus *Gyraulus*. The vas deferens varies greatly in length, being mostly between three and four times the length of the penis sheath. The prostate duct and the sperm duct are separated, its part uncovered by the prostate, called free sperm duct, mostly being slightly longer than the penis sheath (cf. table 2). The carrefour and the albumen gland do

species	locality	ratio $\frac{\text{penis sheath}}{\text{preputium}}$ n*	range	$\bar{x}$ ±s.d.[2]
a) *planorbis*	Fehmarn	16	0.30–0.71	0.44±0.11
b) *planorbis*	Neusiedler See	13	0.43–0.71	0.58±0.08
d) *intermixtus*	N-Iran	16	0.28–0.90	0.75±0.18
f) *atticus*	Mykonos[1]	2	0.97+1.17	
h) *carinatus*	Allgäu	10	0.43–1.00	0.75±0.17
i) *carinatus*	Bodensee	4	0.74+0.76	+ 0.67+0.80

* See footnote of table 1.
[1] Killed in alcohol without relaxation.
[2] t-test: $p<0.001$ in a/d, b/d, and a/b.

Table 2. Length ratios of reproductive organs in *Planorbis*, fixed in extended state, unless indicated otherwise.

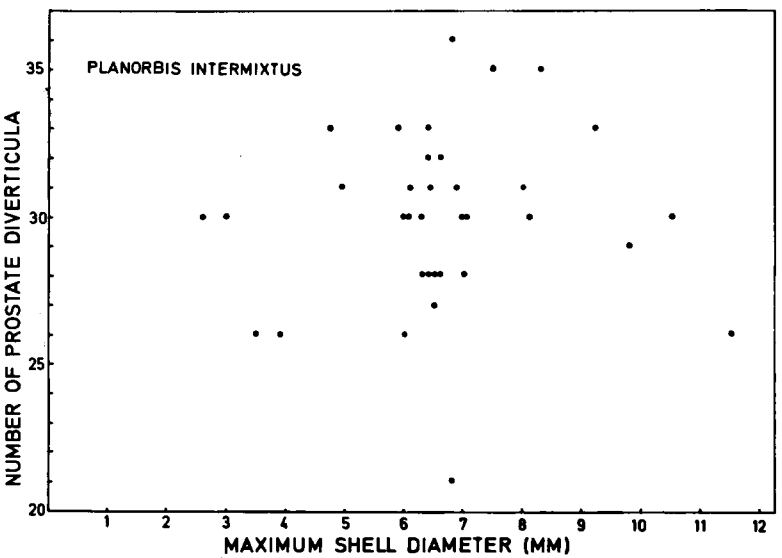

Fig. 3. Numbers of prostate diverticula in various size classes of *Planorbis intermixtus*, N. Iran.

ratio $\frac{\text{vas deferens}}{\text{penis sheats}}$			ratio $\frac{\text{free sperm duct}}{\text{penis sheath}}$		
n*	range	$\bar{x}$ ±s.d.	n*	range	$\bar{x}$ ±s.d.
15	5.6–10.0	7.7±1.3	14	2.0–5.4	3.8±1.0
12	3.0–7.8	5.1±1.1	10	1.2–3.1	2.1±0.6
14	1.3–4.3	3.3±0.7	10	0.7–1.7	1.2±0.4
2	3.9+3.4		1	1.2	
9	3.0–4.9	4.1±0.7	10	1.4–3.6	2.4±0.7
4	3.3+4.6 +	4.5+3.0	4	2.6+2.4 +	3.3+2.1

(Table 2 ctd.)

not show distinct features suitable for species discrimination in the genus. The prostate has around 30 diverticula (range = 21 – 36) (cf. table 1). The number of prostate diverticula, by the way, is not age or size dependent, since no correlation could be found (fig. 3).

The vagina usually broadens just behind the female genital opening; at this part it is entered by the duct of the bursa copulatrix. This organ is more variable in this species than in others of the genus. In the laboratory reared individuals, its shape (fig. 4) varied from tapering towards the vagina (4c) to club-shaped ($4b_1$, $4b_2$) to tadpole-shaped ($4a_2$) where the duct was distinctly set off against the bursa. There were transitions between these types. The majority of specimens had a club-shaped bursa ($4b_2$). The uterus and oviduct did not show any features suitable for species discrimination in this genus.

The seminal vesicles are bulbous and usually carry spinous protrusions. The innumerable lobes of the ovotestis do not permit using them for taxonomical purposes.

Relationships of *Planorbis intermixtus*

The closest relative is *P. planorbis* of which *intermixtus* would appear to be merely a stunted form. The facts opposing this opinion are: (1) Even under optimum breeding conditions *P. intermixtus* does not reach more than 11 or 12 mm in diameter, which *P. planorbis* under normal conditions exceeds by far (14 to 16 mm). (2) *P. inter-*

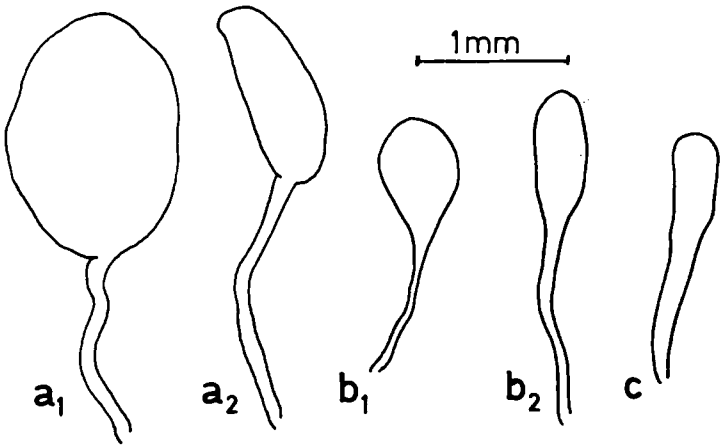

Fig. 4. Shape types of the bursa copulatrix in *Planorbis*. a_1 – tadpole spherical; a_2 – tadpole elongate; b_1 – club spherical; b_2 – club elongate; c – tapering (a_1 – *P. carinatus*, Bodensee; a_2 to c – *P. intermixtus*, N. Iran).

mixtus has a significantly lower number of prostate diverticles than *P. planorbis* (table 1). (3) *P. intermixtus* has a longer penis sheath and, thus, a significantly higher ratio penis sheath/preputium, though it must be admitted that these figures in the two populations studied of *P. planorbis* also differ significantly. The vas deferens and the free sperm duct (definition see fig. 1) are considerably shorter in *P. intermixtus* than in *P. planorbis* both absolutely and relative to the penis sheath. These differences, however, are not sufficiently obvious to enable clear identification. Chromosome numbers, determined in *P. intermixtus*, N. Iran, and in *P. planorbis* from Fehmarn and Neusiedler See, were equally n = 18 and 2n = 36. The radulae in the three populations also showed no differentiating features.

With *P. carinatus* O.F. Müller our species has several common anatomical features, such as the number of prostate diverticula, the length ratio penis sheath/preputium, etc., but the well known conchological characters of *P. carinatus*, particularly the carina in the middle of the shell, as well as the predominance of the "spherical tadpole" shape type of the bursa copulatrix clearly separate these two species, while *P.*

planorbis and *P. intermixtus* could perhaps be regarded as members of the same "Rassenkreis".

Nomenclature. – The conchological resemblance of *P. intermixtus* and *P. atticus* Bourguignat might imply species identity which would mean that *intermixtus* is a junior synonym of *atticus*, but anatomically studied material of *atticus* was too scarce to come to final judgement in this respect.

Planorbis presbensis Sturany, 1894

This species, endemic to the Makedonian Lake Presba, was anatomically studied in twelve individuals (two collected by Dr. W. Rähle and ten collected by Dr. H. Schütt, both in June 1973 near Oteševo) which had been killed by immersion in 70% alcohol and were, thus, fully contracted.

The shell is distinctly pseudodextral with a descending last whorl. Consequently the shell is broadly umbilicate, the aperture oblique and elliptical. The periphery is rounded, not angled. The periostracum is light corneous. *P. presbensis* is unusually thick-shelled (fig. 5).

The animal is dark; its pigmentation is similar to that described for *P. intermixtus*. The kidney has straight margins. The reproductive

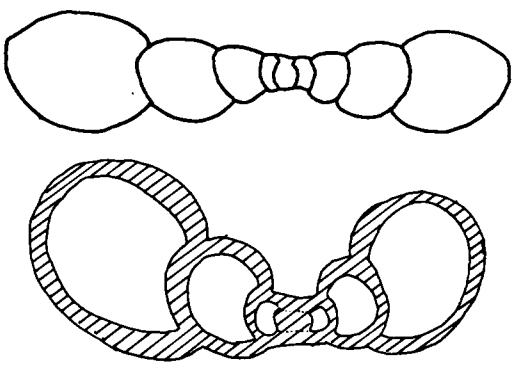

Fig. 5. Median cross sections of shells of *P. intermixtus* (top) and *P. presbensis* (bottom).

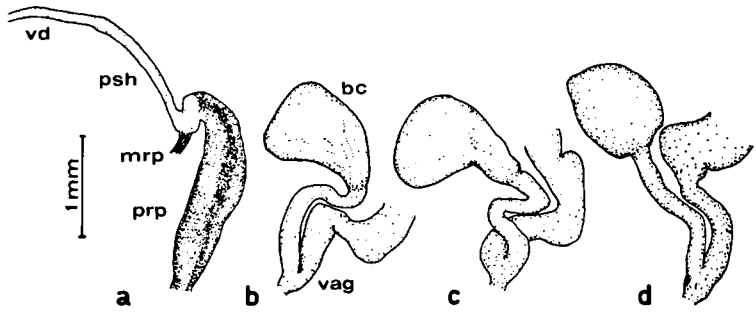

Fig. 6. *Planorbis presbensis*, ♂ copulatory organ (a) and examples of the bursa copulatrix (b to d). For lettering see fig. 1.

organs are so similar to those described for *P. intermixtus* that no distinction can be made except in the bursa copulatrix which is of the tadpole type, i.e. the bursa is always sharply set off against its duct, but usually (in 6 of 12 individuals) it has a clear fig shape (fig. 6b and c); in other cases I found a spherical (in 3/12, cf. fig. 6d) or a more elongate bursa (3/12). The prostate gland has 24 to 32 (mean: 28.3, s.d. ± 2.8) diverticula branching off the prostate duct, which is well separated from the sperm duct, as in *P. intermixtus*. The penis sheath (mean length 1.8 ± 0.2 mm) and the preputium (fig. 6a) are virtually indistinguishable from these organs in *P. intermixtus*, and the ratio penis sheath/preputium ($\bar{x}$ = 0.89 ± 0.15) probably is in the same order of magnitude as in *P. intermixtus*, when the rate of contraction in the studied animals of *P. presbensis* is taken into account (cf. Meier-Brook, 1976b). The observation that the penis was curled (like a cork-screw) within the sheath does not seem to be of any taxonomical significance, since in two individuals this organ was found to be straight and under certain fixing circumstances the penis can be found curled in other planorbid groups too.

Relationships of *Planorbis presbensis*

The anatomical features strongly support a common origin of *P. presbensis* and the widespread species of the genus *Planorbis*. The differences in shell form and colour, however, are so striking that an early branching off from the group leading to the recent species *P.*

planorbis, *P. intermixtus*, *P. atticus*, and *P. carinatus* must be postulated. A close relative of *P. presbensis* appears to be *P. macedonicus* Sturany from Lake Ochrid. This species, described as belonging to the subgenus *Gyrorbis* and subsequently regarded as a *Gyraulus*, has shell characters intermediate between those of *P. presbensis* and *P. atticus*, but more resembling the latter species. *P. macedonicus* has turned out to be a true *Planorbis* species (Hubendick & Radoman, 1959: 243). It has a more brownish shell, a weak angle on the functionally left side, but there is a tendency to deflect the last whorl similarly as in *P. presbensis*. Anatomically there are only slight differences as could be seen in a few individuals of *P. macedonicus* kindly provided by Dr. Rähle. My observations were confirmed by comparison with unpublished drawings of *P. macedonicus* which Dr. Hubendick kindly put at my disposal. While *P. macedonicus* appears to fit relatively well in the group of the remaining *Planorbis* species, the aberrant shell characters of *P. presbensis* make it necessary to place this species in a separate subgenus:

Planorbis (**Crassiplanorbis**) nov. subgen.

Diagnosis. — A subgenus of *Planorbis* O.F. Müller, 1774, which is distinguished by a distinctly convex-concave shell, rapidly increasing whorls, a rounded, not angled, periphery, oblique aperture, an extremely strong shell, and a light corneous periostracum.

Typus subgeneris: *Planorbis presbensis* Sturany, 1894.

Other shell characters as described by Sturany (1894). Anatomical characters distinguishing the subgenus from the nominal subgenus *Planorbis* have not been found.

Shells of anatomically studied snails of *P. intermixtus* (alcohol, RMNH 9027) and *P. presbensis* (dry, RMNH 55126) have been deposited in the Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands.

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SUMMARY

The two planorbid species described as *Planorbis (Gyraulus) intermixtus* Mousson, 1874, from Samava/Euphrates and as *Planorbis presbensis* Sturany, 1894, from Lake Presba, Makedonia, usually considered to belong to the genus *Gyraulus* Charpentier, 1837, turned out to be members of *Planorbis* O.F. Müller, 1774. Their anatomical characters are described and compared with those of *Planorbis planorbis* (L.) and *P. carinatus* O.F. Müller. For the conchologically aberrant *P. presbensis* a new subgenus, *Crassiplanorbis*, is established. The two species studied thus have to be named *Planorbis (Planorbis) intermixtus* Mousson, 1874, and *Planorbis (Crassiplanorbis) presbensis* Sturany, 1894.

REFERENCES

BAKER, F.C., 1945. The molluscan family Planorbidae: I-XXXVI, 1-530. Urbana.

CHU, K.Y., J. MASSOUD & F. ARFAA, 1968. Distribution and ecology of Bulinus truncatus in Khuzestan, Iran. — Bull. Wld Hlth. Org. 39: 607-637.

HUBENDICK, B., & P. RADOMAN, 1959. Studies on the Gyraulus species of Lake Ochrid. Morphology. — Ark. Zool. (2) 12 (16): 223-243.

JAECKEL, S.G., W. KLEMM & W. MEISE, 1957. Die Land- und Süsswassermollusken der nördlichen Balkanhalbinsel. — Abh. Ber. st. Mus. Tierk. Dresden 23: 141-205.

MEIER-BROOK, C., 1975. Mikropräparation kleiner Schnecken. — Mikrokosmos 64: 123-127.

——, 1976a. An improved relaxing technique for mollusks using pentobarbital. — Malac. Rev. 9: 115-117.

——, 1976b. The influence of varied relaxing and fixing conditions on anatomical characters in a Planorbis species. — Basteria 40: 101-106.

MOUSSON, M.A., 1874. Coquilles terrestres et fluviatiles recueillies par M. le Dr. Alex. Schlaefli dans l'Orient. — J. Conchyl., Paris 22: 5-60.

STURANY, R., 1894. Zur Molluskenfauna der europäischen Türkei. — Annln. naturh. Mus. Wien 9: 369-390.

YOUSIF, F., & G. LÄMMLER, 1975. The suitability of several aquatic snails as intermediate hosts for Angiostrongylus cantonensis. — Z. Parasitenk. 47: 203-210.