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Some peculiarities in developmental biology of two forms of the freshwater bivalve *Unio crassus* in northern Germany

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With 7 figures and 1 table in the text

Abstract

The freshwater bivalve *Unio crassus* (Philipsson) is threatened with extinction in many parts of Germany. In the course of more detailed studies on its ecological requirements some regional peculiarities among *Unio crassus* populations in Northern Germany were observed. These peculiarities not only concern the well known variability in bodysize and shape of the shells but also the number of released glochidia and differences in the preference of host fish.

Introduction

The decline of *Unio crassus* observed already by Jaeckel (1952) has become more rapid in recent years (Wiese 1984). In order to provide more knowledge for effective protection measurements of the remaining populations at both the university of Bayreuth (Dr. Bauer; Hochwald 1986) and in this department (Bednarczuk 1986, Maass 1987, Engel in preparation) detailed investigations of habitat requirements and reproduction biology have been initiated. Since 1987 the studies in Northern Germany are supported by the World Wildlife Fund (WWF).

In Northern Germany *Unio crassus* is represented by the subspecies *Unio crassus crassus* (Philipsson). In some rivers in Schleswig Holstein a large form of this subspecies has been distinguished as *Unio crassus crassus* forma *maximus* (Kobelt) by Jaeckel 1952 (Fig. 2). It may reach a shell length of up to 80 mm and its proportions noticably differ from those of the smaller more abundant normal form of *Unio crassus crassus* which apart from Schleswig Holstein also occurs in Lower Saxony (shell length up to 60 mm). Observations on both forms indicate that they differ not only in size and shape but also in their developmental biology.

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Material and methods

Habitats

Population A: The population of *Unio crassus crassus* forma *maximus* studied occurs in the river Alster (District Stormarn Schleswig Holstein). The river at this place is about 4 to 5 m wide and about 30 to 120 cm deep. There are cattle meadows on the banks at both sides. The water flows at moderate speed (10 cm/sec) through a rich vegetation of macrophytes (KUNDY 1984). The mussels prefer sites near the banks often under bank projections in sandy or clayey sediments.

Population B: The specimens of the normal *Unio crassus crassus* were taken from a small brook in the area of Lüchow-Dannenberg 2.5—3 m wide and 50 to 80 cm deep and a flow velocity of 10 to 12 cm/sec. The banks are lined by either wet meadows or alder wood with dense nettle belts. The sites where mussels are found are partly covered by Elodea and Glyceria. The sediment mainly consists of coarse sand and clay with or without thin silt deposits 0.5 to 1.0 cm thick. Here again the clams prefer positions near the banks and underneath bank projections.

In both habitats the size and age structure of the populations were recorded. From 100 mussels out of each population measurements were taken. Age determination was carried out on empty shells by counting annual rings (NEGUS 1966). Gravity in females was controlled from april to july by carefully opening the shells using a pair of special tongues. Gravid females were taken to the laboratory to follow up the output of glochidia. Shed glochidia were counted and put into contact with known or assumed host fish (BRAUN 1878, WELLMANN 1939). The infection was controlled over a period of 30 days.

Results

a) Size of shells

The length of shells determined in this study agrees with earlier data (GEYER 1909, 1927, JAECKEL 1952, GLÖER et al. 1985, BEDNARCZUK 1986):

Unio crassus crassus: up to 60 mm

Unio crassus crassus forma *maximus*: up to 77 mm

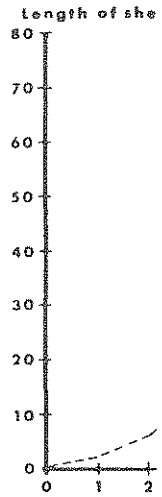
A comparison of annual growth in both forms is given in Fig. 1.

b) Number of glochidia

The number of glochidia released by gravid females is markedly different in both forms

	number of glochidia	length of shell	n^x
Unio crassus crassus	9,500 – 16,500	33 – 52 mm	20
Unio cr. cr. fa. *maximus*	81,000 – 100,000	70 – 71 mm	5

n^x number of specimens controlled.



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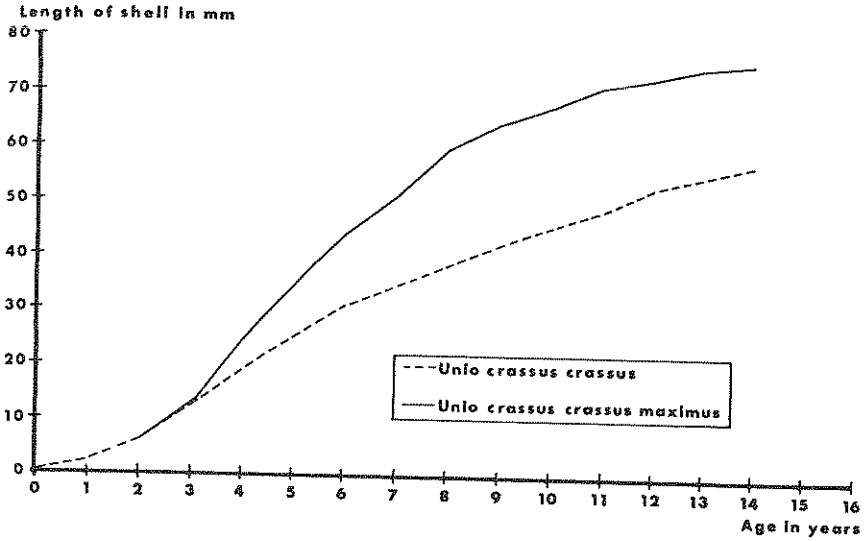

Fig. 1. Growth curve of the shell in two forms of *Unio crassus*.

c) Size of glochidia

Glochidial size (230 × 210 µm) is equal in both forms (Fig. 3). This is in agreement with earlier data (MAASS 1987).

d) Spectrum of host fish

The suitability of local teleosts as host fish for *Unio crassus* is different in both forms. Only on the two species of sticklebacks (*Gasterosteus aculeatus* and *Pungitius pungitius*) glochidia from both origins fully developed into young mussels Figs. 4 and 6.

On dace (*Leuciscus leuciscus*) only glochidia of *Unio cr. cr.* fa. *max.* developed successfully whereas those of the normal *Unio crassus crassus* did not. The present state of both forms of *Unio crassus crassus* is summarized in Table 1.

On some sticklebacks (n = 21) caught in the habitat of population B 10 to 20 encysted glochidia were found per fish whereas other species at this site never carried glochidia: Dace (*Leuciscus leuciscus*) n = 11, rudd (*Scardinius erythrophthalmus*) n = 19, gudgeon (*Gobio gobio*) n = 77, stone loach (*Neomacheilus barbatulus*) n = 8, bitterling (*Rhodeus sericeus*) n = 10, river trout (*Salmo trutta*) n = 1, rainbow trout (*Salmo gairdneri*) n = 3.

Two daces (*Leuciscus leuciscus*) caught at habitat A carried glochidia which developed into young mussels in the laboratory. Glochidia of *Unio crassus crassus* where exclusively found on the gills of their host fish whereas glochidia

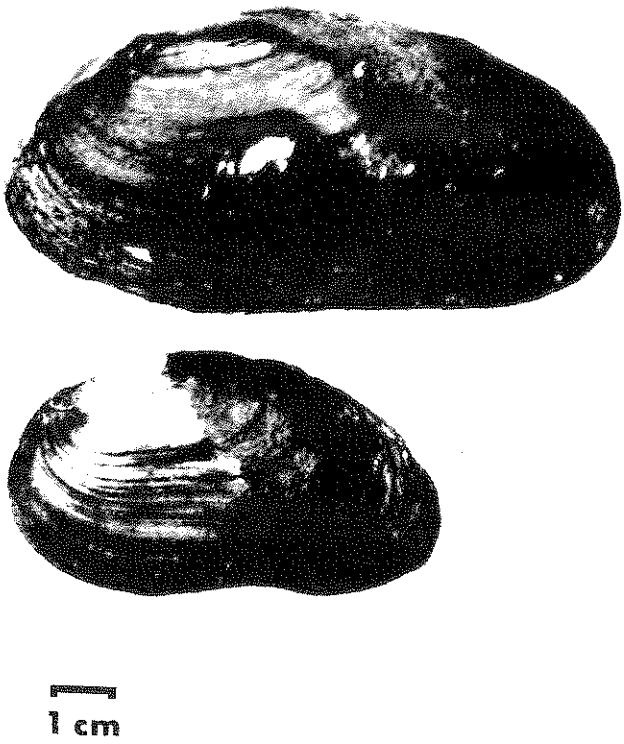

Fig. 2. Shells of the two forms of *Unio crassus crassus*; *maximus* form (above), normal form (below).

from *Unio crassus crassus* forma *maximus* also attached to operculum, eyes, nose and fins (Fig. 5). In both forms however full development is only achieved in gill epithelium. The time of development was the same in both forms. When the host fish were kept at 17 °C young mussels were released 22 to 27 days after infection (Figs. 6 and 7).

Discussion

Age determination of *Unio crassus* is particularly difficult due to the dark periostracum. Counting of annual rings on shells if well illuminated from below was found to be fairly reliable. The growth curve (Fig. 1) indicates that *Unio crassus crassus* forma *maximus* does not live longer but grows more rapidly. For both forms thus a maximal age of 12 to 15 years is assumed (Björk

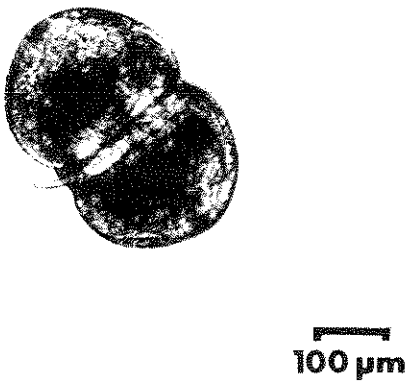

Fig. 3. Glochidium of *Unio crassus crassus*.

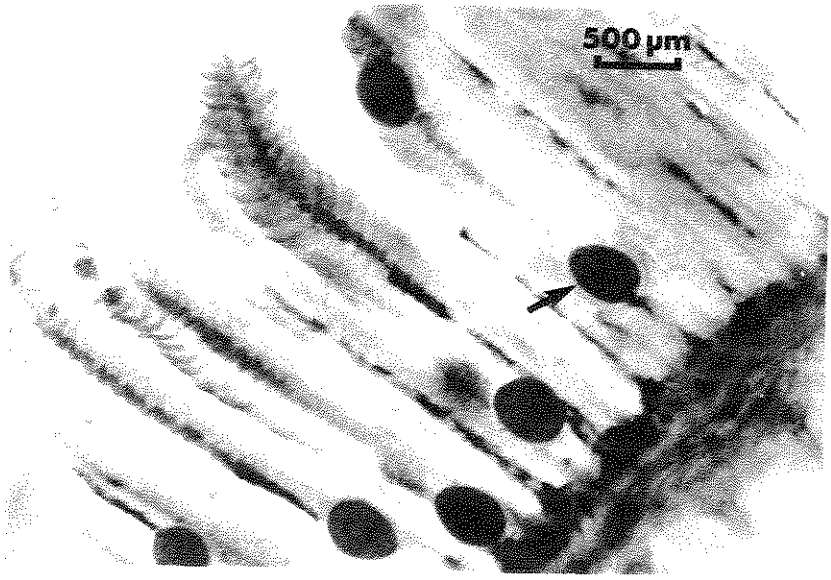

Fig. 4. Glochidium of *Unio crassus crassus* in the gill of the stickleback (*Pungitius pungitius*). The arrow points to the cyst formed by the gill tissue.

1962, TUDORANCEA 1968). The reliability of this age determination is at present being tested on labeled specimens in the field.

Table 1. Host fish spectrum of *Unio crassus* in Northern Germany.

Species of fish	*Unio crassus crassus* Locality B: Number of fish	*Unio crassus crassus* Locality B: preliminary uptake of glochidia per fish	*Unio crassus crassus* Locality B: complete development Release of young mussels per fish	*Unio crassus crassus* forma *maximus* Locality A: Number of fish	*Unio crassus crassus* forma *maximus* Locality A: preliminary uptake of glochidia per fish	*Unio crassus crassus* forma *maximus* Locality A: complete development Release of young mussels per fish
CHUB (*Leuciscus cephalus*)	()	()	()	x	(x) +	(x) +
3 spined STICKLEBACK (*Gasterosteus aculeatus*)	130	6	3	15	20	2
PERCH (*Perca fluviatilis*)	()	()	()	x	(x) +	(x) +
GUDGEON (*Gobio gobio*)	28	0	0	33	350	0
DACE (*Leuciscus leuciscus*)	32	250	0	xx 16	4000	600
9 spined STICKLEBACK (*Pungitius pungitius*)	49	8	4	15	50	12
RUDD (*Scardinius erythrophthalmus*)	29	2	0	x	(x) +	(x) +
TENCH (*Tinca tinca*)	()	()	()	x	(x) +	(x) +

(x) = Data from Bednarczuk 1986, ( ) = not investigated, x = not quantified, xx = These daces (*Leuciscus leuciscus*) are the same specimens not infectable with *Unio crassus crassus* glochidia in a previous experiment.

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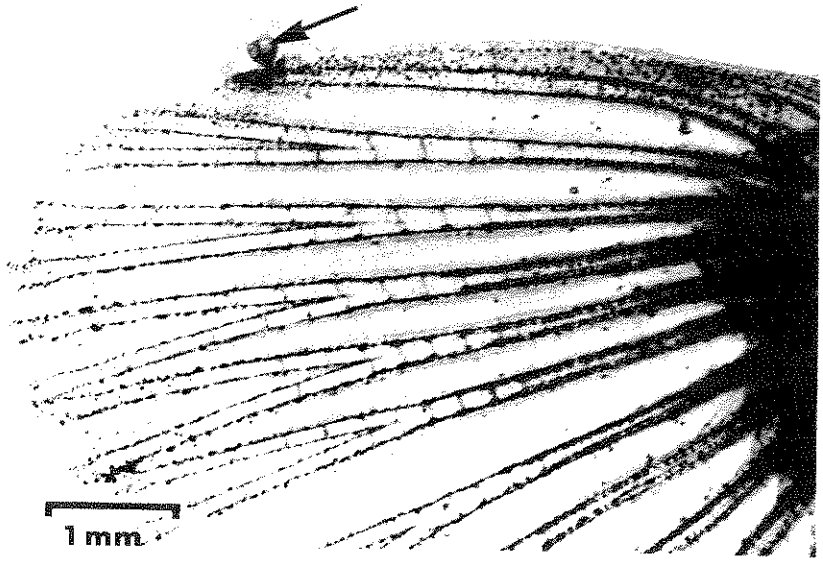

Fig. 5. Glochidium of *Unio crassus crassus* forma *maximus* encysted at the tail fin of the stickleback (*Pungitius pungitius*). Glochidia encysted outside the gills degenerate in the course of a few days (arrow).

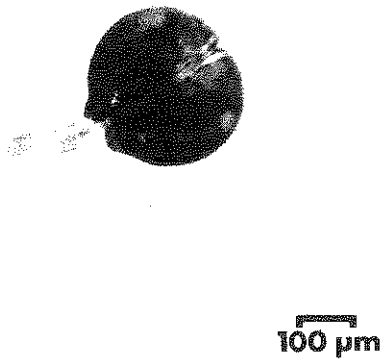

Fig. 6. Young mussel of *Unio crassus crassus* two days after leaving the host fish.

(*Scardinius erythrophthalmus*)					
TENCH	( )	( )	( )	x	(x) +
(*Tinca tinca*)					

(x) = Data from Bednarczuk 1986, ( ) = not investigated, x = not quantified, xx = These daces (*Leuciscus leuciscus*) are the same specimens not infectable with *Unio crassus crassus* glochidia in a previous experiment.

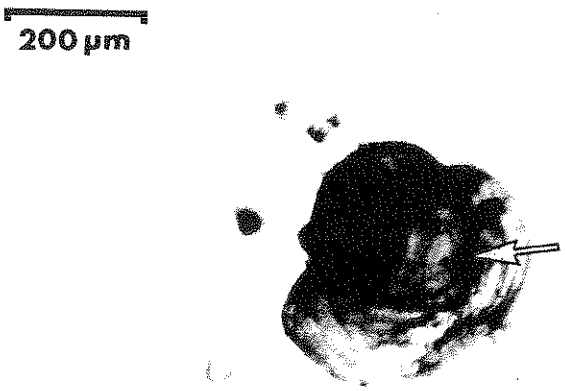

Fig. 7. Young mussel of *Unio crassus crassus*. 3 weeks old. Arrow points to the border of the original shell at the time of release from the host fish.

The number of glochidia produced is markedly higher in the maximus form than in the normal form. This is in agreement with observations of Bednarczuk (1986) who found 237,000 glochidia in a mussel of 65 mm length. As the size of the brood pouch cannot be measured in the living animal, it can so far only be suggested that the production of glochidia is just determined by the size and the storing surface of the gills.

The size of glochidia is evidently not only uniform in *Unio crassus* but the same for all three species occurring in Central Europe (Maass 1987, Nagel 1988).

The main differences found in the *Unio crassus* populations studied concern their host fish preferences. According to our present observations both species of sticklebacks (*Gasterosteus aculeatus* and *Pungitius pungitius*) play an important role as host fish for *Unio crassus* in Northern Germany. While a successful infection of perch (*Perca fluviatilis*), rudd (*Scardinius erythrophthalmus*) and chub (*Leuciscus cephalus*) as reported by Bednarczuk (1986) and in addition dace (*Leuciscus leuciscus*) reported here could be achieved with glochidia of the maximus form, rudd and dace were always negative when infected with glochidia of normal *Unio crassus crassus*. As perch and chub (Table 1) do not occur in the habitat of population B they were not tested with Glochidia of the normal form in this experiment.

The negative results in the gudgeon (*Gobio gobio*) with glochidia of *Unio crassus* confirms our observation that this fish is obviously neither a host for Unionids nor for *Margaritifera*.

Glochidia of the *maximus* form kept on the gill of *Gobio gobio* up to 4 days whereas glochidia of the normal form where not taken up at all.

In *Unio crassus* populations from rivers of Fränkische Schweiz (Southern Germany) in addition to chub (*Leuciscus cephalus*) bullhead (*Cottus gobio*) and minnow (*Phoxinus phoxinus*) recently were found to be host fish (Hochwald 1988). Cystformation around the glochidium on sites other than the gill epithelium of the host fish (Fig. 5), as found in glochidia of *Unio crassus crassus* forma *maximus* but not in normal *Unio crassus crassus* is obviously quite common in other species. It was observed not only with the large glochidia of *Anodonta* and *Pseudanodonta* (Hüby 1988) but also in *Unio tumidus* and *Unio pictorum* (Fleischauer-Rössing 1987).

The findings reported here indicate, that regional differences in its ecological requirements have to be taken into account whenever measurements for the protection of threatened *Unio crassus* populations are considered.

Detailed knowledge on the host fish spectrum and its variability may help to understand better the breakdown of many populations.

As *Unio crassus* is more selective in the choice of its host fish than other Unionids (although less specialized than *Margaritifera*) it is likely that at least in some localities environmental changes affecting host fish ecology may be more destructive than direct effects of pollution. Detailed studies on abiotic and biotic factors governing habitat selection, reproduction and early post parasitic life are in progress.

Summary

From the freshwater bivalve *Unio crassus* several subspecies are known. In *Unio crassus crassus* distributed in Northern Germany a large form "forma maximus" has been distinguished (Jaeckel 1952). It not only differs in size and shape from *Unio crassus crassus* but also in its developmental biology. Differences in reproductivity and host fish preferences of these two forms are described for two populations in Northern Germany.

References

Bednarczuk, J. (1986): Untersuchungen zu Wirtsfischspektrum und Entwicklung der Bachmuschel *Unio crassus*. — Diss. Tierärztl. Hochsch. Hannover, 39 S.

Björk, S. (1962): Investigations on *Margaritifera margaritifera* and *Unio crassus*. — Limnologic Studies in Rivers in South Sweden. — Acta Limnologica **4**: ff.

Braun, M. (1878): Über die postembryonale Entwicklung unserer Süßwassermuscheln (*Anodonta*). — Zool. Anz. **1**: 7—10.

Engel, H. (in prep.): Untersuchungen zur Autökologie von *Unio crassus* in Norddeutschland.

FLEISCHAUER-RÖSSING, S. (1987): Untersuchungen zum Populationsaufbau und zur Entwicklung einheimischer Süßwassermuscheln der Gattungen *Unio* und *Anodonta* in einem Kiesteich. — Dipl. Tierärtzl. Hochsch. Hannover, 174 S.

GEYER, D. (1909): Unsere Land- und Süßwasser-Mollusken. Eine Einführung in die Molluskenfauna Deutschlands. — Stuttgart (K. G. LUTZ), 148 S.

— (1927): Unsere Flußmuscheln und die alten Flußläufe Deutschlands. — Aus der Heimat **40:** 363—369.

GLÖER, P., MEIER-BROOK, C. & OSTERMANN, O. (1985): Süßwassermollusken, ein Bestimmungsschlüssel für die Bundesrepublik Deutschland. Hamburg (DJN).

HOCHWALD, S. (1988): Untersuchungen zur Populationsökologie und Fortpflanzungsbiologie der Bachmuschel *Unio crassus* (PHIL.) 1788. — Dipl. Univ. Bayreuth, 85 S.

HÜBY, B. (1988): Zur Entwicklungsbiologie der Fließgewässermuschel *Pseudanodonta complanata*. — Diss. Tierärtzl. Hochsch. Hannover, 111 S.

JAECKEL, S. H. (1952): Unsere Süßwassermuscheln. — Die Neue Brehm-Bücherei. — Leipzig (Akad. Verl. ges. Geest u. Portig), 40 S.

KUNDY, M. (1984): Ökologische Untersuchungen über das Zoobenthos der oberen Alster. — Dipl. Univ. Hamburg, 132 S.

MAASS, S. (1987): Untersuchungen zur Fortpflanzungsbiologie einheimischer Süßwassermuscheln der Gattung *Unio*. — Diss. Tierärztl. Hochsch. Hannover, 111 S.

NAGEL, K.-O. (1988): Anatomische, morphologische und biochemische Untersuchungen zur Taxonomie und Systematik der europäischen Unionacea (Mollusca: Bivalvia). — Diss. Univ. d. L. Hessen, Kassel, 100 S.

NEGUS, C. L. (1966): A quantitative study of growth and production of Unionid mussels in the river Thames at Reading. — J. Anim. Ecol. **35:** 513—523.

TUDORANCEA, C. & GRUIA, L. (1968): Observations on the *Unio crassus* (PHILIPSSON) Population from the Nera River. — Trav. Mus. hist. nat., ("Gr. Antipa") **8:** 381—394.

WELLMANN, G. (1939): Untersuchungen über die Flußperlmuschel (*Margaritana margaritifera* L.) und ihren Lebensraum in Bächen der Lüneburger Heide. — Zeitschr. f. Fisch **36:** 489—603.

WIESE, V. (1984): Die Verbreitung der Süßwassermollusken in Schleswig-Holstein. — Staatsexamens. Univ. Kiel.