Meded. Werkgr. Tert. Kwart. Geol. | 26(4) | 145-181 | 3 tabs, 2 pls | Leiden, December 1989

NOTES ON QUATERNARY FRESHWATER MOLLUSCA OF THE NETHERLANDS, WITH DESCRIPTIONS OF SOME NEW SPECIES

by

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Meijer, T. Notes on Quaternary freshwater Mollusca of The Netherlands, with description of some new species. — Meded. Werkgr. Tert. Kwart. Geol., 26(4): 00-00, 3 tabs, 2 pls. Leiden, December 1989.

Quaternary freshwater molluscs of The Netherlands are reviewed. The species *Theodoxus serratiliniformis* Geyer, 1914, *Nematurella stenostoma* Nordmann, 1901 and *Dreissena polymorpha* (Pallas, 1771), which were recorded previously from the Dutch Quaternary, do in fact not occur. Other species are demonstrated to represent new taxa and are here described (*Viviparus teschi* n. sp., *Bithynia (Neumayria) bavelensis* n. sp., *Fagotia wuesti* n. sp., *Planorbarius peetersi* n. sp., *Sphaerium (Sphaeriastrum) rosmalense* n. sp.). The taxonomy of several other species is revised [*Parafossarulus priscillae* (Girotti, 1972), *Tanousia runtoniana* (Sandberger, 1880), *Tournouerina belnensis* (Delafond & Depéret, 1893), *Lithoglyphus jahni* Urbansky, 1975]. Three small euryhaline prosobranchs are recorded as fossils from The Netherlands for the first time [*Hydrobia neglecta* Muus, 1963; *Semisalsa stagnorum* (Gmelin, 1791) and *Paludinella littorina* (Chiaje, 1828)]. A lectotype for *Nematurella minima* Tesch, 1939, is designated.

Key words — Freshwater Mollusca, Quaternary, biostratigraphy, bibliography, The Netherlands.

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CONTENTS

SAMENVATTING

Aantekeningen over Kwartaire zoetwatermollusken van Nederland met beschrijvingen van enkele nieuwe soorten.

In dit artikel wordt een overzicht gegeven van de huidige kennis van de zoetwatermollusken uit Nederlandse Kwartaire afzettingen. Er wordt uitgegaan van de overzichten die Tesch (1929b, 1944) en Van der Vlerk & Florschütz (1950, 1953) gegeven hebben. Het commentaar en de nieuwe feiten zijn nomenclatorisch, taxonomisch en stratigrafisch van aard. Het bleek nodig enkele nieuwe soorten te introduceren (*Viviparus teschi* n. sp., *Bithynia (Neumayria) bavelensis* n. sp., *Fagotia wuesti* n. sp., *Planorbarius peetersi* n. sp. en *Sphaerium (Sphaeriastrum) rosmalense* n. sp.). Enkele door vroegere auteurs genoemde soorten blijken niet in Nederlandse Kwartaire afzettingen voor te komen [*Theodoxus seratiliniformis* Geyer, 1914, Nematurella stenostoma Nordmann, 1901 en *Dreissena polymorpha* (Pallas, 1771)]. Het stratigrafische bereik van alle nu uit Nederland bekende soorten is samengevat in Tabel 1, terwijl in Tabel 2 een overzichtje wordt gegeven van in vroegere literatuur veel gebruikte soortnamen, met daarbij de nieuwe taxonomie. Drie kleine euryhaliene kieuwslakken worden voor de eerste maal als fossielen uit Nederland gemeld [*Hydrobia neglecta* Muus, 1963; *Semisalsa stagnorum* (Gmelin, 1791) en *Paludinella littorina* (Chiaje, 1828)].

Bij een selectie van soorten worden enkele aantekeningen gemaakt en waar dat nodig werd geacht, is ingegaan op het stratigrafisch bereik in Nederland en ook daar buiten. In een apart hoofdstuk worden enkele biostratigrafische aantekeningen gemaakt.

In de literatuurlijst is geprobeerd alle referenties op te nemen die betrekking hebben op zoetwatermollusken uit Nederlandse Kwartaire afzettingen.

INTRODUCTION

The only reviews of the Quaternary non-marine molluscs of the Netherlands written so far are by Tesch (1929b, 1944) and van der Vlerk & Florschütz (1950, 1953). These authors noted the potential of several freshwater species for dating purposes. However, a good understanding of the taxonomy and as complete as possible a knowledge of presence and absence of all recognised species is essential for a biostratigraphical application of this group of molluscs.

Since 1953 many investigations for mapping purposes have been carried out by the Rijks Geologische Dienst; most of them remained unpublished. Several authors have published additional data on Early and Middle Quaternary non-marine molluscs (Kuijper, 1973; Meijer, 1974, 1976, 1987a, 1987b, 1988a, and 1988b; Spaink, 1968; among others). These publications and the unpublished work at the geological survey demonstrated the need of a critical review.

In the first part several new species are introduced. The second part describes the stratigraphical ranges of all known species. In Table 1 the presence or absence in the temperate stages and in two of the cold stages of the Quaternary is indicated. If necessary, the taxonomy and the stratigraphical and geographical distribution of a species is discussed in more detail. Table 2 compares the former and the present nomenclature of a number of species.

For lithostratigraphical and chronostratigraphical data on the Dutch Quaternary the reader is referred to Zagwijn & van Staalduinen (1975) and Zagwijn (1985). A full stratigraphical treatment of numerous unpublished exposures, boreholes and other sites is beyond the scope of this review. For several key localities such a discussion is planned for the near future.

The third part discusses the biostratigraphical use of freshwater molluscs. An extensive bibliography, which lists not only the titles referred to in the text, but which comprises also all relevant literature as far as the Quaternary freshwater molluscs of The Netherlands are concerned, concludes this paper.

ABBREVIATIONS IN THE TEXT

The following abbreviations are used:

BM(NH)	—	British Museum of Natural History, Department of Palaeontology (London, U.K.)
LHB	—	coll. L.W. Hordijk (Brielle, The Netherlands)
MCL	—	coll. M.C. Cadee (Leiden, The Netherlands)
RGD	—	coll. Rijks Geologische Dienst (Haarlem, The Netherlands) (= Geological Survey of The Netherlands)
RGM	—	coll. Nationaal Natuurhistorisch Museum (formerly the Rijksmuseum van Geologie en Mineralogie) (Leiden, The Netherlands)
SMF	—	coll. Senckenberg Museum (Frankfurt am Main, F.R.G.)
TMA	—	coll. T. Meijer (Alkmaar, The Netherlands)
WKN	—	coll. W.J. Kuijper (Noordwijk, The Netherlands)
m	—	metres below surface
H	—	height of shell (in front view)
HB	—	height of body-whorl
HA	—	height of aperture
W	—	width of shell (gastropods); in bivalves W denotes the semidiameter
WA	—	width of aperture
L	—	length of shell
AA	—	apical angle
FAD	—	first appearance datum
LAD	—	last appearance datum

RO — restricted occurrence
54A/34 — RGD file number of a borehole.

All dimensions are given in mm.

ACKNOWLEDGEMENTS

The author is grateful to the following persons for support and permission to publish their data: Mr J. Cooper [BM(NH)], Mr L.W. Hordijk (Brielle, The Netherlands), Mr A.W. Janssen (RGM), Dr R. Janssen (SMF), Mr K. Jonges (Amsterdam, The Netherlands), Dr E. Krolopp (Hungarian Geological Survey, Budapest), Mr W.J. Kuijper (Noordwijk, The Netherlands), Dr C.P. Nuttall [BM(NH)], Dr R.C. Preece (Department of Zoology, University of Cambridge, U.K.).

Mr G.A. Peeters (Schiedam, The Netherlands) prepared the drawings, his help is highly appreciated. Mr J.W.M. Jagt (Venlo, The Netherlands) improved the English text, which took him quite some time.

I am indebted to the Director of the Rijks Geologische Dienst, for giving me permission to publish the results of this research.

DESCRIPTION OF NEW SPECIES

Viviparus teschi n. sp.
Pl. 1, Figs 1-3

1944 *Viviparus* sp. — Tesch, p. 6, figs 9-10.

Holotype — Pl. 1, Fig. 1a-b, kept in the RGD collection.

Locus typicus — Borehole Arnhem B.15 (40B/60) (province of Gelderland, The Netherlands), 83.20 m.

Stratum typicum — Tegelen Formation (Tiglian, Early Pleistocene).

Derivatio nominis — The species is named after P. Tesch (1879-1961), who stressed the value of freshwater molluscs in Quaternary stratigraphy.

Diagnosis — A species of the genus *Viviparus* Montfort, 1810, related to *V. glacialis* (Wood, 1872), but differing by a much wider apical angle.

Description — A solid, rather high-spired species of the genus *Viviparus* Montfort, 1810. The shell has five whorls, in all specimens the apex is corroded. The body-whorl is about 70% of shell height. At the periphery the whorls are bluntly angular; above it they are flattened. The shallow suture follows the periphery, which results in a flattened outline of the shell. Consequently, the bluntly angular periphery is only visible on the body-whorl. The apical angle is 50° in the holotype; it may reach values up to 65°. The sutural slope is 7°. The aperture is oval, with an angular upper side. Peristome

continuous. Callus thin, not far exceeding the aperture. Narrow umbilicus, partly covered with callus.

Surface of the shell smooth and glossy, with fine growth lines and very fine, regularly spaced, narrow furrows. At higher magnification (25 x) the striae appear to be lined series of densely packed small pits. Just below the suture two or three sharp, elevated spiral striae may be present. There are no prominent other sculptural elements.

Dimensions — H 28.2, W 19.0, HB 20.0, HA 13.1, WA 11.5 (holotype).

Material — This species is known only from boreholes. RGD collections: Leerdam (38H/148), 58.60-61.10 m (55 apical fragments, 107 fragments) Kedichem Formation (Leerdam Interglacial).

Arnhem B.1 (40B/48), 88.40-89.35 m (1 fragment); Arnhem B.12 (40B/56), 88.70-90.00 m (3 apical fragments, 4 fragments). Arnhem B.15 (40B/60), 83.20 m (2 adult specimens one of which is the holotype). Haaren (45C/125), 91.00-94.00 m (134 near-adult specimens and apical fragments and many additional fragments). Tegelen Formation (Tiglian).

Coll. LHB: Zuurland (37C/554), 65.00-66.00 m (1 specimen). Tegelen Formation (Tiglian).

Remarks — *Viviparus teschi* n. sp. is known only from the Early Pleistocene of The Netherlands. The species is most closely related to *Viviparus glacialis* Wood, 1872. These two species seem to be taxonomically distinct from other fossil and Recent Viviparidae of Western Europe and might represent a separate subgenus of *Viviparus*. Turriform, smooth-shelled Viviparidae from Villafranchian beds in Italy may be related to *V. glacialis* and *V. teschi* n. sp. See also the remarks under *V. glacialis*.

Bithynia (Neumayria) bavelensis n. sp.
Pl. 1, Figs 4-7

1968 *Bithynia tentaculata* — Spaink, p. 1383.
1974 *Bithynia tentaculata* subsp. — Meijer, p. 154, 159, pl. 3, fig. 42-49, pl. 5, fig. 71-78.
1986a *Pseudemmericia* n. sp. — Meijer, p. 162.

Holotype — Pl. 1, Fig. 4a-b, kept in the RGD collection.

Locus typicus — Clay-pit North of the village of Bavel (province of Noord Brabant, The Netherlands), Dutch coordinates (map-sheet 50B): 116.710/399.510.

Stratum typicum — Kedichem Formation (Bavel Interglacial, Early Pleistocene).

Derivatio nominis — The species is named after the village of Bavel (province of Noord Brabant, The Netherlands).

Diagnosis — A species of *Bithynia (Neumayria)*, to be distinguished from the most closely related species, *B. (N.) labiata* (Neumayr, 1875) and *B. (N.) neumayri* (Girotti, 1972), by its relatively more slender shell and its smaller size.

Description — Shell conical, elongated, rather solid and with a large body-whorl, pointed apex. Five convex, relatively high whorls, regularly and slowly expanding. Sutural slope 10-12°. Very narrow umbilicus, often covered with callus. Fine irregularly spaced growth lines, crossed by many indented

longitudinal striae, often obliquely crossed by raised sharp ridges, especially on the last whorl. The combination of all these elements gives a hammered sculpture. Aperture oval, adapically bluntly angular. Peristome continuous, reflected without preceding expansion of the shell. Reflected peristomes of near-adult stages are preserved as varices. Inside the aperture, at a small distance of its edge, the peristome is bordered by a faintly raised, narrow fringe.

Operculum calcareous, asymmetrically ovoid in outline, adapically with a sharp point, parietally concave, well-rounded otherwise. Exteriorly, fine growth lines are present. The small paucispiral nucleus is located below the centre. The paucispirally arranged growth lines in the nucleus continuously develop into concentrically arranged growth lines that comprise the largest area of the operculum. An indented furrow runs in a regular curve from the nucleus to the adapical point. This furrow is often very pronounced, giving the operculum a folded outlook. Interiorly, its surface is delicately granulate and shows a smooth, weakly raised fringe.

Dimensions — H 9.5, W 5.8, HB 6.9, HA 4.5, WA 3.5, AA: 45-60° (mean values of 10 paratypes).

Material — (All specimens from the type locality). RGM 229 730-732: 2 adults, 14 near-adults, 7 isolated opercula; RGD: 2 adults, 34 near-adults and apical fragments, 3 apertural fragments, 47 opercula; MCL: 6 near-adults, 48 isolated opercula; WKN: 4 adults (one of which with operculum), 11 near-adults, 130 isolated opercula; TMA: 2 adults, 14 near-adults, 60 isolated opercula.

Remarks — A discussion of the taxonomy of this species will be deferred to another occasion (Meijer, in prep. 3).

Seeing that the opercula are very similar to those of *Bithynia (Bithynia) tentaculata* (Linné, 1758) the species is certainly bound to be more widespread than is now known. In The Netherlands the species is known only with certainty at the type locality. There, it co-occurs with typical *Bithynia tentaculata*. Isolated opercula, perhaps of the same species, were found in coarse sediments of a com-

Plate 1

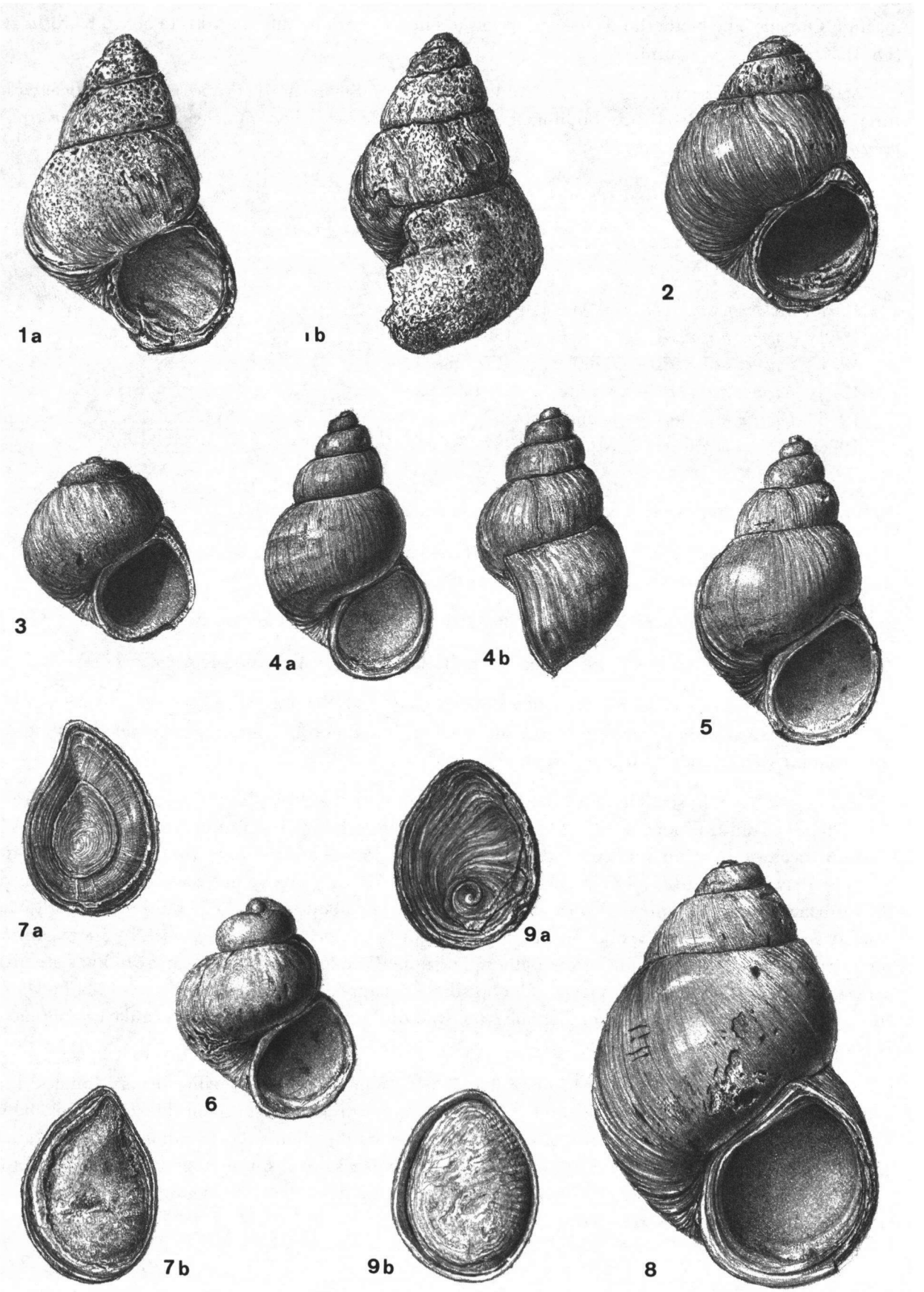
Viviparus teschi n. sp.
Fig. 1a-b Holotype. Borehole Arnhem B. 15 (40B/60), depth 83.20 m; a: front view, b: right lateral view, x 2.
Figs 2-3 Paratypes. Borehole Haaren (45C/125), depth 91-94 m; front views, 2: × 3½, 3: × 6.

Bithynia (Neumayria) bavelensis n. sp.
Clay-pit North of Bavel.
Fig. 4a-b Holotype; a: front view, b: right lateral view, × 8.
Fig. 5 Paratype; front view, × 8.
Fig. 6 Paratype, juvenile; front view, × 20.
Fig. 7a-b Paratype, operculum; a: external view, b: internal view, × 8.

Parafossarulus priscillae (Girotti, 1972)
Borehole Rosmalen (45B/6-7).
Fig. 8 Depth 110-120 m. Front view, × 8.
Fig. 9a-b Depth 113-115 m. Operculum, a: external view, b: internal view, × 8½.

All specimens in coll. RGD

Plate 1



parable age, formerly outcropping in an excavation some hundreds of metres to the North of the type locality. Outside The Netherlands the species occurs in Hungary in Villanian strata of *e.g.* Köröshegy (Dr E. Krolopp, pers. comm.).

Schlickum & Puisségur (1977) considered material from St. Bernard (France) to be identical with the present, new species. In my opinion the only available last whorl matches *Bithynia (Neumayria) neumayri* (Girotti, 1972) more closely.

Fagotia wuesti nov. sp.
Pl. 2, Figs 1-2

1901 *Melanopsis acicularis* — Wüst, p. 230, pl. 1.
1968 *Fagotia acicularis* — Spaink, p. 1383.
1971 *Fagotia acicularis* — Zeissler, p. 257, fig. 1.
1973 *Fagotia acicularis* — Mania, p. 81, tab. 25.
1986a *Fagotia acicularis* — Meijer, p. 162.
1988c *Fagotia acicularis* — Meijer, p. 387, 3 figs.

Holotype — Pl. 2, Fig. 1a-b, kept in the RGD collection.

Locus typicus — Clay-pit North of the village of Bavel (province of Noord Brabant, The Netherlands), Dutch coordinates (map-sheet 50B): 116.710/399.510.

Stratum typicum — Kedichem Formation (Bavel Interglacial, Early Pleistocene).

Derivatio nominis — The species is named after the late German palaeontologist E. Wüst.

Diagnosis — A species of the genus *Fagotia* Bourguignat, 1884, characterised by a high-spired, very straight-sided shell without obvious spiral and axial ornamentation. There is a relatively small body-whorl and a well-pronounced sinus in the growth-lines.

Description — Shell tall, straight-sided, occasionally slightly coeloconoid. The apical angle ranges from 25 to 30°. The sutural slope is 10°. There are at least nine whorls. The number of whorls is difficult to count because in adult specimens the apex is always lost. The first five whorls are convex with a moderately deep suture; all younger whorls are flattened with a very narrow and shallow suture. Shell surface glossy, ornamented with very fine spiral striae, about 35 on the penultimate whorl. The fine striae are most clearly visible on the upper half of the whorl. They are crossed by more prominent, irregularly spaced, sinuous growth lines. The upper and lower parts of the growth lines are prosocyrt, the middle part is opisthocyrt. The opisthocyrt part is situated at a distance of about 1/3 of the whorl height below the suture. Actually, the wall of the shell is sometimes irregularly undulated in axial direction.

The aperture is oval-elongated, adapically sharply angular. The inner lip forms a small callus that only covers a minor part of the body-whorl. The outer lip is sharp and not thickened, it is, however, hardly ever preserved. At the base it curves towards the columella, forming a small siphonal notch with hardly any canal. On the shell the canal gives rise to a spiral ridge turning around the columella. Adapically the ridge is covered by callus of the inner lip. The columella is rather short and slightly s-shaped. There is no umbilicus.

Several shells preserve a colour pattern. A narrow dark spiral band runs just below the suture. The band is therefore only visible on the last whorl. This pattern is also found in the Recent Aegean taxon *Fagotia acicularis stussineri* Schütt & Bilgin, 1974.

Dimensions — H 18.5, W 6.3, HB 10.6, HA 6.6, WA 3.2. These dimensions should be considered as minima because no undamaged shells are available. One exceptionally large specimen measures H 20.8, W 9. This specimen lacks the lower part of the aperture and at least 6 top whorls.

Material — (Known only from the Kedichem Formation, Bavel Interglacial). Clay-pit Bavel 1:RGD (64 specimens); RGM 229 733- 734 (84 specimens); MCL (24 specimens); WKN (158 specimens); TMA (79 specimens).

Clay-pit Bavel 1A: RGD (2 specimens); WKN (5 specimens); TMA (4 specimens, 1 fragment).

Remarks — In The Netherlands known from pits near the village of Bavel, East of Breda (province of Noord Brabant), now no longer accessible. The age of the deposits is late Early Pleistocene (Interglacial of Bavel).

Outside The Netherlands the species was already recognised about a century ago in Thuringia (G.D.R.). Mania (1973) and Zeissler (1971) mentioned the following localities: Voigtstedt/Edersleben, Kalbsrieth, Hoppberg near Rossleben, Zeuchfeld and Bottendorf. The deposits are assigned to the Borntal Interglacial and the Artern Interglacial, both of an early Middle Pleistocene age.

The most closely related species is the extant *Fagotia acicularis* (Férussac, 1823), which differs from the present species by its less tall, slightly cyrtoconoid spire with more convex whorls and a larger body-whorl. *Fagotia acicularis* has a lower number of whorls, while the sinus in the growth lines of this species is also less pronounced.

Until now, most fossil occurrences of *Fagotia* were ascribed to *F. acicularis*. Partly, these are now considered to belong to the present species. In my view fossil *Fagotia acicularis* does occur at the following localities: Andovce (Czechoslovakia; Ložek, 1964), Eurach (F.R.G.; Dehm, 1979), Moosburg (F.R.G.; Nathan, 1953), Sesselfelsgrotte (F.R.G.; Reisch; 1985), Tata (Hungary; Krolopp, 1969) and Vertesszöllös (Hungary; Krolopp, 1977). The deposits of these localities range in age between early Middle Pleistocene and Holocene. At present this species has a Danubian, Ponto-Caspian distribution.

Planorbarius peetersi n. sp.
Pl. 2, Fig. 4

1968 *Planorbis corneus* var. — Spaink, p. 1384.

Holotype — Pl. 2, Fig. 4a-b, kept in the RGD collection.

Locus typicus — Clay-pit North of the village of Bavel (province of Noord Brabant, The Netherlands), Dutch coordinates (map-sheet 50B): 116.710/399.510.

Stratum typicum — Kedichem Formation (Bavel Interglacial, Early Pleistocene).

Derivatio nominis — The species is named after Mr G.A. Peeters (Schiedam), the artist who prepared the excellent drawings of all species illustrated here.

Diagnosis — A species of the genus *Planorbarius* Froriep, 1806, closely related to *P. corneus* (Linné, 1758), from which it differs by the absence of a faint carina on the upper side of the whorls and by the relatively high body-whorl.

Description — (Shell interpreted as being sinistral). A species of the genus *Planorbarius* Froriep, 1806, with 4 3/4 rather rapidly expanding whorls. The embryonic shell comprises about 3/4 whorls. There is a rather deep suture. The body-whorl is relatively tall, with a height approximating that of the aperture. The axial curvature of the whorl is regularly circular in outline, with the periphery halfway the whorl height. A keel at the upper side of the whorl, running around the pseudo- umbilicus, is missing.

Height and width of the aperture are about equal. The aperture is in the shell's plane. The upper point of attachment to the preceding whorl lies exactly above the lower one, therefore the aperture has no oblique position in front view (Fig. 4a). In lateral view the apertural margin has a slightly oblique position. The upper side of the aperture is slightly flattened, but still moderately curved. Adapically the curvature increases regularly, without any sudden change. There is a narrow, deep umbilicus, in which the first whorls cannot be seen.

On the upper side all whorls are visible, with the apical whorls sunken down, forming a pseudo-umbilicus. Growth lines densely spaced, irregular, crossed by a spiral sculpture of many elevated striae. Superimposed, but not visible on the whole shell, there is an oblique arranged, hammered sculpture.

Dimensions — H 12.4, W (largest) 26.3, W (smallest) 21.0, WB 19.4, HA 12.3, WA c. 11.4 (holotype)

Material — With certainty known only from the Kedichem Formation (Bavel Interglacial). Clay-pit Bavel 1: RGD [1 adult specimen (holotype), 4 immature specimens, many fragments].

Plate 2

Fagotia wuesti n. sp.
Clay-pit North of Bavel.
Fig. 1a-b Holotype; a: front view, b: dorsal view, × 3½.
Fig. 2 Paratype, juvenile; front view, × 7.

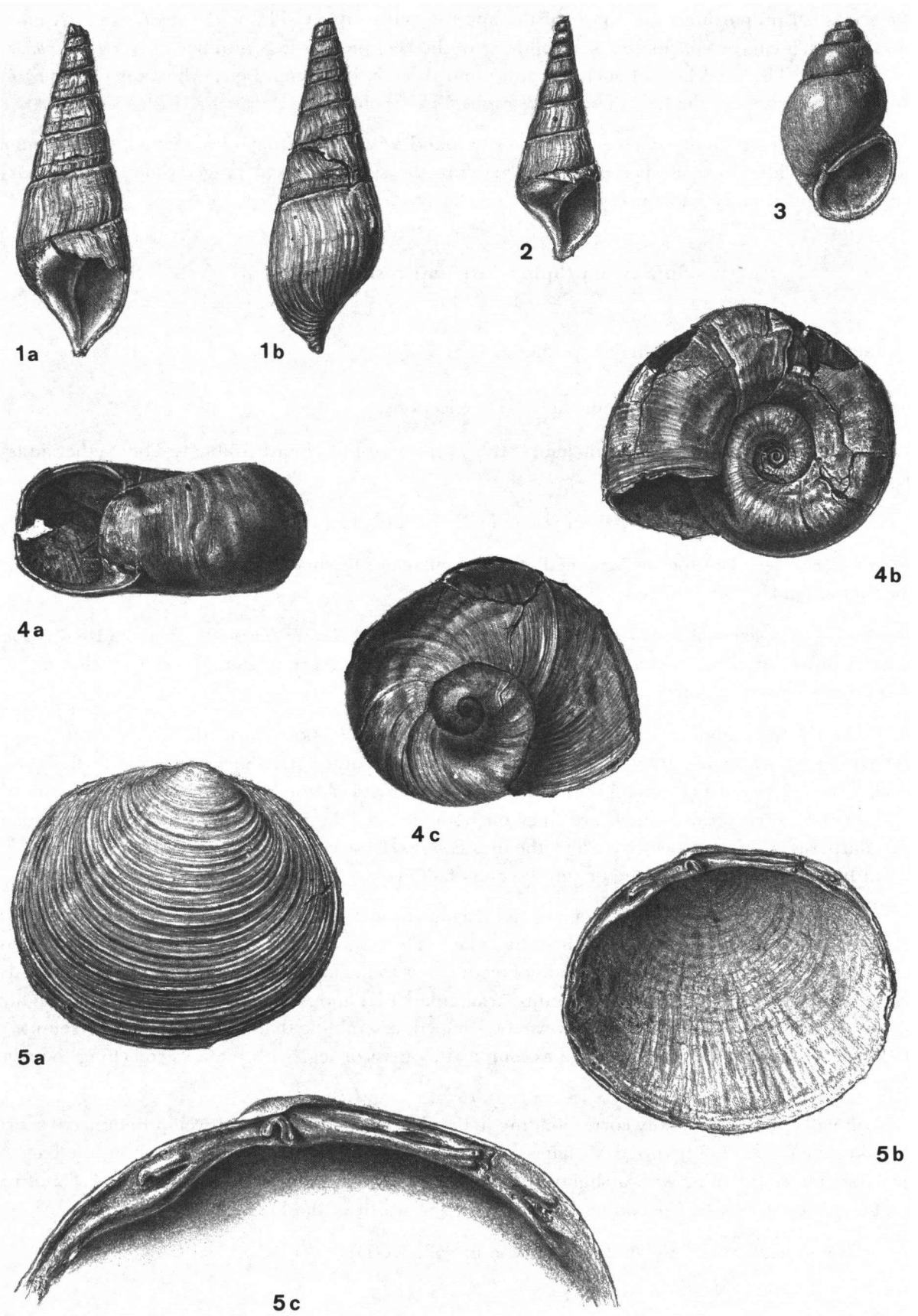
Tournouerina belnensis (Delafond & Depéret, 1893)
Borehole Rosmalen (45B/6-7), depth 110-120 m.
Fig. 3 Front view, x 15 (= lectotype of *Nematurella minima* Tesch, 1939)

Planorbarius peetersi n. sp.
Clay-pit North of Bavel.
Fig. 4a-c Holotype; a: frontal, b: apical, c: umbilical view, × 2.

Sphaerium rosmalense n. sp.
Borehole Rosmalen (45B/6-7), depth 110-120 m.
Fig. 5a-c Right valve, holotype; a: external view, b: internal view, x 6; c: hinge, × 12.

All specimens in coll. RGD

Plate 2



Remarks — In Bavel *P. peetersi* n. sp. occurs together with *P. corneus* (Linné, 1758) from which it clearly differs in shell proportions and shape of the aperture. The upper side in *P. corneus* is much more angular, which can be considered as a remnant of the keel present in a number of Neogene *Planorbarius* species. The total lack of such a feature and the relatively high body-whorl distinguishes *P. peetersi* n. sp. from *e.g.* the late Pliocene *P. garsdorfensis* Schlickum & Strauch, 1979.

Planorbarius is in Quaternary deposits mostly found as wall and apical fragments, which cannot adequately be identified to species level. Therefore the stratigraphical range of both Quaternary species is insufficiently known, especially in the Early Pleistocene.

Sphaerium (Sphaeriastrum) rosmalense n. sp.
Pl. 2, Fig. 5

1988 *Sphaerium* sp. — Meijer, p. 53.

Holotype — Pl. 2, Fig. 5a-c, kept in the RGD collections.

Locus typicus — Borehole near Rosmalen (45B/6-7) (province of Noord Brabant, The Netherlands). Depth: 110.00-120.00 m.

Stratum typicum — Tegelen Formation (Late Tiglian, Early Pleistocene).

Derivatio nominis — The species is named after the village of Rosmalen (province of Noord Brabant, The Netherlands).

Diagnosis — A species of *Sphaerium (Sphaeriastrum)*, related to *S. (S.) rivicola* (Lamarck, 1818), from which it differs by a more quadrate outline, a smaller size, a more obviously striate shell, and the shape of especially the cardinal teeth.

Description — Shell almost quadrate, well rounded in outline, posteriorly slightly truncate, compressed. Umbones small, situated subcentrally and directed anteriorly. Shell moderately solid, comparable with *S. corneum* (Linné, 1758). Outer surface irregularly sculptured with well pronounced, close-set concentric striae, which are finer on both sides of the umbo. Inner surface with broad, irregularly radiating grooves, crossed by the impressions of the concentric striae on the outer surface. Pallial line hardly visible, adductor impressions shallow.

Right valve: hinge plate rather strong. Ligament externally visible, distinct, long, almost reaching 3/5 of the posterior part of the hinge plate. The largest width of the ligament equals about 2/3 of the width of the hinge plate. Cardinal teeth closer to the anterior than to the posterior laterals. Lateral teeth well pronounced, short, bluntly triangular. PIII and AIII of about equal size, PI slightly larger, AI is the largest. C3 distinct, inverted U-shaped, resembling that in *Pisidium clessini* Neumayr, 1875. Posterior leg bifid, almost twice as long as the anterior leg, with the apex reaching the edge of the hinge plate.

Left valve: hinge generally corresponding to the right valve. AII and PII well pronounced, short, of about equal size. C2 inverted V-shaped, both legs of about equal size and reaching the edge of the hinge plate. C4 thin, with a slightly clavate apex, parallel to, and in length about 1 1/2 of the neighbouring leg of C2. C4 ending before 2/3 of the width of the hinge plate.

Dimensions — L 9.3, H 7.9, W 2.4 (paratype in coll. RGD).

Material — RGD: Rosmalen (45B/6-7), 110.00-120.00 m (2 left valves, 2 defective right valves, dozens of fragments). Raamsdonkveer (44E/10), 85.50-98.50 m (1 defective right valve). Gemert (51F/39), 17.60-27.70 m (1 hinge fragment of a right valve, 2 fragments). All Tegelen Formation (Tiglian).

LHB: Zuurland (37C/554). 52.00-53.00 m (1 hinge fragment of a left valve); 53.00-54.00 m (1 defective right valve of a juvenile specimen, 1 hinge fragment of a right valve, 1 fragment of a left valve); 54.00-55.00 m (1 defective left valve); all Kedichem/Tegelen Formation (Waalian ?)

Remarks — *S. rosmalense* n. sp. is known only from Tiglian and ?Waalian beds of The Netherlands.

NOTES ON OTHER SPECIES

Neritidae

The fossil occurrence of *Theodoxus* in The Netherlands, together with some data for the neighbouring countries have recently been reviewed by Meijer (1988b). The only specimen recorded from The Netherlands as *Theodoxus serratiliniformis* Geyer, 1914, found in borehole Wanrooy (45H/6; Tesch, 1944), belongs most probably to a Tertiary species.

Theodoxus danubialis is now known from the Middle Tiglian in borehole Prinsenheuvel (44A/156; Tesch, 1944), in marine deposits influenced by the River Rhine (Maassluis Formation), and in Eemian deposits of the River Scheldt at two localities in Zeeuwsch Vlaanderen: boreholes Bakkersdam (54A/34) and IJzendijke (54B/5) (Meijer, 1988b).

Theodoxus fluviatilis (Linné, 1758) is known only from Eemian and Holocene deposits. In the Eemian the species is found in fluvial and estuarine Rhine deposits, in the Holocene it is more widespread. It is the only Recent species in The Netherlands. Outside The Netherlands the stratigraphical occurrence of *Theodoxus* corresponds to the Dutch data: *T. danubialis* occurs in Holsteinian and older deposits, *T. fluviatilis* in Eemian and Holocene deposits, except for Great Britain, where it is found only in the Holocene (Kerney, 1978).

Valvatidae

Valvata naticina Menke, 1845.

This species was recorded earlier from ice-pushed Holsteinian deposits in several outcrops near Neede (Tesch, 1944; Meijer, 1972). The occurrence in borehole Noord Bergum (6D/38; Tesch, 1939a, 1942) was formerly supposed to be Holsteinian in age as well. However, the estuarine beds at a depth of 55-60 m in which the species was found, locally underlie Elsterian fluvioglacial deposits (Peelo Formation) and are therefore older than Holsteinian. The estuarine beds are nowadays assigned to the fourth interglacial of the Cromerian ('Interglacial of Noord Bergum'; de Jong, 1988). The species was also recorded from borehole Exmorra (10B/168; Ter Wee, 1976, pl.5) from the same stratigraphical unit.

The only Early Pleistocene record of the species is in borehole Tilburg (50E/113), where it occurs in the Middle Tiglian Maassluis Formation. The species is not known younger than Holsteinian in

The Netherlands. Recent investigations of temperate Intra Saalian fluvial deposits, *e.g.* at the Belvédère (Meijer, 1985) and Fransche Kamp (Meijer, in prep. 2) localities, did not yield *Valvata naticina*.

Outside The Netherlands and to the west of its present-day distribution *V. naticina* is also known only from Holsteinian or older deposits.

Valvata goldfussiana Wüst, 1901.

This large *Valvata* is related to *Valvata naticina* Menke, 1845. The shape varies in Dutch shells. The oldest specimens dating from the Tiglian have less convex whorls than later forms. The significance of this difference is not clear.

The stratigraphical range of the species is Middle Tiglian up to and including the Leerdam Interglacial. In borehole IJsselstein (38F/134) *V. goldfussiana* is known from a deposit that may belong to the (heavy mineral) Sterksel Zone, which constitutes the oldest part of the Sterksel Formation. The Sterksel Zone ranges in age between the Bavel Interglacial and Glacial A of the Cromerian. This means that the youngest possible occurrence may be in Interglacial 1 of the Cromerian. However, molluscan remains from the latter interglacial are unknown elsewhere and therefore it seems not unlikely that the last occurrence is in the Leerdam Interglacial.

Outside The Netherlands the species is known from England and the G.D.R. In England it is recorded from East Runton (Weybourne Crag, Late Tiglian), West Runton, Kessingland and Sugworth (Cromerian) (Preece, in prep. 1). From the G.D.R. the species is mentioned from the type locality Wendelstein (Borntal Interglacial) and Kalbsrieth (Artern Interglacial) (Mania, 1973; Wüst, 1901; Zeissler, 1968). From the Löwenbrau borehole in Berlin (Holsteinian) I studied material labelled as *Valvata goldfussiana*; all specimens can be referred to *Valvata naticina*. Zilch & Jaeckel's (1962) view that the species became extinct after the Riss Glacial (= Saalian) is almost certainly based upon this Berlin sample. This means that the only Holsteinian record of the species is based upon a misidentification, hence the species does apparently not occur in this interglacial.

Species related to *V. goldfussiana* are *V. juxi* Schlickum & Strauch, 1979 from the Late Pliocene of Cologne (F.R.G.) and the Italian Villafranchian species *V. anconae* Stefani, 1877 and *V. interposita* Stefani, 1880.

Other notes on *Valvata* Müller, 1774

The recently discovered mollusc-bearing fluvial deposit of (Late ?) Tiglian age in a clay pit near Tegelen (pit Maalbeek, Tegelen, Province of Limburg), yielded several specimens of an unusual *Valvata* taxon. The shells show an overall similarity to *Valvata pulchella* Studer, 1820, but are spirally as well as axially sculptured. One specimen of exactly the same form was found earlier in Bavel (RGD collections), but was interpreted as an aberrant *V. pulchella*. However, now that more material has been found at another locality, also differing in age, it cannot be excluded that this material represents an undescribed species. Possibly related taxa are *V. sibirica* (Middendorf, 1851) and *V. frigida* (Westerlund, 1873). I have not yet been able to study material of these species.

The range of this taxon is still insufficiently known, but includes the (Late ?) Tiglian and the Bavel Interglacial.

Viviparidae

Viviparus glacialis (Wood, 1872)

The taxonomy of this species is still rather obscure. I do not agree with Boettger (1955), who considered *V. glacialis* to be a subspecies of *Viviparus diluvianus* Kunth, 1865. *V. glacialis* has a very small juvenile stage, which is quite different from most other West European Viviparidae. The small juvenile stage, the turriform shape, and the often straight, flattened whorls of *V. glacialis* are so typical, that a close relationship with *V. diluvianus* can be excluded. *V. glacialis* varies only slightly in shape and size, in contrast to *V. diluvianus*. They are not closely related to each other and it may even be argued to place both in separate supraspecific taxa. *Viviparus medius* (Woodward, 1833), occurring in the Norwich Crag of East Anglia (England) is not a turriform *Viviparus*, and is therefore not related to *V. glacialis*, as was suggested by Tesch (1944) and others. Together with *V. teschi* n. sp. *Viviparus glacialis* may be closely related to the turriform Italian Villafranchian species *Viviparus belluccii* De Stefani 1880. The latter species was well illustrated by Malatesta (= *Viviparus bergeroni etruscus* Malatesta, 1964) and by Girotti (*Viviparus etruscus* in Girotti, 1966, figs 4-23). Of *V. belluccii* I studied material kept in the SMF collection. Among these, two, in my opinion not closely related species could be recognised: a 'high-spired' and a 'low-spired' species. The 'high-spired' ('turriform') species fits De Stefani's original description and may be related to *V. glacialis*. The 'low-spired' species (*Viviparus* s.str.) was illustrated by Girotti [*Viviparus etruscus* Girotti, 1966 (non Malatesta, 1964), figs 3, 26/30]. The 'high-spired' forms, however, may represent a separate subgenus of *Viviparus*.

In The Netherlands *Viviparus glacialis* is restricted to Tiglian deposits of the River Rhine (Tegelen Formation) and marine deposits influenced by this river (Maassluis Formation). In these beds the species is not uncommon.

Viviparus glacialis is known outside The Netherlands from a couple of British localities only (Weybourne Crag and Bure Valley Beds, Late Tiglian; Meijer, in prep. 1; Preece, in prep. 1).

Ložek (1972) mentioned *Viviparus* sp. from 'claylayer B' in the Quaternary strata exposed in the lignite-pit 'Frechen' near Cologne (F.R.G.). This record may be identical to *V. glacialis*. The stratigraphical age of 'claylayer B' is supposed to be Late Pliocene (Reuverian). However, the molluscan association undoubtedly points to a Tiglian age. A re-examination of the Quaternary molluscan material of this important locality is urgently needed.

Viviparus diluvianus (Kunth, 1865)

There is a vast literature on the taxonomy of this species. This is not surprising as the shape of the shell varies considerably between different localities. However, within the same population the shape is rather constant. It is questionable whether all Viviparidae assigned to *Viviparus diluvianus* actually belong to the same species. This is most probably not the case. For the time being I consider *V. diluvianus* as a complex of closely related species. The Dutch material, ranging in age between Late Tiglian and Holsteinian, is rather uniform and clearly belongs to one species. Some typical specimens were well illustrated by Tesch (1929a, b).

The species was first described from deposits of Holsteinian age (the so-called 'Paludinen Bank') penetrated in a borehole in Berlin. The Dutch form does indeed differ from Berlin *V. diluvianus* as was noted already by Boettger (1955). The Berlin form has a higher spire. This is, however, a very

variable character which should not be considered of taxonomic value. I do not subscribe to Boettger's (1955) views on the taxonomy of Dutch Quaternary Viviparidae. The Dutch form of *V. diluvianus* is not identical with *Viviparus viviparus* (Linné, 1758). The latter species differs in overall proportions, and has more convex whorls and a deeper suture. *Viviparus medius* from the Middle Tiglian of East Anglia is probably closely related to the Dutch form of *V. diluvianus*. *V. medius* does not occur in The Netherlands. Tesch (1929a, b; 1944) erroneously identified Tiglian *Viviparus* as *V. medius*. All his *V. medius* can certainly be assigned to *V. glacialis*. Moreover, if Tesch were right in assuming that both taxa constitute extreme forms of the same species, the proper name would then be *V. medius* (by priority) and not *V. glacialis* (because this was considered the 'main' form).

In the Middle Pleistocene deposits of Mosbach (F.R.G.) *Viviparus acerosus* (Bourguignat, 1862) occurs. It does not occur in The Netherlands, contrary to what Boettger (1955) stated about forms from 'older deposits in The Netherlands.'

Viviparus viviparus (Linné, 1758)

The species is known from the Holocene, the Bavel Interglacial and the Tiglian. *Viviparus clactonensis* (Wood, 1872) may be identical with *V. viviparus* (see Preece, in prep. 1).

Hydrobiidae

The taxonomy of *Hydrobia stagnorum* auctt. was elaborated upon by Bank, Butot & Gittenberger (1979) and Bank & Butot (1984). They showed the presence in the Recent fauna of Western Europe of two similar but not closely related species: *Hydrobia ventrosa* (Montagu, 1803) and *Semisalsa stagnorum* (Gmelin, 1791). Because both euryhaline species endure low salinities, they often live in isolated populations in which they tend to develop local forms. This explains the extreme range of variation of both species. Moreover, they may co-occur, and are found together with other hydrobiid species.

It is difficult to decide whether or not all observations of *Semisalsa* are referable to the same species. For the time being it seems reasonable to assign them to a single, highly variable, species, *S. stagnorum*. The same holds true for *Hydrobia ventrosa* (Montagu, 1803). *Hydrobia neglecta* Muus, 1963 and *Peringia ulvae* (Pennant, 1777) are less variable and better defined species.

Due to the taxonomical confusion, the stratigraphical range is still not very well known. *P. ulvae* is the most frequent species, and occurs in most mollusc-bearing temperate marine deposits from the Late Pliocene onwards. The other species are less commonly represented (see Table 1).

Data on the fossil occurrence of *S. stagnorum* outside The Netherlands may be found in Bank & Butot (1984), Meijer (1988b) and Keen (1989). According to these authors the first appearance of the species in the North Sea Basin goes back at least to the Holsteinian. However, it may possibly be traced back into the Middle Tiglian. I studied a sample of Hydrobiidae from the Norwich Crag at Bramerton (England) which was collected by Mr P. Cambridge (Norwich, England). I was able to identify *Peringia ulvae*, *Hydrobia ventrosa*, *Hydrobia neglecta* and *Semisalsa stagnorum*. Of the last-mentioned species only two defective specimens were present, while *Peringia ulvae* was the most common species. Other interesting British records include the localities of Bath (known as 'Roman Bath'; Late Holocene) (Kennard & Woodward, 1901), Selsey, and Woodston near Peterborough (Holsteinian) (West, Sparks & Sutcliffe, 1960; Keen, 1989). I studied material that is housed in the RGD and BM(NH) collections. At all three localities *S. stagnorum* occurs.

Mercuria confusa (Frauenfeld, 1863)

This is a characteristic species of tidally influenced freshwater habitats. It may tolerate low salinities within the oligohalinicum. As a fossil it is known from several Holocene localities (Kuijper, 1980, 1981a; Meijer, 1984, 1988a) and from Middle Tiglian marine deposits of borehole Zuurland (37C/554), at a depth of 95 m (Maassluis Formation). The published results of this borehole reach to a depth of 63 m (Meijer, 1988a). Results of research below this depth will be published later in more detail.

Marstoniopsis scholtzi (Schmidt, 1856)

Known from several Holocene localities, among which the Krekerak Sluice Pit (Kuijper, 1980) and Hekelingen (with a Subboreal age) may be mentioned (Kuijper, 1981a). Recently, the species has been found in Holocene and Waalian deposits in borehole Zuurland (Meijer, 1988a).

Lithoglyphidae

Lithoglyphus naticoides (Pfeiffer, 1828)

In The Netherlands this is a recently immigrated species, which was first recorded by Schepman (1874). The natural Recent distribution is Danubian/Ponto-Caspian.

Tesch (1929b, 1944) mentioned shells and opercula of *Lithoglyphus naticoides* from the Early Pleistocene. Spaink (1968) and later Meijer (1974) pointed out the real identity of the calcareous opercula assigned by Tesch to this species, by showing that these opercula belong to *Parafossarulus crassitesta* (Brömme, 1885) and related forms.

The shell of the fossil *Lithoglyphus* species shows significant differences with *Lithoglyphus naticoides*. These are found *e.g.* in a more slender shape, and in a much more pronounced callus. Sexual dimorphism, as observed in the shells of the Recent *Lithoglyphus naticoides*, is not present in the fossil species. The size of the Dutch shells varies and seems to be larger in older material of a Tiglian age. The Early Pleistocene form differs sufficiently from *L. naticoides* to consider it a separate taxon (see below).

L. naticoides is also reported from the Holsteinian deposits in Western Europe. Meijer (1972) recorded a compressed shell of *L. naticoides* from a clay-pit at Neede (The Netherlands, province of Overijssel). This is a misidentified *Bithynia tentaculata* (Linné, 1758). Kempf (1968) mentioned *L. naticoides* from supposedly Holsteinian deposits of Tönisberg (F.R.G.). Examination of the specimen, which is kept in the SMF collection, revealed it to be a corroded apex of *Bithynia* sp. (personal observation).

L. naticoides most probably only occurs in the Recent fauna of Western Europe.

Lithoglyphus jahni Urbanski, 1975

From Polish middle Pleistocene deposits Urbanski (1975) introduced *Lithoglyphus jahni*. The West European material fits in all respects the description of *L. jahni* and is therefore considered to be conspecific.

The stratigraphical range in The Netherlands is Middle Tiglian up to and including the Bavel Interglacial.

Outside The Netherlands the species is known from East Runton and North Walsham (England;

Weybourne Crag, Late Tiglian; Meijer, in prep. 1), Zeuchfeld and Voigtstedt/Edersleben (G.D.R.; Borntal and Artern Interglacial, respectively) (Mania, 1973; Wüst, 1901; Zeissler, 1968). The stratigraphy of the British records and those from the G.D.R seems to be in accordance with the Dutch records. The Polish records are supposed to date from the Holsteinian (Urbanski, 1975).

Tanousia Servain, 1881

Tanousia was reviewed by Schlickum & Schütt (1971) and by Schlickum (1974). Additional data may be found in Schlickum (1971). In my view the taxonomy of this genus is not yet fully understood. Schlickum enumerated eight species, ranging in age between Miocene and (supposedly) Holocene. Brusina (1902, pl. 9, figs 10-21) illustrated several taxa which may also be *Tanousia* species. Most species vary considerably in shape and size within the same, as well as between different localities. Distinction between species is not always easy, as may for instance be observed in British populations of *T. runtoniana* (Sandberger, 1880) and *T. stenostoma* (Nordmann, 1901). In this respect, it may also be worthwile to investigate the taxonomic relationships of both these species with the obviously related *T. zrmanjae* (Brusina, 1866).

The Italian Villafranchian species *T. lithoglyphoides* (Girotti, 1972) is closely related to, if not identical with, *T. arminiensis* (Jekelius, 1932) from Dacian beds in Rumania. I was able to study material of both species in the SMF collections. From this examination one series of *T. lithoglyphoides*, which was identified by Girotti, appeared to be another species, possibly to be assigned to the Amnicolidae. This makes it doubtful if all observed *T. lithoglyphoides* really belong to the same species (Girotti, 1972b; Esu & Girotti, 1974). I do not agree with Girotti, who suggested a relationship of this species with *T. stenostoma*. The proportions of the shell and the shape of the aperture differ enough to exclude such a relationship. Another Italian species, *Nematurella subovata* Settepassi & Verdel, 1965, was apparently overlooked by Schlickum as a member of *Tanousia*. *T. subovata* seems closely related to *T. runtoniana*. I agree with Schlickum (1974), who identified *T. runtoniana* from ,,Isle-les-Villenoy, Bois de l'Epinette'' (France). Material from this locality is present in the SMF collections. The generic assignment of *T. schlickumi* Schütt, 1976 is doubtful.

The conclusion of these notes may be that a revision of *Tanousia* is urgently needed. This should preferably be based on statistical methods, which course of action is, in this case, not hampered by the lack of material. Large samples of various species are present in several public collections. Awaiting the results of such an investigation I treat the two North West European taxa as separate species.

Tanousia runtoniana (Sandberger, 1880)

A single specimen was reported from Middle Tiglian marine deposits in a borehole on the former isle of Schokland (21A/38; Tesch, 1944: *Nematurella runtoniana*). This is a misidentified specimen of *Peringia ulvae*.

Later the species was found in deposits of the Bavel interglacial in the former clay-pit near Bavel (Province of Noord Brabant).

Outside The Netherlands *T. runtoniana* is known from Cromerian deposits in West Runton and Sugworth (England; Preece, in prep. 1), and from 'Mindel-II' (Middle Terrace) deposits in Isle-les-Villenoy (France; Schlickum, 1974).

Tanousia stenostoma (Nordmann, 1901)

Of this species too only a single specimen was known to Tesch (1944). It was found in borehole 's-Gravendeel (44A/145) in marine Middle Tiglian deposits. The specimen is now lost. This species shows an overall similarity to *P. ulvae* as well. Therefore, and because it was found in marine deposits this is most probably also a misidentified *P. ulvae*.

Meijer (1976) mentioned the species from Tiglian fluvial deposits at Tegelen. These specimens prove to be compressed *Tournouerina belnensis* (Delafond et Depéret, 1893).

The above were the only data on this species, and it is therefore probable that it does not occur in the Pleistocene of The Netherlands.

Tournouerina belnensis (Delafond & Depéret, 1893)

Before considering the Dutch material assigned to this taxon, some notes concerning *Tournouerina* Schlickum, 1971 are necessary.

Schlickum (1978) reviewed this genus which he introduced a few years earlier. The genus was erected for small fusiform hydrobiids with a large last whorl and an egg-shaped aperture which is angularly rounded adapically. The peristome is continuous, detached in the adult state, and has a backward fallen lower part (,,zurück fallendem Mundrand''). Furthermore, the simple peristome is noted. The thickening of the shell, just before and parallel to the sharp edge of the peristome, a feature which is characteristic of *Nematurella* Sandberger 1874, is lacking in *Tournouerina*. Type species of *Tournouerina* is *Nematurella lugdunensis* Locard, 1883. Schlickum (1971, 1978) illustrated material of this species from the type locality Bas- Neyron (France) and from Mollon-ravin (France). However, judging from the illustrations, the latter material clearly belongs to another species, probably even another genus. The same author introduced two other species, *viz. Tournouerina chalinei* Schlickum & Puisségur, 1977 and *T. quarta* Schlickum, 1978. The reason for the introduction of the second species is not clear: the resemblance with *T. lugdunensis* is striking (compare Schlickum 1978, pl. 17, figs 6 and 7) and leaves hardly any doubt as to the taxonomical relationships of both species. In my opinion both species are identical. *T. quarta* Schlickum, 1978 therefore is a junior synonym of *T. lugdunensis* (Locard, 1883).

T. chalinei differs only slightly in proportions from *T. belnensis*. Both species are of about equal size. Their stratigraphical ranges are about the same: Late Pliocene and earliest Pleistocene (*T. belnensis*) and Early Pleistocene (*T. chalinei*).

Tesch (1939b) introduced *Nematurella minima* from Tiglian deposits in borehole Rosmalen (45B/6-7) and compared his new species with other '*Nematurella*' species: *N. stenostoma* Nordmann, 1901, *N. runtoniana* Sandberger, 1880 (both now assigned to *Tanousia* Servain, 1881) and *N. ovata* Bronn, 1831 (now in *Prosothenia* Neumayr, 1869). Because the holotype of *N. minima* is lost, the illustrated specimen (Pl. 2, Fig. 3) is herewith designated lectotype. I agree with Schlickum & Schütt (1971), who thought a relationship with *Tanousia* and *Nematurella* unlikely. In an earlier paper (Schlickum, 1971) a relationship with *Tournouerina* was also excluded. This assumption was based on the large gap in time between *T. lugdunensis* and *N. minima*. This is peculiar, because later the same author did assign several Late Pliocene and Early Pleistocene species to *Tournouerina*. In my opinion *N. minima* undoubtedly is a *Tournouerina* (compare Tesch, 1939b; Schlickum & Puisségur, 1977, pl. 24, figs 7 and 8). I was able to study material of *Tournouerina* present in the SMF collections and in my private

collection (kindly supplied by Mr Schlickum). This convinced me of the conspecificity of *T. belnensis, T. chalinei* and *N. minima*. In populations of the latter species, forms which may be assigned to both other species occur mixed together without sharp discontinuities. I regard *T. chalinei* and *N. minima* to be junior synonyms of *T. belnensis*.

In The Netherlands this species is known from Middle Tiglian up to and including the Waalian. Tiglian localities include *e.g.* borehole Rosmalen (45B/6-7), Brielle (37D/134; Kuijper, 1973) and the clay-pits Russel Tiglia (*Tanousia stenostoma* non Nordmann, 1901: Meijer, 1976) and Maalbeek near Tegelen. Waalian localities are borehole Leerdam (38H/148) and Zuurland (37C/554; Meijer, 1988a). The specimens of the Zuurland borehole show a slightly deeper suture than specimens from other localities but are clearly the same species.

Outside The Netherlands *T. belnensis* is known from localities in the Bresse (France: Schlickum & Puisségur, 1977, 1978; Schlickum, 1978; Puisségur, 1984; etc.), and from one locality in Italy near Tavernelle (Umbria; Conti & Esu, 1981). The stratigraphical range may reach from Late Pliocene up to and including the Waalian (Early Pleistocene).

Summarizing it may be stated that there are two species of *Tournouerina*: the oldest is *T. lugdunensis* (Locard, 1883) (junior synonym: *T. quarta* Schlickum, 1978), and the youngest, smaller sized, species is *T. belnensis* (Delafond & Depéret, 1893) (junior synonyms: *Nematurella minima* Tesch, 1939, *Tournouerina secunda* Schlickum & Puisségur, 1977 and *T. chalinei* Schlickum & Puisségur, 1977).

Moitessieriidae

Belgrandia marginata (Michaud, 1831)

Tesch (1929b) mentioned the species from outcropping ice-pushed deposits of Middle Pleistocene age ('Horizon van *Viviparus diluvianus*') in clay-pits near Herike and Neede. The age of these deposits is now considered to be Holsteinian. In the vicinity of these localities the species was found in Holsteinian deposits of borehole Gelselaar (34B/218).

Recently the species has also been encountered at Belvédère near Maastricht. It was found after the results of previous investigations were published (Meijer, 1985). The age of these deposits is Interglacial of Belvédère, which is an Intra Saalian temperate period. Up to now, *B. marginata* is in The Netherlands known only from the Holsteinian and the subsequent Interglacial of Belvédère. In Great Britain the species is also a member of Cromerian and Ipswichian (= Eemian) freshwater assemblages (cf. Kerney, 1978).

Bithyniidae

The taxonomy of Neogene West European Bithyniidae will be discussed in detail in a separate paper (Meijer, in prep. 3). In this paper it is shown that the group of species possessing a mainly paucispiral operculum ('*crassitesta*' like species), formerly assigned to *Neumayria* Stefani 1877, should be placed in the Recent genus *Parafossarulus* Annandale, 1925. Species with a reflected peristome, which were placed in *Pseudemmericia* Schlickum, 1968, *Neumayria* Stefani, 1877 and *Bithynia* Leach, 1818, are now assigned to *Bithynia (Neumayria)*.

Parafossarulus priscillae (Girotti, 1972) (Pl. 1, Figs 8, 9a-b)

From Tiglian deposits penetrated in borehole Rosmalen (45B/6-7) Tesch (1929a) mentioned *Bithynia tentaculata* Linné, 1758. Four shells are present in the RGD collections. These shells were overlooked

by Meijer (1974). At the same depth Tesch noted dozens of opercula of *Lithoglyphus naticoides*. Meijer (1974) considered the opercula to belong to *Parafossarulus crassitesta* (Brömme, 1885). Opercula of *P. crassitesta,* however, are usually much larger than those found in Rosmalen. In one of the shells an operculum was found *in situ* in the aperture. This operculum does not differ from the isolated '*Lithoglyphus*' (= *Parafossarulus*) opercula. Consequently, the '*Bithynia*' shells and the '*Lithoglyphus*' opercula both belong to the same species, which is identified as *Parafossarulus priscillae* (Girotti, 1972). Rosmalen is the only locality in The Netherlands where shells of this species have so far been found. Small sized *Parafossarulus* opercula are known from several other Tiglian localities.

Parafossarulus crassitesta (Brömme, 1885)

This species occurs in Waalian-Holsteinian deposits (Meijer, 1974). A smaller form, most probably belonging to the same species, is found in the Late Tiglian of Tegelen and Maalbeek.

Assimineidae

Paludinella littorina (Chiaje, 1828)

The only fossil record is from Middle Tiglian marine deposits of borehole Zuurland (37C/554), where the species is found at a depth of 95 m (Maassluis Formation). It is not known in the Recent fauna of The Netherlands.

Lymnaeidae

Myxas glutinosa (Müller, 1774)

The specimen from Holocene deposits in borehole Hazerswoude (Tesch, 1944) turned out to be a juvenile specimen of *Succinea* sp. This species is known only from (Late ?) Tiglian deposits in the clay-pit Maalbeek near Tegelen (Province of Limburg).

Ferrissiidae

Ferrissia wautieri (Mirolli, 1960)

The fossil occurrence of the species has recently been published by Meijer (1987b). The most striking observation is the fact that only juveniles are known, which were mostly found in shallow marine or estuarine deposits. *Ferrissia* is encountered there with other freshwater species amidst marine molluscan associations. Almost consistently the species is accompanied by juvenile specimens of *Ancylus fluviatilis* (Müller, 1774). This peculiar occurrence is puzzling.

The species is known from the Tiglian, Eemian and Holocene (Meijer, 1987b).

Planorbidae

Gyraulus Charpentier, 1837

Especially the large species of *Gyraulus* were often confused in the past. Meier-Brook (1964 & 1983) showed that *G. acronicus* (Férussac, 1807), *G. rossmaessleri* (Auerswald, 1851) and *G. albus* (Müller, 1774) are anatomically well-separated species. Discrimination of species using shell characters is less problematic than was assumed by earlier authors. Significant characters are the size and convexity of the first whorls, the sculpture, the shape of the aperture, the size of the adult shells and the regularity of the construction of the shell.

G. laevis (Alder, 1838) and *G. rossmaessleri* normally have rather glossy shells without noticeable spiral sculpture on the teleoconch. They may be distinguished by differences in the first whorls: *G. laevis* starts with much smaller and more convex whorls than *G. rossmaessleri*. Rather large and flat first whorls are very characteristic of *G. rossmaessleri* and may help to distinguish this species from *G. acronicus* and *G. albus* (see Bisschops, 1973: photo 4, figs 1a and 2a). Both latter species are larger than the other two species. *G. acronicus* may reach the largest dimensions. Occasionally this species has some spiral sculpture, but mostly this is lacking, contrary to *G. albus* in which the spiral sculpture is very prominent.

In The Netherlands *G. albus* is confined to interglacial deposits. This is also the case with *G. laevis*, although there are indications for a preference of pioneer associations which may be found in early phases of interglacials (Meijer, 1985). Both other species are able to endure severe climatic conditions and are often found in subarctic associations (*e.g.* Bisschops, 1973; Kuijper, 1968, 1985; van den Toorn, 1967).

Dreissenidae

Dreissena polymorpha (Pallas, 1771)

In the modern fauna of The Netherlands this is a recently immigrated species which now occurs very abundantly in *e.g.* the IJsselmeer. In present-day sediments of this lake *Dreissena* is very common.

Tesch (1951) noted the presence of this species in a borehole near the village of Harderwijk (26F/1) (= 'Warderwijk II' in Steusloff, 1953). One specimen was encountered in sample 88 at a depth of 291-293 m in deposits of what is now considered the Maassluis Formation. This is the only fossil record of the species from The Netherlands. The specimen, however, is not present in the RGD collections. In my view, this occurrence in the Maassluis Formation is due to contamination with present-day IJsselmeer sediments. Consequently, *Dreissena polymorpha* is only known from the Recent fauna in The Netherlands.

Sphaeriidae

Sphaerium Scopoli, 1777

Complete material of *Sphaerium* specimens is rare. Mostly only fragments are found, which are not always easy to identify. Therefore, the stratigraphic range of the various species is poorly known. Moreover, the identity of several taxa is not yet clear, as is the case with *e.g. S. dickenii* Clessin, 1877, and *S. subsolidum* (Clessin, 1888) (see Kuiper, 1988). Both *S. radleyense* Kennard & Woodward, 1924 and *S. bulleni* Kennard, 1911 are forms of *S. corneum* (Linné, 1758). Especially *S. bulleni* has a peculiar shape, which cannot easily be overlooked (compare Ellis, 1962, pl. 10). This taxon does not occur in The Netherlands. Recently *S. icenicum* Holyoak & Preece, 1986 has been described for Middle Tiglian deposits of East Anglia. This species is not known from The Netherlands either. The reverse is true for *S. rosmalense* n. sp., which is known only from The Netherlands.

The recent discovery of the Tiglian Maalbeek fauna (see above) shed new light on certain occurrences of *S. rivicola* (Lamarck, 1818) in the Early Pleistocene. In this locality a number of well-preserved valves, several of which were still united, of a very thin *Sphaerium* were found. The general shape is similar to *S. transversum* (Say, 1829), although some differences are to be noted. Based upon defective shells Meijer (1988a) identified the same taxon as juvenile specimens of *S. rivicola* (Lamarck,

1818). From the Maalbeek material this appears to be a misidentification. Similar, poorly preserved, valves were found in borehole Rosmalen (45B/6-7) where they occur together with *S. rosmalense* n. sp. This co-occurrence is also found in borehole Zuurland (37C/554; Meijer, 1988a), but not at Maalbeek. Whether this thin-shelled *Sphaerium* is to be considered a separate taxon is not yet clear. Anyway, the stratigraphical range of this form is limited to the Tiglian and possibly the Waalian.

Pisidium clessini Neumayr, 1875

This is an extinct fluvial species resembling *Pisidium amnicum* (Müller, 1774). *P. clessini* is more rounded in outline, and has more prominent and wider spaced concentric ribs. The first two concentric ribs are much better developed than the others. This is a clear difference with *P. amnicum* where a rather regular grow of the the first ribs is observed. In the Tiglian a smaller form occurs. The shell of this form may be completely smooth, except for the first two concentric ribs.

Although the differences are outstanding, both species are often confused. Especially many records of *P. clessini* are in fact misidentified *P. amnicum*. From The Netherlands the species is mentioned from the Tiglian up to and including the Eemian. However, all Eemian data turned out to be *P. amnicum*, which is *e.g.* the case with those of Brouwer (1941, 1944) and Meijer (1973). The molluscan fauna of the Eemian is very well known, although not much of it has so far been published and *P. clessini* has never found. Apparently, it is not present in Dutch Eemian deposits. The species is rather common in Holsteinian deposits of, among other localities, Neede (Oostingh & Florschütz, 1928; Meijer, 1972), Enter, Markelo (van Baren, 1924) and boreholes Gelselaar (34B/218) and Neede (34B/217). In temperate fluvial Intra Saalian deposits the species is absent, although the fluvial associations suggest favourable conditions. It is absent in the associations of Belvédère (Meijer, 1985) and Fransche Kamp near Wageningen (Meijer, in prep. 2). In the latter locality the deposits were ice-pushed by the Saalian glaciers. All Dutch data point to an extinction of *P. clessini* immediately after the Holsteinian. This is an important conclusion because the moment of extinction of this species is still the subject of some debate. Several authors claim younger occurrences (Kerney, 1978; Zhadin, 1955). In my opinion these claims may mainly result from misidentifications of the species, but reworking and wrong stratigraphic correlations will certainly have played a role as well. From a palaeogeographic point of view a post-Holsteinian occurrence in British rivers is less plausible than such an occurrence in the (south)eastern part of the European mainland (compare the stratigraphic range and the former and present-day distribution of *Valvata naticina*). Obviously, many data should be critically revised.

BIOSTRATIGRAPHIC NOTES

Quaternary malacostratigraphy is based mainly upon the interglacial record. Only interglacial associations differ significantly from each other, as the extinctions of demanding species and the first appearances of new immigrants are expressed in these intervals. At present the extinction record is best known. Last appearances of non-marine, especially fluvial species, have lately been used to propose a malacostratigraphy for the Quaternary (Meijer, 1986a, b).

Twenty freshwater species became extinct during the Quaternary. Remarkably, sixteen of these extinctions comprised prosobranchs, only three are bivalves and one is a pulmonate (Table 3).

I consider the extinct species more or less characteristic of various lotic, *viz.* fluvial environments. This may be concluded from the facies of the sediments in which they occur, and from the accompa-

SPECIES	R	H	We	E	IS	Ho	C4	L	Ba	Wa	Eb	LT	MT
Theodoxus (Theodoxus) danubialis (Pfeiffer, 1828)	-	-	-	x	-	-	-	-	-	-	-	-	x
Theodoxus (Theodoxus) fluviatilis (Linné, 1758)	x	x	-	x	-	-	-	-	-	-	-	-	-
Viviparus (Viviparus) contectus (Millet, 1813)	x	x	-	x	x	-	x	-	x	-	-	x	x
Viviparus (Viviparus) diluvianus (Kunth, 1865)	-	-	-	-	-	x	-	-	-	?	-	x	x
Viviparus (Viviparus) viviparus (Linné, 1758)	x	x	-	-	-	-	-	-	x	-	-	x	x
Viviparus (Viviparus) glacialis (Wood, 1872)	-	-	-	-	-	-	-	-	-		-	x	x
Viviparus (Viviparus) teschi n. sp.	-	-	-	-	-	-	-	?	-	-	-	x	-
Valvata (Valvata) cristata Müller, 1774	x	x	x	x	x	-	-	-	x	x	-	x	-
Valvata (Atropidina) pulchella Studer, 1820	x	x	x	x	-	-	-	-	x	x	x	x	x
Valvata (Cincinna) piscinalis (Müller, 1774)	x	x	x	e	x	x	x	x	x	x	x	x	x
Valvata (?Borysthenia) goldfussiana Wüst, 1901	-	-	-	-	-	-	-	x	x	x	x	x	x
Valvata (Borysthenia) naticina Menke, 1845	-	-	-	-	-	x	x	-	-	-	-	-	?
Hydrobia (Hydrobia) neglecta Muus, 1963	-	x	-	x	-	-	-	-	-	-	-	-	x
Hydrobia (Hydrobia) ventrosa (Montagu, 1803)	x	x	-	x	-	-	-	-	-	-	-	-	x
Peringia (Peringia) ulvae (Pennant, 1777)	x	x	-	x	-	x	x	-	-	x	-	-	x
Mercuria (Mercuria) confusa (Frauenfeld, 1863)	x	x	-	-	-	-	-	-	-	-	-	-	x
Bythinella (Bythinella) dunkeri (Frauenfeld, 1857)	x	-	-	-	-	-	-	-	-	-	-	-	-
Marstoniopsis (Marstoniopsis) scholtzi (Schmidt, 1856)	x	x	-	-	-	-	-	-	-	x	-	-	-
Avenionia (Avenionia) brevis roberti Boeters, 1967	x	-	-	-	-	-	-	-	-	-	-	-	-
Semisalsa (Semisalsa) stagnorum (Gmelin, 1791)	x	x	-	x	-	-	-	-	-	-	-	-	-
Potamopyrgus (Potamopyrgus) jenkinsi (Smith, 1889)	I	-	-	-	-	-	-	-	-	-	-	-	-
Group A - convex, brown form from brackish water	I	-	-	-	-	-	-	-	-	-	-	-	-
Group B - slender, white form from fresh water	I	-	-	-	-	-	-	-	-	-	-	-	-
Lithoglyphus (Lithoglyphus) naticoides (Pfeiffer, 1828)	I	-	-	-	-	-	-	-	-	-	-	-	-
Lithoglyphus (Lithoglyphus) jahni Urbanski, 1975	-	-	-	-	-	-	-	-	x	x	x	x	x
Tanousia (Tanousia) runtoniana (Sandberger, 1880)	-	-	-	-	-	-	-	-	x	-	-	-	-
Tournouerina (Tournouerina) belnensis (Delafond & Depéret, 1893)	-	-	-	-	-	-	-	-	-	x	-	x	x
Belgrandia (Belgrandia) marginata (Michaud, 1831)	-	-	-	-	x	x	-	-	-	-	-	-	-
Bithynia (Bithynia) leachii (Sheppard, 1823)	x	x	-	x	x	-	-	-	x	x	x	-	-
Bithynia (Bithynia) tentaculata (Linné, 1758)	x	x	x	x	x	x	x	-	x	x	x	x	x
Bithynia (Bithynia) troscheli Paasch, 1842	-	-	-	o	x	x	x	x	x	x	x	x	x
Bithynia (Neumayria) bavelensis n. sp.	-	-	-	-	-	-	-	-	x	-	-	-	-
Parafossarulus (Parafossarulus) crassitesta (Brömme, 1885)	-	-	-	-	-	x	x	x	x	x	-	x	-
Parafossarulus (Parafossarulus) priscillae (Girotti, 1972)	-	-	-	-	-	-	-	-	-	-	-	x	-
Paludinella (Paludinella) littorina (Chiaje, 1828)	-	-	-	-	-	-	-	-	-	-	-	-	x
Fagotia (Microcolpia) wuesti n. sp.	-	-	-	-	-	-	-	-	x	-	-	-	-
Acroloxus (Acroloxus) lacustris (Linné, 1758)	x	x	-	x	x	x	-	-	x	-	-	x	-
Aplexa (Aplexa) hypnorum (Linné, 1758)	x	x	x	-	-	-	-	-	x	-	-	-	-
Physa (Physa) fontinalis (Linné, 1758)	x	x	x	x	x	?	-	x	x	-	?	-	-
Physella (Costatella) acuta (Draparnaud, 1801)	I	-	-	-	-	-	-	-	-	-	-	-	-
Galba (Galba) truncatula (Müller, 1774)	x	x	x	x	x	x	-	x	x	x	x	x	x
Lymnaea (Lymnaea) stagnalis (Linné, 1758)	x	x	x	x	x	x	-	x	x	x	x	x	x
Radix (Radix) auricularia (Linné, 1758)	x	x	-	x	-	-	-	-	x	-	-	-	-
Radix (Radix) peregra (Müller, 1774) s.l.	x	x	x	x	x	x	x	x	x	x	x	x	x
Myxas (Myxas) glutinosa (Müller, 1774)	x	-	-	-	-	-	-	-	-	-	-	x	-
Stagnicola (Stagnicola) palustris (Müller, 1774) s.l.	x	x	x	x	x	x	-	x	x	x	-	x	x

Stagnicola (Omniscola) glabra (Müller, 1774)	x	-	-	-	-	-	-	-	-	-	-	-	-
Ancylus (Ancylus) fluviatilis (Müller, 1774)	x	x	-	x	x	x	x	-	x	x	-	x	-
Ferrissia (Ferrissia) wautieri (Mirolli, 1960)	x	x	-	x	-	-	-	-	-	x	-	-	x
Planorbarius (Planorbarius) corneus (Linné, 1758)	x	x	x	x	x	x	-	x	x	x	x	x	x
Planorbarius (Planorbarius) peetersi n. sp.	-	-	-	-	-	-	-	-	x	-	-	-	-
Planorbis (Planorbis) carinatus Müller, 1774	x	x	-	x	x	x	-	x	x	x	-	x	-
Planorbis (Planorbis) planorbis (Linné, 1758)	x	x	x	x	x	x	-	x	x	x	x	x	x
Anisus (Anisus) leucostomus (Millet, 1813)	x	x	x	x	x	x	-	x	x	x	x	x	x
Anisus (Disculifer) septemgyratus (Rossmaessler, 1835)	-	-	-	-	-	-	-	-	x	-	-	-	-
Anisus (Disculifer) vortex (Linné, 1758)	x	x	x	x	x	x	-	x	x	x	?	x	x
Anisus (Disculifer) vorticulus (Troschel, 1834)	x	x	-	-	x	-	-	-	x	-	-	x	-
Bathyomphalus (Bathyomphalus) contortus (Linné, 1758)	x	x	-	x	x	x	-	x	x	x	x	x	x
Gyraulus (Gyraulus) acronicus (Férussac, 1807)	-	-	x	x	-	-	-	-	x	-	-	x	-
Gyraulus (Gyraulus) albus (Müller, 1774)	x	x	-	x	x	x	-	-	x	x	-	x	x
Gyraulus (Armiger) crista (Linné, 1758)	x	x	x	x	x	x	-	x	x	x	x	-	-
Gyraulus (Torquis) laevis (Alder, 1838)	x	x	-	x	x	x	-	x	x	x	-	-	x
Gyraulus (Lamorbis) riparius (Westerlund, 1865)	x	x	-	-	-	-	-	x	-	x	-	o	-
Gyraulus (Lamorbis) rossmaessleri (Auerswald, 1851)	-	-	x	x	-	-	-	-	x	x	-	x	x
Hippeutis (Hippeutis) complanatus (Linné, 1758)	x	x	-	x	x	x	-	-	x	-	-	-	-
Segmentina (Segmentina) nitida (Müller, 1774)	x	x	-	x	x	-	-	-	?	x	-	x	-
Margaritifera (Pseudunio) auricularia (Spengler, 1793)	o	x	-	-	-	-	-	-	-	-	-	-	-
Unio (Unio) tumidus Philipsson, 1788	x	x	-	x	x	x	-	-	x	-	-	x	x
Unio (Unio) crassus Philipsson, 1788 s. lat.	x	x	-	-	-	-	-	-	-	-	-	-	-
Unio (Unio) pictorum (Linné, 1758)	x	x	-	x	-	-	-	-	x	-	-	-	x
Unio indet.	-	x	-	x	x	x	-	x	x	x	-	x	x
Anodonta (Anodonta) anatina (Linné, 1758)	x	x	-	-	-	-	-	-	-	-	-	-	-
Anodonta (Anodonta) cygnea cygnea (Linné, 1758)	x	x	-	-	-	-	-	-	-	-	-	-	x
Anodonta (Anodonta) cygnea zellensis (Gmelin, 1791)	x	-	-	-	-	-	-	-	-	-	-	-	-
Anodonta indet.	-	x	-	x	x	x	-	-	x	x	-	x	x
Pseudanodonta (Pseudanodonta) complanata (Rossmaessler, 1835)	x	?	-	-	-	-	-	-	-	-	-	-	-
Mytilopsis (Mytilopsis) leucophaeta (Conrad, 1831)	I	-	-	-	-	-	-	-	-	-	-	-	-
Dreissena (Dreissena) polymorpha (Pallas, 1771)	I	-	-	-	-	-	-	-	-	-	-	-	-
Corbicula (Corbicula) fluminalis (Müller, 1774)	-	-	-	x	x	-	-	-	x	x	-	x	x
Sphaerium (Sphaerium) corneum (Linné, 1758)	x	x	x	x	x	x	-	-	x	x	x	x	-
Sphaerium (Cyrenastrum) solidum Normand, 1844	x	x	-	x	-	-	x	-	x	x	-	-	x
Sphaerium (Musculium) lacustre (Müller, 1774)	x	x	-	-	x	x	-	x	x	x	-	x	-
Sphaerium (Musculium) transversum (Say, 1829)	I	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerium (Sphaeriastrum) rivicola (Lamarck, 1818)	x	x	-	x	-	x	x	-	x	x	-	-	-
Sphaerium (Sphaeriastrum) rosmalense n. sp.	-	-	-	-	-	-	-	-	-	x	-	x	-
Pisidium (Pisidium) amnicum (Müller, 1774)	x	x	x	x	x	x	x	-	x	x	x	x	x
Pisidium (Pisidium) clessini Neumayr, 1875	-	-	-	-	-	x	x	x	x	x	x	x	x
Pisidium (Odhneripisidium) stewarti Preston, 1909	-	-	x	x	-	-	-	-	-	x	-	x	-
Pisidium (Odhneripisidium) tenuilineatum Stelfox, 1918	x	x	-	-	-	-	-	-	x	-	-	-	-
Pisidium (Neopisidium) moitessierianum Paladilhe, 1866	x	x	-	x	x	x	-	x	x	x	x	x	x
Pisidium (Rivulina) casertanum (Poli, 1791)	x	x	x	x	x	-	-	-	x	x	-	-	-
Pisidium (Rivulina) casertanum (Poli, 1791) f. *ponderosa* Stelfo	x	x	x	-	x	x	-	-	-	-	x-	-	-
Pisidium (Rivulina) conventus Clessin, 1877	-	-	x	-	-	-	-	-	-	-	-	-	-

Pisidium (Rivulina) henslowanum (Sheppard, 1823)	x	x	x	x	x	x	-	x	x	x	x	x	x
Pisidium (Rivulina) hibernicum Westerlund, 1894	x	x	x	x	-	-	-	-	x	-	-	-	-
Pisidium (Rivulina) lilljeborgi Clessin, 1886	-	-	x	-	-	-	-	-	-	-	-	?	-
Pisidium (Rivulina) milium Held, 1836	x	x	x	x	x	-	-	-	x	-	-	-	-
Pisidium (Rivulina) nitidum Jenyns, 1832	x	x	x	x	x	x	-	x	x	x	-	-	-
Pisidium (Rivulina) nitidum Jenyns, 1832 f. *crassa* Stelfox	x	x	-	-	-	-	-	-	-	-	-	-	-
Pisidium (Rivulina) obtusale obtusale Pfeiffer, 1821	x	x	x	x	x	-	-	x	x	x	-	x	x
Pisidium (Rivulina) obtusale Pfeiffer, 1821 f. *lapponica* (Clessin, 1877)	-	-	x	-	-	-	-	-	x	x	-	x	-
Pisidium (Rivulina) personatum Malm, 1855	x	x	-	-	-	-	-	-	-	-	-	-	-
Pisidium (Rivulina) pseudosphaerium van Benthem Jutting & Kuiper, 1942	x	x	-	-	-	x	-	-	x	-	-	-	-
Pisidium (Rivulina) pulchellum Jenyns, 1832	x	x	-	-	-	-	-	-	x	-	-	-	-
Pisidium (Rivulina) subtruncatum Malm, 1855	x	x	x	x	x	x	-	x	x	x	-	x	x
Pisidium (Rivulina) supinum Schmidt, 1850	x	x	x	x	-	x	-	x	x	x	-	x	x

Table 1. Stratigraphical range of fresh water mollusc species in The Netherlands
R = Recent, H = Holocene, We = Weichselian, E = Eemian, IS = intra Saalian temperate phase, Ho = Holsteinian, C4 = 4th Cromerian interglacial, L = Leerdam interglacial, Ba = Bavel interglacial, Wa = Waalian, Eb = Eburonian, LT = Late Tiglian temperate phase, MT = Middle Tiglian temperate phase.
X = present, O = stratigraphical interpreation not certain, I = introduced by human activity, ? = identification not certain.

nying, still living, molluscan species of which the ecology is known. Most fluvial species are dependent on a stable environment, in which a continuous flow of oxygen and nutrients takes place and where extreme fluctuations in temperature are limited. Prosobranch snails are more dependent on these stable conditions than pulmonates are and this may account for their over-representation among the extinct species. In the high extinction rate, fluvial molluscs resemble inhabitants of shelf seas and forest dwellers, which also comprise a number of extinct species in the Quaternary.

Not all extinct species are equally valuable for stratigraphical purposes. This also depends on their abundance and their (palaeo)geographical distribution. For instance, during Middle and Late Quaternary *Theodoxus danubialis* is known only from Scheldt deposits, which considerably reduces the regional biostratigraphic potential. Other species are rather rare or have been found in one locality only. If such species are excluded then the following useful indicators remain:

Viviparus glacialis
Valvata goldfussiana
Parafossarulus crassitesta
Lithoglyphus jahni
Tournouerina belnensis
Pisidium clessini.

Several species are confined to one interglacial only and here the position of the Bavel Interglacial may be noted with the occurrence of *Fagotia wuesti* n. sp. and *Tanousia runtoniana*. Several further extant species may be added as useful indicators: (see p. 172)

Name in previous papers:	interpretation in this paper:
Belgrandia sp. Tesch, 1944	*Belgrandia marginata* (Michaud, 1831)
Bithynia crassitesta (Brömme, 1885)	*Parafossarulus crassitesta* (Brömme, 1885)
Bithynia s.l. (nov. spec. ?) Spaink, 1968	*Parafossarulus crassitesta* (Brömme, 1885)
Bithynia tentaculata Tesch, 1929a (non Linné, 1758)	*Parafossarulus priscillae* (Girotti, 1972)
Bithynia tentaculata subsp. Meijer, 1974	*Bithynia (Neumayria) bavelensis* n. sp.
Bithynia tentaculata var. *crassitesta* Brömme, 1885	*Parafossarulus priscillae* (Girotti, 1972)
Congeria cochleata (Kickx, 1835)	*Mytilopsis leucophaeta* (Conrad, 1831)
Fagotia acicularis Meijer, 1986 (non Férussac, 1822)	*Fagotia wuesti* n. sp.
Fagotia acicularis Spaink, 1968 (non Férussac, 1822)	*Fagotia wuesti* n. sp.
Hydrobia stagnorum auctt. (non Gmelin, 1790)	*Hydrobia ventrosa* (Montagu, 1803)
Lithoglyphus naticoides Meijer, 1972 (non Pfeiffer, 1828)	*Bithynia tentaculata* (Linné, 1758)
Lithoglyphus naticoides auctt. (non Pfeiffer, 1828) (shells)	*Lithoglyphus jahni* Urbanski, 1975
Lithoglyphus naticoides auctt. (non Pfeiffer, 1828) (opercula)	*Parafossarulus* sp. (mostly *P. crassitesta*)
Lithoglyphus neumayeri Brusina var. michaeli Cov. (in Menzel, 1914)	*Lithoglyphus jahni* Urbanski, 1975
Lithoglyphus sp. Meijer, 1988	*Lithoglyphus jahni* Urbanski, 1975
Nematurella minima Tesch, 1939	*Tournouerina belnensis* (Delafond & Depéret, 1893)
Nematurella runtoniana Tesch, 1929a (non Sandberger, 1880)	*Tournouerina belnensis* (Delafond & Depéret, 1893)
Nematurella sp. Tesch, 1929b	*Tournouerina belnensis* (Delafond & Depéret, 1893)
Nematurella runtoniana Sandberger, 1880	*Tanousia runtoniana* (Sandberger, 1880)
Nematurella stenostoma Meijer, 1976 (non Nordmann, 1901)	*Tournouerina belnensis* (Delafond & Depéret, 1893)
Nematurella stenostoma Tesch, 1944 (non Nordmann, 1901)	*Peringia ulvae* (Pennant, 1777)
Neumayria crassitesta (Brömme, 1885)	*Parafossarulus crassitesta* (Brömme, 1885)
Paladilhia bourguignati (Locard, 1883)	*Avenionia brevis roberti* Boeters, 1967
Paludestrina sp. Tesch, 1929b	*Belgrandia marginata* (Michaud, 1831)
Pisidium astartoides Sandberger 1880	*Pisidium clessini* Neumayr, 1875
Pisidium cinereum Alder, 1837	*Pisidium casertanum* (Poli, 1791)
Pisidium clessini Meijer, 1973 (non Neumayr, 1875)	*Pisidium amnicum* (Müller, 1774)
Pisidium vincentianum Woodward, 1913	*Pisidium stewarti* Preston, 1909
Planorbis arcticus auctt. (partim)	*Gyraulus acronicus* (Férussac, 1807)
Planorbis arcticus auctt. (partim)	*Gyraulus rossmaessleri* (Auerswald, 1851)
Planorbis corneus var. Spaink, 1968 (partim)	*Planorbarius peetersi* n. sp.
Planorbis glaber Forbes & Hanley, 1852, non Jeffreys, 1830	*Gyraulus laevis* (Alder, 1838)
Planorbis gredleri auctt. (partim)	*Gyraulus acronicus* (Férussac, 1807)
Planorbis gredleri auctt. (partim)	*Gyraulus rossmaessleri* (Auerswald, 1851)
Planorbis spirorbis Linné, 1758	*Anisus leucostomus* (Millet, 1813)
Pseudamnicola confusa (Frauenfeld, 1863)	*Mercuria confusa* (Frauenfeld, 1863)
Pseudemmericia spec. Meijer, 1986	*Bithynia (Neumayria) bavelensis* n. sp.
Theodoxus cantianus Kennard & Woodward 1924	*Theodoxus danubialis* (Pfeiffer, 1828)
Theodoxus serratiliniformis Tesch (non Geyer, 1914)	*Theodoxus* sp.
Valvata macrostoma Mörch, 1864	*Valvata pulchella* Studer, 1820
Viviparus fasciatus Müller, 1774	*Viviparus contectus* (Millet, 1813)
Viviparus medius Tesch (non Woodward, 1833)	*Viviparus glacialis* (Wood, 1872)
Viviparus sp. Tesch, 1944	*Viviparus teschi* n. sp.

Table 2. Names of Quaternary freshwater species used in Dutch literature and their present-day interpretation.

	R	H	E	IS	Ho	C4	L	Ba	Wa	LT	MT
Prosobranchia	15	14	13	7	8	8	4	14	14	15	18
Pulmonata	25	23	22	19	17	17	14	25	18	18	13
Bivalvia	28	27	19	15	14	14	9	24	20	17	14
Totals	68	64	54	41	39	39	27	63	52	50	45
Extinct species	-	-	-	-	3	2	3	8	8	10	6
Last appearances	-	-	-	-	3	-	1	5	3	2	-

Table 3. Numbers of freshwater molluscan species in temperate phases of the Quaternary in The Netherlands, with numbers of extinct species and last appearances. Abbreviations see explanation of Table 1.

Theodoxus fluviatilis
Valvata naticina
Bithynia troscheli
Corbicula fluminalis.

For the recognition of single interglacials with the help of freshwater molluscs, the following biostratigraphic events are of significance.

Tiglian:

FAD: since no older deposits which regularly yield freshwater molluscs occur in The Netherlands, no first appearances for this stage are given.
LAD: *Viviparus glacialis, Parafossarulus priscillae.*
RO: -

Waalian:

FAD: -
LAD: *Viviparus teschi* n. sp., *Tournouerina belnensis*, *Sphaerium rosmalense* n. sp.
RO: -

Bavel Interglacial:

FAD: -
LAD: *Lithoglyphus jahni.*
RO: *Fagotia wuesti* n. sp., *Bithynia bavelensis* n. sp., *Tanousia runtoniana*, *Planorbarius peetersi* n. sp., *Anisus septemgyratus*. Except for the last species all are extinct. However, the age of their LAD is not yet clear.

Leerdam Interglacial:

FAD: -
LAD: *Valvata goldfussiana*. The LAD of this species may possibly be in the subsequent, first Cromerian Interglacial.
RO: -

First three interglacials in the Cromerian: no data.

Cromerian, 4th Interglacial:

FAD: -
LAD: -
RO: *Valvata naticina* (not extinct).

Holsteinian:

FAD: -
LAD: *Viviparus diluvianus, Parafossarulus crassitesta, Pisidium clessini.*
RO: *Valvata naticina, Belgrandia marginata* (both not extinct).

Belvédère Interglacial:

FAD: -
LAD: -
RO: *Belgrandia marginata* (not extinct).

Eemian:

FAD: *Theodoxus fluviatilis.*
LAD: -
RO: *Theodoxus danubialis* (not extinct).

Holocene:

FAD: *Margaritifera auricularia.*
LAD: -
RO: During the last 200 years several species have been introduced as a consequence of human activities. These are: *Lithoglyphus naticoides* (Pfeiffer, 1828), *Potamopyrgus jenkinsi* (Smith, 1889) s.l., *Physella acuta* (Draparnaud, 1801), *Mytilopsis leucophaeta* (Conrad, 1831), *Dreissena polymorpha* (Pallas, 1771) and *Sphaerium transversum* (Say, 1829).

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Manuscript received 11 November 1989, revised version accepted 20 November 1989.