

Two subspecies of *Unio crassus* Philipsson, 1788 (Bivalvia, Unionoidea, Unionidae) in The Netherlands

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The former distribution of *Unio crassus* in The Netherlands is reconstructed on the basis of the collections of the Netherlands Centre for Biodiversity Naturalis, Leiden, and the private collection of the author. The most recent record of live *U. crassus* in The Netherlands dates from 1967, when two individuals were collected in the Biesbosch, in the southwestern part of The Netherlands. A rather common form of *U. tumidus* Philipsson, 1788, here referred to as forma *curtus* has often been confused with *U. crassus* and has caused considerable misunderstanding about the distribution of that species in the past. Next to the most common subspecies, *U. crassus riparius*, *U. c. crassus* is reported as a second subspecies from the northeastern part of The Netherlands. The conchological differences between the two subspecies are described and illustrated. A new way of measuring, using the prodissoconch instead of the umbo, is introduced.

Key words: Unionoidea, *Unio crassus riparius*, *Unio crassus crassus*, *Unio tumidus*, morphometrics, taxonomy, The Netherlands.

INTRODUCTION

Of the three *Unio* species that were living in The Netherlands until recently, *U. crassus* Philipsson, 1788, is the one most sensitive to pollution (Patzner & Müller, 2001: 328) and most clearly restricted to streaming fresh water. Especially during the seventies of the last century the Rhine and Meuse became heavily polluted (Middelkoop, 1998: 67). As a consequence, *U. crassus* was not observed alive anymore after 1967 in the Netherlands. The exact period in which it became extinct will never be known. In the early nineties of the last century, H. Wallbrink, Nieuwegein, and the author began an intensive search for *U. crassus*, but found only shells with a brown periostracum. Nowhere specimens with a periostracum with yellow and green colours were found. Because it takes 10 to 20 years after dying to develop shades of brown (Nienhuis, 2003: 81) we can accept that *Unio crassus* became extinct in the Netherlands before 1980.

In 1990 (personal data) four of the five Unionoidea species, which were known from the two large Dutch river systems before the severe pollution started were found alive again, at least at species level (in some cases different forms

or even subspecies may have reinvaded The Netherlands), viz. *Unio pictorum* (L., 1758), *U. tumidus* Philipsson, 1788, *Anodonta anatina* (L., 1758) and *Pseudanodonta complanata* (Rossmässler, 1835). It can be expected that *U. crassus* will once also be found alive again if the water quality continues to improve.

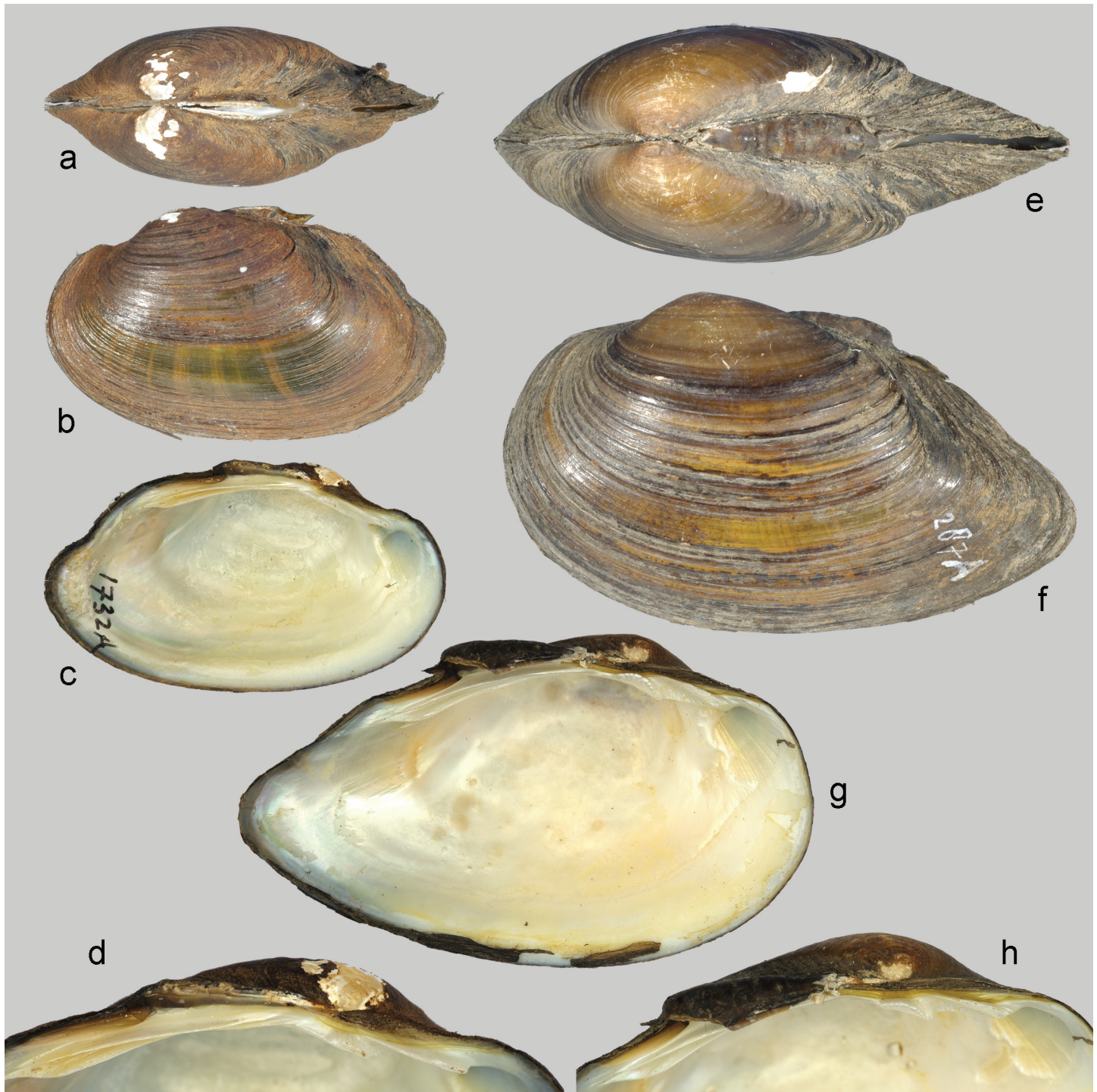
Much incorrect information about the distribution of *Unio crassus* was published in the past. Most of the mistakes have to do with a form of *U. tumidus*, which is for convenience called forma *curtus* here. Because the cardinal teeth of *U. crassus* differ from those of *U. tumidus*, the two species can be distinguished despite the similarity in general shape. In this article the conchological differences between *U. crassus* and *U. tumidus* forma *curtus* are clarified and their former distribution in The Netherlands is summarized. Moreover, *U. crassus* is dealt with in more detail since it turned out that this species has been represented by two forms. For the moment being, well aware of the difficulties in the recognition of subspecies in *U. crassus* on the basis of shell characters only (Nagel, 2011), these forms are given that taxonomic status here.



Fig. 1. Records of *Unio crassus riparius* C. Pfeifer, 1821, and *U. c. crassus* Philipsson, 1788, in the Netherlands. 18 means 1918 etc. Only the spot in the north-east of the Netherlands ('96') refers to the latter subspecies. O collected alive or with flesh rests; □ Periostracum yellow with green or with shades of brown (only '39' and '96'); ? no dates available (colln C.H.Oostingh; Meppeler Diep, colln M.M. Schepman; Oude IJssel and Kromme Rijn).

All the specimens of *Unio crassus* that were present 2004 in the Zoological Museum, Amsterdam, and in the National Museum of Natural History, Leiden (recently united as the Netherlands Centre for Biodiversity Naturalis, Leiden) were studied (see Fig. 1), as well as the samples in the private collection of the author. All the shells have at least traces of the periostracum. During this study, three categories of specimens are distinguished: (1) animals collected alive or shells with remains of flesh, a yellow periostracum with green rays (changing into brown in alcohol material), which is sometimes covered by a dark layer; (2) shells with a yellow and green periostracum, without any remains of the soft parts; (3) shells with a light brown periostracum with dark rays. In all categories both valves can be found still together. When more than one category was present in a sample the best preserved specimen determined the category (Fig. 1). Category (3) is only indicated in Figure 1 when there is no sample of the categories (1) or (2) known from nearby.

(next page) Fig. 2. *Unio tumidus* forma *curtus*. **a-d**, Collected alive in the Vecht, De Haandrik near Gramsbergen, Province of Overijssel, 2004. Example of less abrupt diminishing diameter. Shell length 5.3 cm (leg. J.A.J.H. Nienhuis). **e-h**, Collected alive in the Oude Rijn, Herwen near Lobith, Province of Gelderland, 1981. Example of abrupt diminishing diameter. Shell length 7.6 cm (leg. J.A.J.H. Nienhuis). Photographs by J. Goud, Leiden.



For measurements were used: 9 shells from the Drentse Aa and 52 from the Waal near Doodewaard, 19 extremely well preserved shells from the Meuse in the provinces of Noord-Brabant and Limburg, 6 shells collected near Leiden, 3 shells collected near Uitgeest and the only known shell from the Dinkel.

RESULTS

Historical data.— In The Netherlands, the last sample of live *Unio crassus* was collected in the southwestern part of the country, in the Biesbosch, on 6.ii.1967 (Wolff, 1968: 25). Two animals with shell lengths of 6.0 and 6.7 cm, respectively, were collected in the Steurgat, Het Kooike, at a depth of 3-4 m. In the Meuse the last proof of live *U. crassus* (6.1 cm) was established near Roosteren in 1946 by W.H. Neuteboom. Both records are of adult animals. Because juvenile animals are much more sensitive to eutrophication than adult ones (Patzner & Müller, 2001: 328), it is possible that reproduction had ceased already long before 1967. That might explain why in a sample of 320 valves of subrecent *U. crassus* (Colln Nienhuis), collected in 1996 and 2003 in the Waal near Doodewaard, all shells are over 4.0 cm long.

Outside the Dutch large river systems populations of *U. crassus* were known from: (1) a locality near Uitgeest near Alkmaar, province of Noord-Holland; (2) the Vliet and the Oude Rijn, near Leiden, province of Zuid-Holland; (3) the Dinkel, near Denekamp, province of Overijssel; (4) the Drentse Aa, near Glimmen, provinces of Groningen and Drente.

U. crassus was only found in small to large streaming waters. The data published by Wolff (1968: 27) are mainly based on *U. tumidus* forma *curtus* (see next paragraph) or dead *U. crassus* and cannot contribute to a better understanding of the ecology of *U. crassus* in The Netherlands.

The provenance of two samples allegedly collected in the Uitgeestermeer near Uitgeest remains unclear. They were most certainly not collected in that lake (W.J. Kuijper, personal communication, 2004), since in 1937 and 1941, shortly after the closing of the Afsluitdijk in 1933, the salinities in the Alkmaardermeer, which was directly connected with the Uitgeestermeer, were 1.51 ‰ and 0.67 ‰, respectively (Anonymus, 1946: 68), whereas *U. crassus* can tolerate salini-



Fig. 3. Records of *Unio tumidus* forma *curtus*. ? no dates available (colln C.A. van der Willigen; Kromme Rijn); 18 means 1918 etc. except 02 and 04 which must be read as 2002 and 2004. See Fig. 1 for explanation of other symbols.

ties up to only 0.5‰ (Jaeckel, 1960: 207 [although referring to *U. c. crassus*]). The populations from near Uitgeest might have occurred in running waters flowing from the dunes a little more to the west.

Unio tumidus forma *curtus*.— Since the shapes of the shells of *Unio tumidus* forma *curtus* and *U. crassus* overlap to some extent, specimens of both species have been misidentified regularly in the past. The variety of *U. tumidus* with short shells, referred to here as forma *curtus*, has caused much confusion. It always lives together with normal *Unio tumidus*, to which it is connected by intermediate forms. [Kobelt (1880: 32) de-

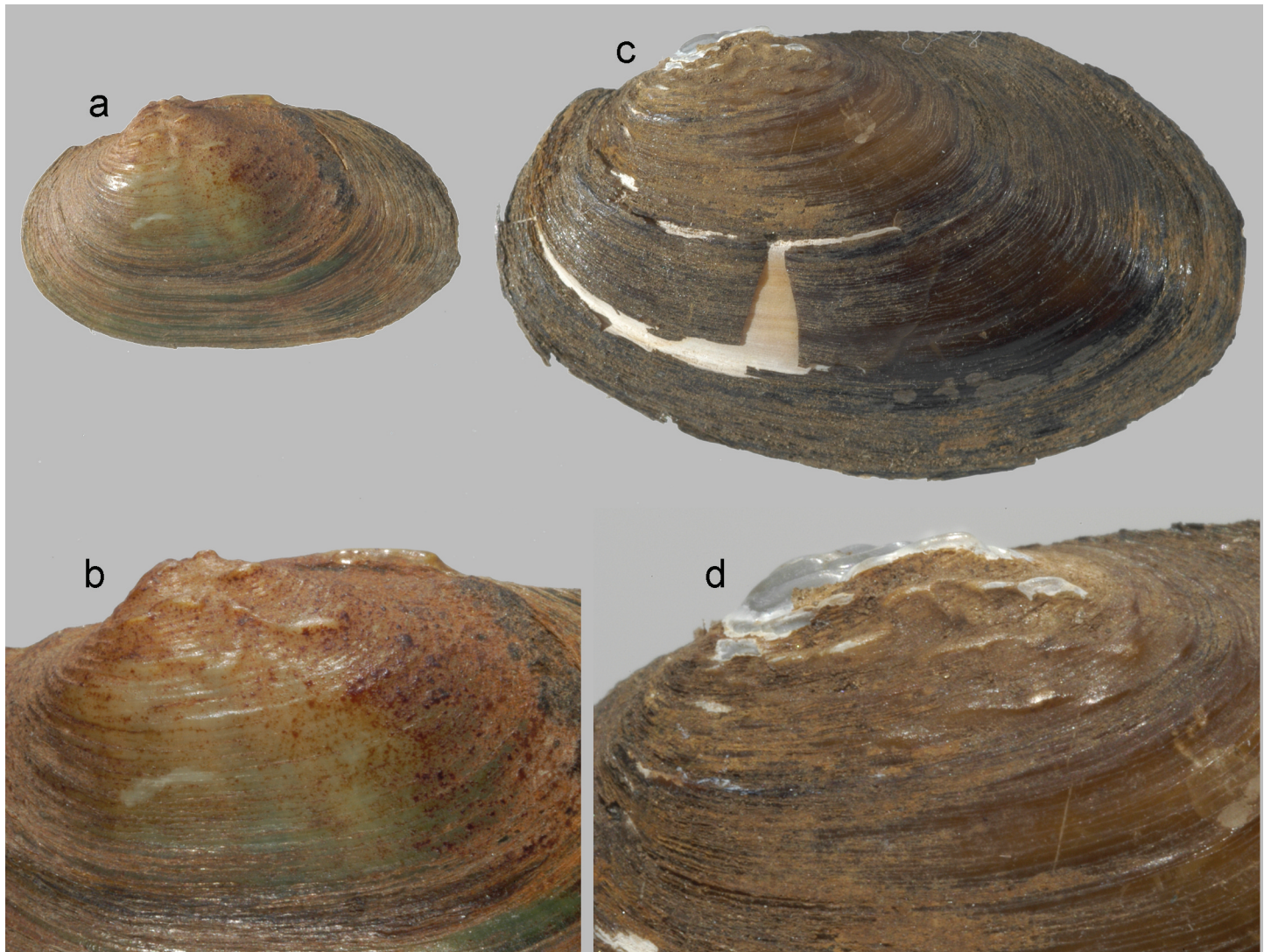


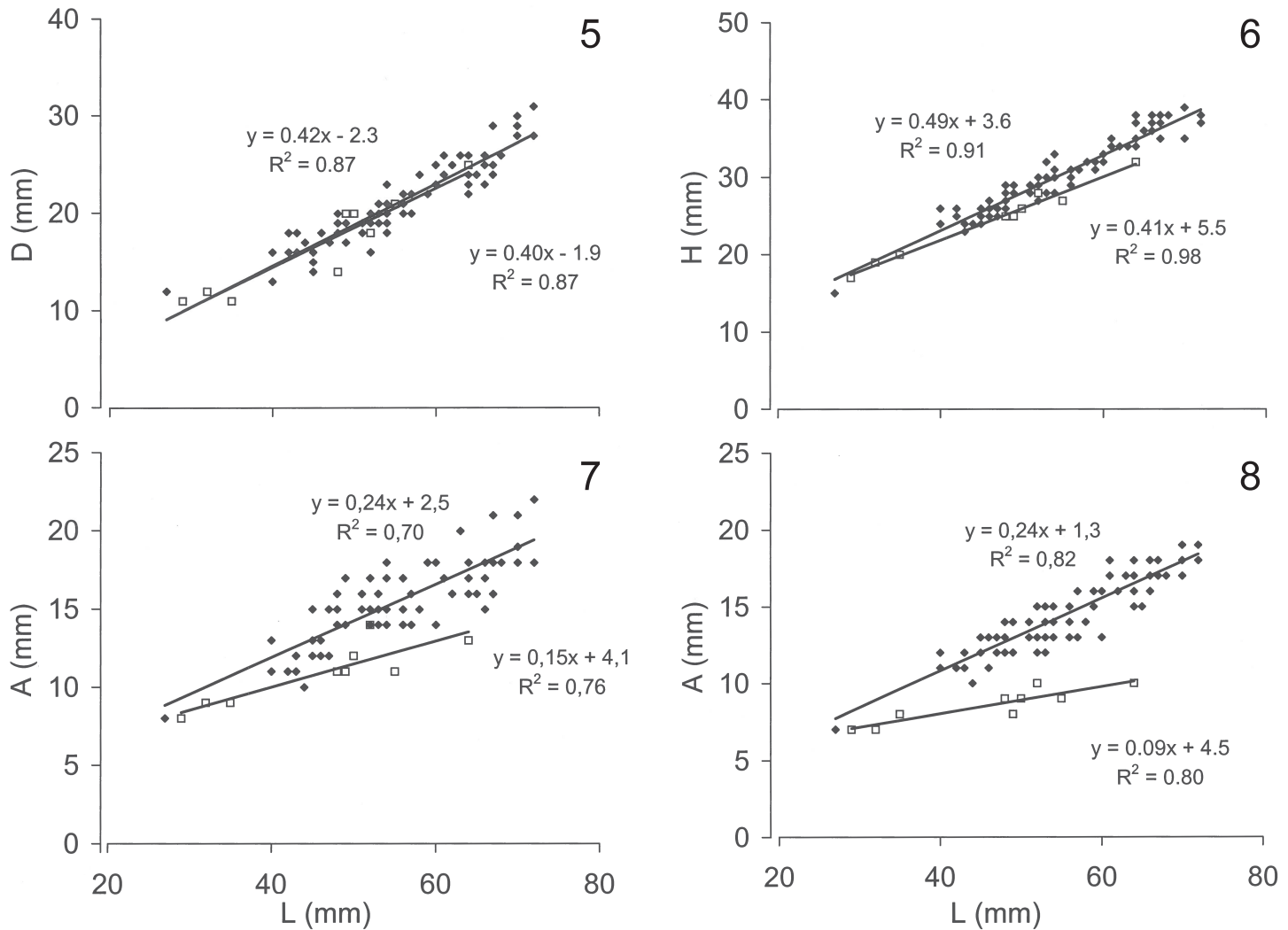
Fig 4. Juvenile specimens of *Unio crassus riparius* and *U. c. crassus*. **a-b**, *Unio crassus riparius* collected alive in the Meuse, Niers, province of Noord-Brabant, A.M.H. Schepman leg., 1912; shell length 1.7. cm. **c-d**, *Unio crassus crassus* collected without flesh rests in the Drentse Aa near Glimmen, provinces of Groningen and Drenthe, H.J. Kwant, Haren, leg. 2000; shell length 2.9 cm. Photographs by J. Goud, Leiden.

scribed *Unio tumidus* var. *Rohrmani* from Schwierse near Oels in Silesia for a population with short shells that are more flattened however, than the shells from The Netherlands].

In *U. tumidus* both cardinal teeth in the left valve are

sharp and long, and point approximately to the outline of the shell, whereas in *U. crassus* these teeth are blunt and short, and point to the inside of the shell.

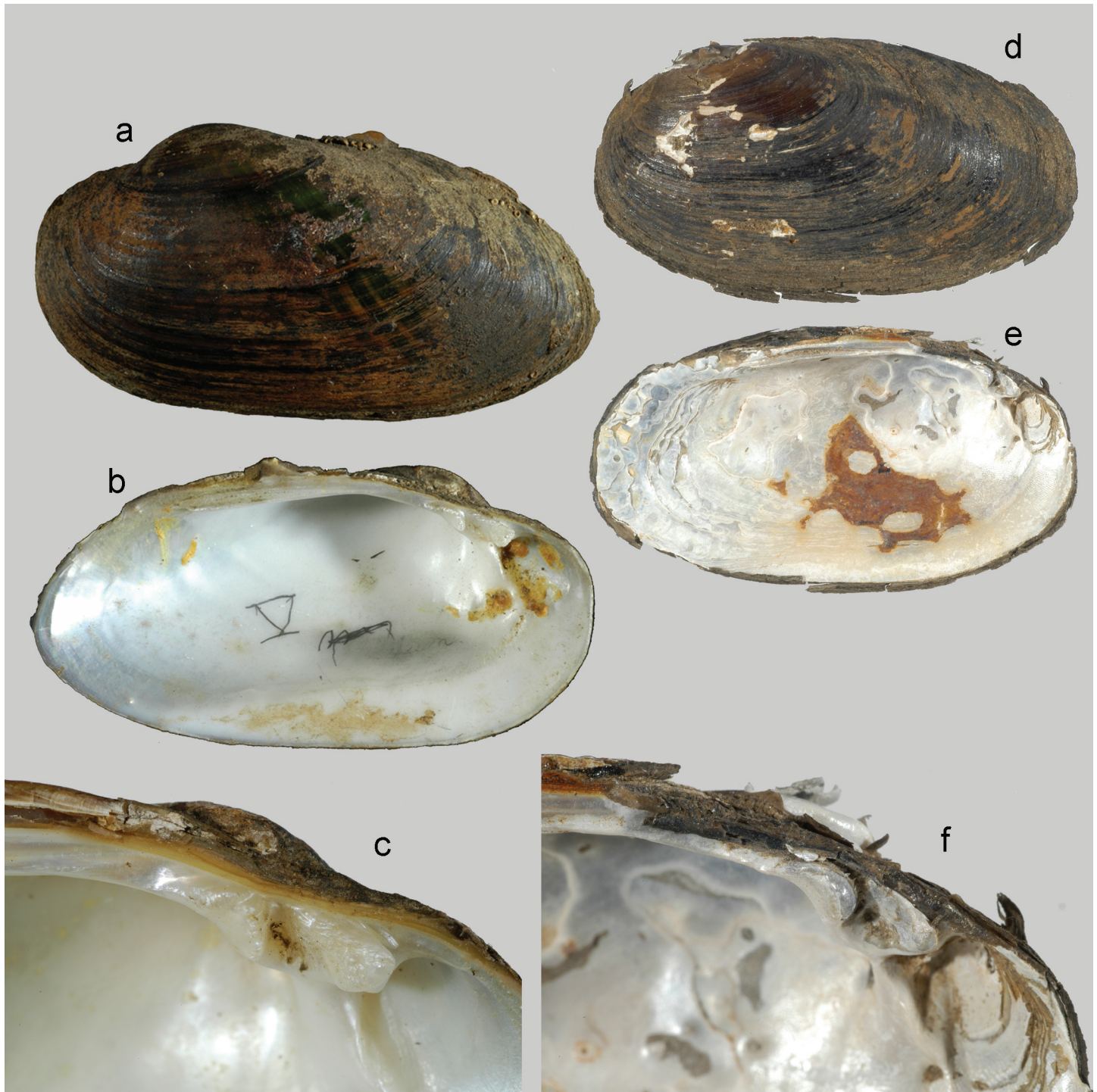
Unio tumidus and its varieties have the same form of rugae on the umbo. Almost always *U. tumidus* forma *curtus*



Figs 5-8. Measurements in *Unio crassus riparius* of 5 different localities which are lumped together (black rhombs) and *U. c. crassus* from the Drentse (open squares), with regression lines and correlation coefficients. 5, maximum diameter versus length; 6, height versus length; 7, anterior part (determined after Gittenberger et al., 1998) versus length; 8, anterior part (determined as described in this paper) versus length.

starts growing like normal *U. tumidus*, but after having reached a length of 2.5-6.8 cm the growth at the distal end may decrease rather abruptly, which results in an irregular diminishing of the diameter from that point on. A more normal growth at the distal end may be resumed, however. Especially when there is a more gradual change in growing,

Fig. 9. Fully grown *Unio crassus*. a-c, *U. c. riparius* collected alive in the Meuse, Eegden, province of Limburg, by Comité Onderzoek Maasfauna leg., 1918, shell length 7.0 cm. With remains of adductor muscles; d-f, *U. c. crassus* collected without flesh rests in the Drentse Aa near Glimmen, provinces of Groningen and Drenthe, H.J. Kwant, Haren, leg. 2000; shell length 5.4 cm. Photographs by J. Goud, Leiden.



the shells may become very similar to *U. crassus* in shape.

Unio tumidus forma *curtus* can still be found alive in The Netherlands, where it is always accompanied by more 'typical' *U. tumidus*. The species occurs in stagnant to streaming waters (Gittenberger et al., 1998: 179), but its forma *curtus* was never observed in stagnant water. Maybe this variety should be considered a growth disorder, caused by heavy infestation of the mantle tissue at the distal end by watermites of the genus *Unionicola*, which differ in their ecological requirements. Maybe a species of watermites preferring streaming water is involved, what might explain why *Unio tumidus* forma *curtus* is restricted to that type of habitat. See for general information on the relations between mites of the genus *Unionicola* and Unionidae in Europe Davids (1973), Hevers (1975, 1980) and Mitchell (1953).

Unio crassus riparius and *U. crassus crassus* in The Netherlands.— In 1996, bottom samples were dredged from the Drentse Aa, a brook in the northeastern part of The Netherlands, between Haren and Tynaarlo and shells of *U. crassus* with a brown periostracum were selected from the mud. In 2000 additional material was collected by H.J. Kwant, Haren. This population differs from the *U. crassus* from other localities in The Netherlands, which has been classified with *U. crassus riparius* C. Pfeiffer, 1821 (= *U. c. batavus* sensu auct., = *U. c. nanus* Lamarck, 1819 [Gittenberger & Janssen, 1998: 176]; see Falkner et al., 2002: 172). In shells longer than 4 cm, the anterior part is shorter, i.e. measures less than a quarter of the total shell length, the umbo is protruding less, and there is a 'dorsal curve'. If a line parallel to the length axis and touching the dorsal side of the outline of the shell does not touch the umbo, the valve is supposed to have a 'dorsal curve'. This character state is very rare in *U. crassus riparius* (see Fig. 9). Moreover, the rugae of a juvenile shell that was found in the Drentse Aa differ from those of a specimen of *U. c. riparius* (see Fig. 4), but since these two specimens are the only ones available and because rugae prove to be very variable even within populations of *Unio* species in general (personal observation), this might not at all be diagnostic.

The Drentse Aa may be considered isolated since it drains into the Dutch Wadden Sea, in contrast to the other

Dutch waters where *Unio crassus* once occurred, where some gene-flow might have been possible. According to for example Ehrmann (1933 [1956]: 224), Falkner et al. (2002: 171), Haas (1969: 45), Jaeckel (1952: 19), Jungbluth (1973: 162), Modell (1924: 47; 1941: 169), and Nesemann (1993: 21), *U. c. crassus* is the subspecies that is represented in the Scandinavian glacial area, so that biogeographically it may be considered most likely that *U. c. crassus* once occurred in the Dutch province of Drente. The nearest record for *U. c. crassus* mentioned in the literature is the Weser (Ehrmann, 1965: 224; Haas, 1969: 45; Nesemann, 1993: 21; Gloër & Meier-Brook, 2003: 72). I looked for *U. crassus* in the Elbe in vain.

Ehrmann (1956: 224), Gloër & Meier-Brook (1994: 69), Haas (1969: 45, 52), and Jaeckel (1952: 20, Fig. 8) give information concerning the presence of a dorsal curve and the less pronounced umbo in *Unio c. crassus* as opposed to *U. c. riparius*. Their data do not contradict the results obtained for the two forms of *U. crassus* that once occurred in The Netherlands (Fig. 8).

Zettler (1997: 218) gives extensive information concerning length, height, width and weight for 27 populations of *Unio crassus* in Germany (Mecklenburg-Vorpommern), Estonia and Lithuania. Because all these populations are found in the Scandinavian glacial area, they 'should' belong to *U. c. crassus*. The quantitative data show that the various populations are quite variable in most relative dimensions, so that Zettler (1997: 225) concludes that in northern Europe *U. c. crassus* is the most variable unionoid. Nevertheless, according to the literature the ratio anterior part/shell length for *U. c. crassus* is very constant, i.e. 23-25 % (Table 1). Zettler (1997) does mention neither a more or less protruding umbo nor the dorsal curve that is shown on his illustrations, however.

While investigating the differences between the Dutch populations of *Unio crassus riparius* and *U. c. crassus*, three ratios were studied, viz. height/length, maximum diameter/length and anterior part/length. Measuring the various dimensions is more complicated than suggested by Gittenberger & Janssen et al. (1998: 17) on the basis of a picture of *Unio pictorum*. For that reason, the measurements are defined here in more detail.

Usually, as in Gittenberger & Janssen et al. (1998: 17) the anterior part of the shell is determined as the distance

between the projection of the umbo on the length axis and the anterior side. Because umbones can be rather flat or corroded however, the exact spot from which to measure can pose problems. On the contrary, the location of the prodissoconch, i.e. the former glochidium, can be determined exactly. Here, the anterior part is defined as the distance between the projection of the prodissoconch on the length axis and the anterior side (see Figs 7, 8). The shell height is measured perpendicularly to the length axis, as the distance between the umbo and the line parallel to the length axis touching the ventral side. By diameter the diameter of a complete specimen is meant, so that the measured distance has to be doubled when only a single valve is available. The results of the measurements are summarized in Figs 5-8, where Figs 7 and 8 additionally show the differences resulting from the methods used by Gittenberger & Janssen (1998) and in this paper. Obviously, *U. c. crassus* and *U. c. riparius* are most clearly different in the ratio anterior part versus length (Figs 7, 8).

CONCLUSIONS

The shells of *U. crassus* from the Drentse Aa correspond with *U. c. crassus* regarding umbo and dorsal curve. Their anterior part/total length ratio is much smaller than in Dutch *U. c. riparius*, and very short even for *U. c. crassus*. Anyway, the Drentse Aa material is too different to be classified as *Unio crassus riparius*. Therefore, on the basis of both morphological and biogeographical arguments, it is hypothesized that *Unio crassus crassus* once occurred as a second subspecies of *U. crassus* in The Netherlands, next to *U. crassus riparius* C. Pfeiffer, 1821 (= *U. c. batavus* sensu auct., = *U. c. nanus* Lamarck, 1819, see Falkner et al., 2002: 172). Following Modell (1924: 27), the Dutch form of *U. c. crassus* could be referred to as forma *tenuis*, supposedly the most common variety of *U. c. crassus* outside the Baltic states.

ACKNOWLEDGEMENTS

I thank J. Goud, Leiden, for making the photographs and helping with the lay-out; D.F. Hoeksema, Middelburg, for information on bivalve terminology; E. Gittenberger, Leiden, for the loan of *Unio crassus* of the NCB Naturalis and for crit-

ically reading and commenting on the manuscript; H.K. Kaput, Assen, for typing and correcting the original manuscript; W.J. Kuiper, Noordwijk, for informing me on brackish water molluscs and *Unionoidae*; H.J. Kwant, Haren, for showing me additional *U. c. crassus* of the Drentse Aa; R.G. Moolenbeek, Amsterdam, for the loan of *U. crassus* of the Zoological Museum, Amsterdam; F.P. Wesselingh, Leiden for the loan of fossil *U. crassus* of the NCB Naturalis; A.J. de Winter, Wageningen, for making the graphs.

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