TAXONOMIC NOTES ON EURO-SIBERIAN MOLLUSCS. 5. *VALVATA* (*CINCINNA*) *AMBIGUA* WESTERLUND 1873 – A DISTINCT SPECIES OF THE GROUP OF *VALVATA PISCINALIS* O.F. MÜLLER 1774

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Abstract *The taxonomic identity of* Valvata ambigua *Westerlund 1873 has been examined by using the type materials and samples of snails collected in Europe (Northern Germany) and Western Siberia.* V. ambigua *is considered to be a distinct species closely allied to* Valvata piscinalis *O.F. Müller 1774. It can be distinguished from the latter by differences in shell shape and growth patterns. The characteristic features of the two species are stable under conditions of syntopy and therefore these can be regarded as two biologically meaningful entities, or biospecies. The range of* V. ambigua *covers north, central and eastern Europe and the south part of western Siberia.*

Keywords Valvata ambigua, *Valvatidae, taxonomy, distribution.*

INTRODUCTION

The current taxonomy of the European species of the family Valvatidae J.E. Gray 1840 is far from unambiguous. Western European authors distinguish only five nominal species of the genus *Valvata* O.F. Müller 1774 in the waterbodies of northern and central Europe, one of which, *Valvata* (*Cincinna*) *piscinalis* O.F. Müller 1774, includes five subspecies (Falkner, Bank & Proschwitz, 2001; Glöer, 2002). The other four nominal species are: *Valvata* (*Valvata*) *cristata* O.F. Müller 1774; *V.* (*Tropidina*) *macrostoma* Mörch 1864; *V.* (*T.*) *sibirica* Middendorff 1851; and *V.* (*C.*) *studeri* Boeters & Falkner 1998.

The alternate system developed by Russian and Ukrainian authors through application of the 'comparatorial method' (Shikov & Zatravkin, 1991) is much more detailed and includes a lot of taxa of species rank that are not accepted in west European taxonomy. According to recent taxonomic surveys published in the ex-USSR countries (Chernogorenko & Starobogatov, 1987; Anistratenko, 1998; Anistratenko & Anistratenko, 2001; Starobogatov *et al.*, 2004), there are as many as 28 valvatid species in the waterbodies of northern, central and eastern Europe, and the five subspecies of *V. piscinalis* sensu Glöer (2002) are regarded as "good" species.

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Such a discrepancy between experts in taxonomy obviously can affect studies in ecology, zoogeography and conservation of European freshwater snails. Partly, this discrepancy is an outcome of differences in taxonomic methodologies and species concepts followed by particular scientific schools (Meier-Brook, 1993; Vinarski & Andreyeva, 2007). One of the possible ways to resolve this contradiction is to study the type series of nominal taxa of unstable rank (different authors treat them as species, subspecies, or even varieties) as well as to examine large series of specimens of controversial species by strict statistical methods. We designate as 'controversial' those species in which taxonomic interpretration varies among researchers (some accept them, whereas other consider them non valid).

This study is aimed at discussing the question of taxonomic status in *Valvata ambigua* Westerlund 1873[1], a valvatid species described from Sweden (type locality Göteborg). It is assumed that *V. ambigua* is a Euro-Siberian species occurring eastward to western Siberia (Starobogatov *et al.*, 2004; Kantor & Sysoyev, 2005), however this snail is absent from European check-lists (Falkner *et al.*, 2001; Bank, 2011). Recently the species has been recorded from waterbodies in Hamburg, north Germany (Glöer & Diercking, 2010), but

[1]The Russian and Ukrainian authors refer this species as to *Cincinna* (*Cincinna*) *ambigua* (Westerlund, 1873).

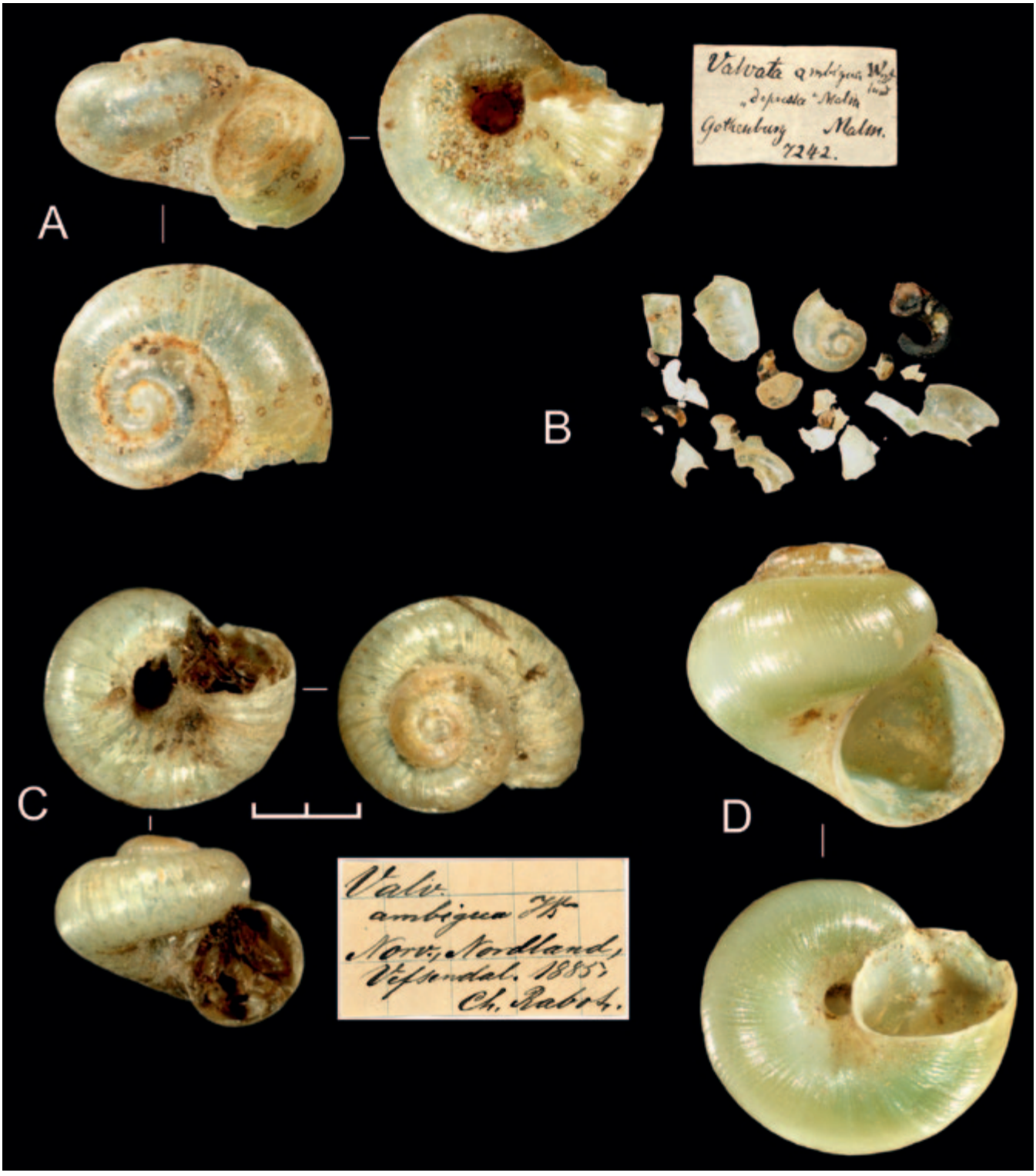

Figure 1 *Valvata ambigua* (A–C) and *V. piscinalis* (D) shells. A juvenile specimens from the Malm collection. B remainders of the second (broken) shell from the Malm collection. C shell from the Westerlund collection housed in Göteborg. D juvenile shell from Hamburg, Germany. Scale bars 1 mm.

no taxonomic considerations were presented in the publication announcing its discovery. The species identity of *V. ambigua* thus requires special discussion.

MATERIALS AND METHODS

We used samples of valvatids of the *Valvata piscinalis* group collected in waterbodies of northern

Table 1 Samples of mollusks of the *Valvata piscinalis* group studied

Species	n	Locality
Valvata ambigua	20	14.05.2003. Germany, Hamburg City, Hamburg harbour.
V. ambigua	9	10.06.2003. Germany, Hamburg City, Wulmstorfer Moor.
V. ambigua	10	18.09.2001. Germany, Hamburg City, canal in Hamburg harbour.
V. ambigua	8	02.08.1999. Russia, south of Western Siberia, Irtysh River in Omsk City.
V. ambigua	9	06.08.1982. Kazakhstan, Kostanay Region. Karatamarskoy Reservoir.
V. ambigua	4	28.06.1999. Russia, Sverdlovsk Region, Pyshma River.
V. ambigua	1	05.06.1978. Russia, Tyumen Region, Sosnovoye Lake.
V. piscinalis	32	14.05.2003. Germany, Hamburg City, Hamburg harbour.

Europe (Hamburg) and western Siberia. These samples are deposited in the collection of the Museum of Siberian Aquatic Molluscs (Omsk State Pedagogical University, Russia) as well as in the private collection of P. Glöer (Hetlingen, Germany).

V. ambigua was described from three specimens (empty shells) collected by Malm and deposited in the Museum für Naturkunde Berlin (see Westerlund, 1873 for details). We could only find 1 juvenile and 1 broken shell in the Museum (Fig. 1). Because Westerlund only mentioned one lot of Malm's *Valvata* from Göteborg, and because this sample is labelled with the original handwriting of Westerlund, we speculate that these are the syntypes. In addition, we used a specimen of *V. ambigua* from Norway (see Fig. 1) kept in the Westerlund collection (Göteborgs Naturhistoriska Museet, Sweden). Presumably, its identification was carried out by Westerlund himself.

Sixty-one shells of *V. ambigua* and 32 shells of *V. piscinalis* from eight localities situated in Germany and western Siberia (Table 1) were measured using an ocular-micrometer in a stereomicroscope to the nearest 0.1 mm. Six standard measurements were taken: shell height (SH), shell width (SW), spire height (SpH), body whorl height (BWH), aperture height (AH), and aperture width (AW). The whorl number was counted as well. The results were analyzed by means of discriminative analysis and principal components analysis (PCA) using STATISTICA for Windows 6.0 (StatSoft Inc., USA).

Results and Discussion

Shell morphology of V. ambigua One of the shells of *V. ambigua* in the sample from the Berlin Museum is almost totally destroyed and only debris of a shell could be found in the tube (see Fig. 1B). Another specimen from this sample is obviously juvenile (shell width is only 2.7 mm). Its proportions, however, are distinct from those of juvenile *V. piscinalis* (Fig. 1D). The height of the spire of this miniature specimen is less than in adult *V. ambigua* (compare Fig. 1A and Fig. 2A), but we may assume that this difference is explained by ontogenic variation in shell shape. There is a significant positive correlation between SH and SpH in *V. ambigua* shells from Europe and Siberia measured by us (Spearman's rank correlation coefficient r_s is equal to 0.79, $p = 0.000$; $n = 103$). Hence, the height of spire tends to increase with age in this species.

Under syntopic conditions, the two species, *V. ambigua* and *V. piscinalis*, can be distinguished confidently by differences in their shell shape and proportions. The shells of *V. ambigua* are characterized by a lesser number of whorls as compared to *V. piscinalis*. Also, the shells of the former species are wider than those of *V. piscinalis*, and their spire is relatively lower (Table 2). The tangent-line of the spire is almost straight in *V. piscinalis*, whereas in *V. ambigua* it is visibly concave (Fig. 2). The umbilicus in *V. ambigua* is clearly wider than that in *V. piscinalis* (see Fig. 1, A, Fig. 2, A), and this dissimilarity is characteristic of the juvenile snail as well. Therefore shells of young specimens of *V. ambigua* have sometimes been confused in Germany with *V. macrostoma*.

The shell differences are reflected by values of standard conchological indices calculated on the base of shell measurements. For example, SW/SH ratio in *V. piscinalis* is always less than 1.00, whereas in another species it usually exceeds 1.00. The mean values of most conchological indices in syntopic samples of the both species are statistically significant (see Table 2). The only

Table 2 Morphological comparison between *V. ambigua* and *V. piscinalis* in syntopy (14.v.2003, Hamburg Harbour, Germany)

Character	*V. ambigua*	*V. piscinalis*	Student t-test (p values are given in brackets)*
Whorls number	3.83±0.19 (3.25–4.12)	4.08±0.10 (3.87–4.25)	**–6.47 (0.0000)**
SH	4.6±0.3 (3.7–5.2)	4.9±0.3 (4.4–5.4)	**–3.70 (0.0005)**
SW	4.8±0.4 (4.0–5.4)	4.5±0.3 (4.0–5.0)	**3.61 (0.0006)**
SpH	2.2±0.3 (1.7–2.7)	2.5±0.2 (2.0–2.9)	**–4.27 (0.0000)**
BWH	3.9±0.3 (3.2–4.4)	3.9±0.2 (3.5–4.4)	–1.07 (0.29)
AH	2.4±0.2 (2.0–2.7)	2.5±0.2 (2.0–2.9)	**–2.78 (0.007)**
AW	2.4±0.2 (2.1–2.7)	2.3±0.1 (2.0–2.6)	**2.22 (0.03)**
SW/SH	1.06±0.05 (0.96–1.17)	0.93±0.03 (0.87–0.99)	**–11.75 (0.0000)**
SpH/SH	0.49±0.03 (0.42–0.54)	0.51±0.03 (0.44–0.57)	**2.97 (0.004)**
BWH/SH	0.85±0.03 (0.81–0.91)	0.81±0.02 (0.77–0.85)	**–6.92 (0.0000)**
AH/SH	0.53±0.04 (0.42–0.61)	0.52±0.03 (0.46–0.58)	–0.81 (0.42)
AW/AH	1.00±0.08 (0.76–1.22)	1.10±0.08 (0.98–1.26)	**4.51 (0.0003)**

*Significant differences between mean values are marked by bold.

Figure 2 Shells of species of the *Valvata piscinalis* group from Hamburg waterbodies. A *V. ambigua* (Vier- und Marshlande). B *V. piscinalis* (Alster River). Scale bars 1 mm.

character that does not discriminate between *V. ambigua* and *V. piscinalis* is BWH.

The first two principal components taken together explain 77.3% of the variation in shell characters of *V. ambigua* and *V. piscinalis* from a syntopic sample studied. Specimens of the two species from the same habitat form two slightly overlapping clusters of points in the two-dimensional plane of PC1 and PC2 (Fig. 4). The same picture was observed in other pairs of closely

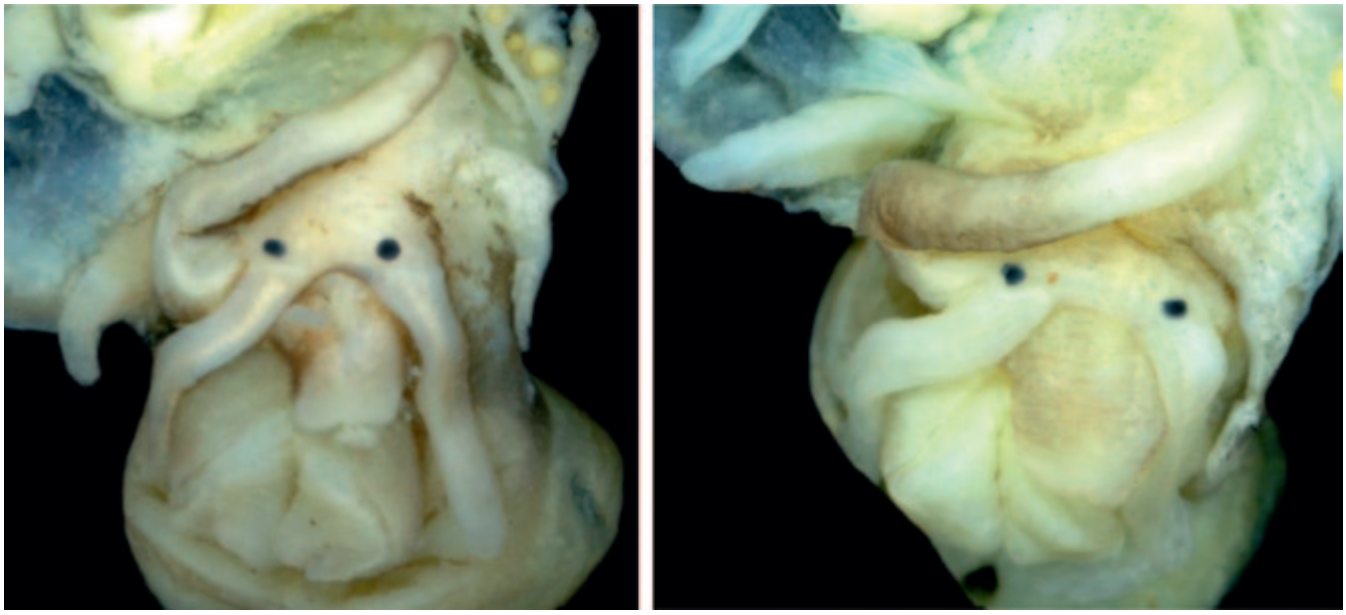

Figure 3 View of the head region of the soft body of *V. piscinalis* (left) and *V. ambigua* (right) from waterbodies of Hamburg.

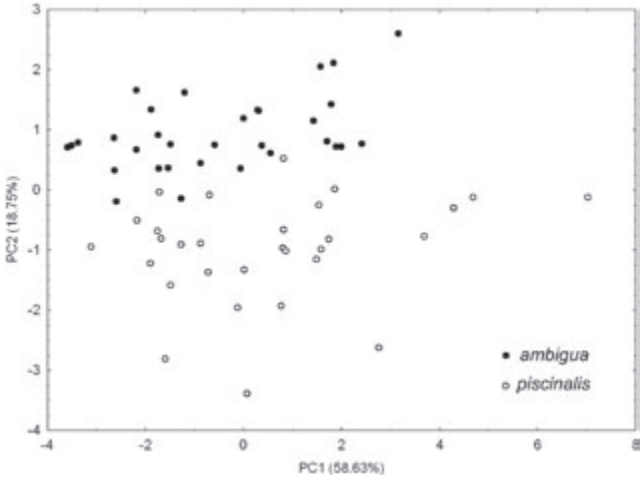

Figure 4 Individuals of *V. ambigua* and *V. piscinalis* (14.v.2003, Hamburg Harbour) in the two-dimensional plane of the two first principal components.

related species of freshwater snails living syntopically. For example, similar pattern was found in the study of variation of two lymnaeid species, *Radix auricularia* (Linnaeus 1758) and *R. parapsilia* Vinarski et Glöer 2009 (Vinarski & Andreyeva, 2007; Vinarski & Glöer, 2009).

Soft body morphology Some differences were found in external morphology of the soft body of snails. The snout is broader in *V. ambigua* than in *V. piscinalis* (Fig. 3) which may reflect possible niche separation between the species. The distance between the eyes is also different in the two species compared. The head of *V. piscinalis* is brownish, whereas that of *V. ambigua* is of a light brown colouration.

There are also some ecological differences between the two species: in Northern Germany *V. ambigua* prefers ditches and canals with muddy ground but high in oxygen. *V. piscinalis* is more euryoecous and can be found in nearly all waterbodies.

Intraspecific differences between spatially remote populations of *V. ambigua* are slight (Table 3, Fig. 5) therefore we united all samples of this species from Europe and Siberia in two pools for performing the discriminative analysis. Its results (Table 4) show that specimens of *V. piscinalis* can be discriminated from those of *V. ambigua* in 100% cases. Besides, there are some differences between European and Siberian populations of *V. ambigua* that possibly reflects a certain degree of intraspecific spatial divergence of conchological traits.

Individuals of *V. ambigua* from Europe and western Siberia fall into a single cluster of points in the plane of the two canonical roots (Fig. 6). This cluster is visibly separated from that of *V. piscinalis* though certain overlapping between clusters should be mentioned. Thus we can observe here the same pattern as above in PCA results.

As a conclusion, we may assume that *V. ambigua* represents a group of morphologically distinct

Table 3 Values of standard conchological indices of European and Siberian populations of *Valvata ambigua.*

Locality	Conchological index				
	SW/SH	SpH/SH	BWH/SH	AH/SH	AW/AH
Wulmstorfer Moor	1.07–1.14	0.36–0.42	0.87–0.90	0.61–0.65	0.66–0.76
	1.11±0.02	0.39±0.02	0.88±0.01	0.63±0.01	0.70±0.03
Canal in Hamburg harbour	1.01–1.13	0.34–0.44	0.83–0.89	0.51–0.63	0.74–1.00
	1.05±0.03	0.40±0.02	0.86±0.01	0.59±0.03	0.83±0.06
Karatamarskoye reservoir	1.01–1.11	0.25–0.39	0.86–0.92	0.54–0.68	0.79–0.95
	1.05±0.02	0.36±0.04	0.90±0.02	0.60±0.04	0.87±0.05
Pyshma River	1.04–1.10	0.40–0.43	0.81–0.87	0.60–0.61	0.83–0.92
	1.08±0.04	0.42±0.02	0.85±0.05	0.61±0.01	0.88±0.06
Irtysh River	1.01–1.14	0.37–0.43	0.85–0.95	0.55–0.63	0.90–0.95
	1.07±0.04	0.40±0.02	0.89±0.03	0.58±0.03	0.94±0.02

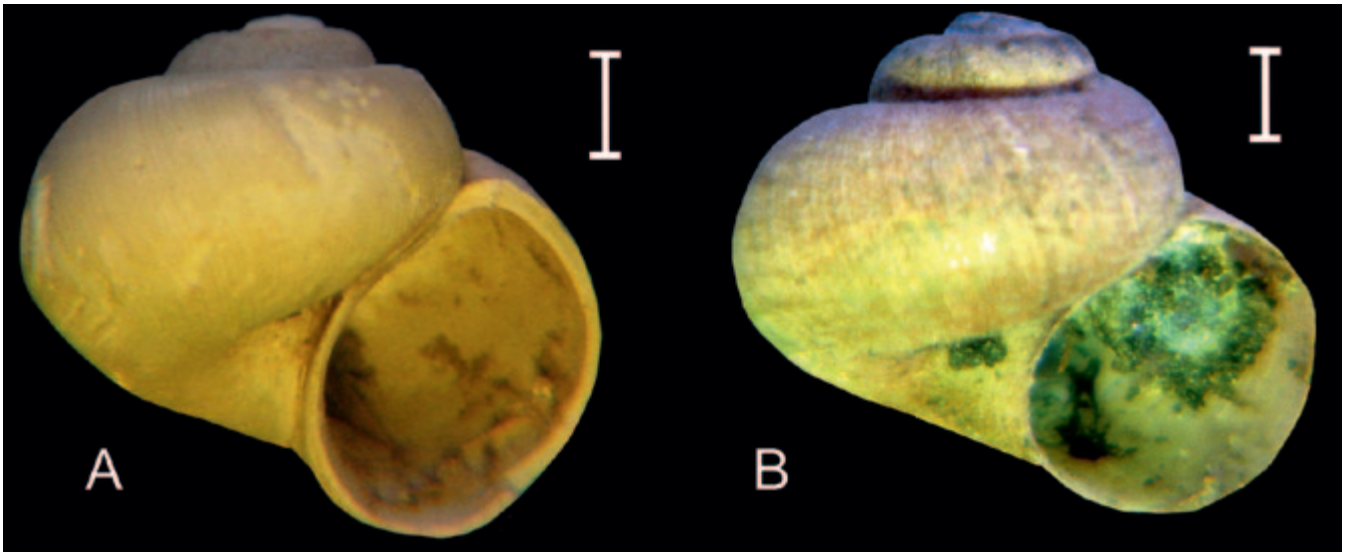

Figure 5 Shells of Siberian (A) and European (B) representatives of *V. ambigua.* A Kazakhstan, Karatamarskoye Reservoir. B Germany, Hamburg, Wulmstorfer Moor. Scale bar 1 mm.

Table 4 Classification matrix of a discriminant analysis on 6 conchological characters for all groups

Group	% correct	*ambigua*Sib	*ambigua*Eu	*piscinalis*
*ambigua*Sib	95.5	21	1	0
*ambigua*Eu	93.9	2	46	1
piscinalis	100.0	0	0	32
Total	96.12	23	47	33
Wilks' Lambda = 0.0743				

from *V. piscinalis*. Conchological peculiarity of the former species is observed under syntopic conditions as well as when geographically separated samples are studied. Shell differences between the two species possibly may be explained by different growth patterns as it is shown on a graph where SH is scattered against SW (Fig. 7).

Given that statistically significant differences between *V. ambigua* and *V. piscinalis* were revealed on samples collected from the same locality without obvious physical barriers to gene flow, it seems probably that the two morphologically defined species (morphospecies) are isolated reproductively and thus

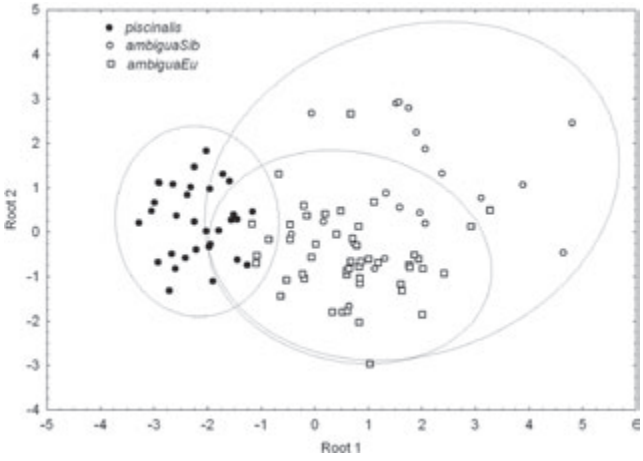

Figure 6 Individuals of *V. ambigua* from Siberia and Europe (designated as *ambigua*Sib and *ambigua*Eu, correspondingly) plus *V. piscinalis* from Europe (Hamburg) in the plane of the two first canonical roots.

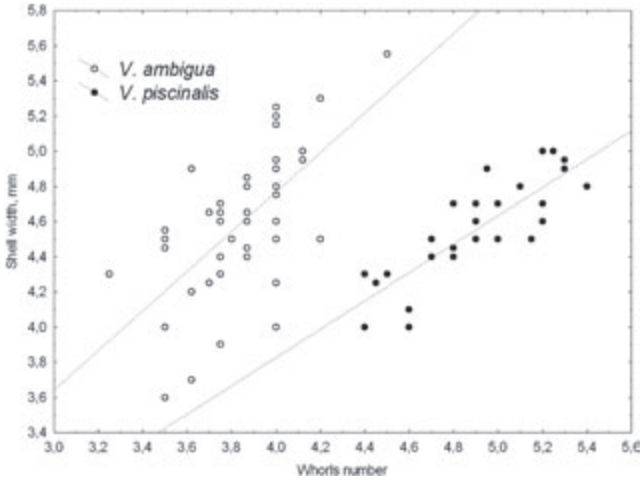

Figure 7 Relationships between SH and SW in two species of *Valvata*. Measurements of shells from Hamburg waterbodies are used.

can be considered two biologically meaningful entities, or biospecies (Starobogatov, 1968, 1977; Vinarski, & Andreyeva, 2007). Weak overlap between clusters corresponding to the two species in the multidimensional spaces (see above) indicates that possible 'intermediate' forms between *V. ambigua* and *V. piscinalis* are rare and that there is no intense interspecific hybridization.

It should be stressed, although, that our conclusion about the 'biological' nature of the two morphospecies of *Valvata* is based on indirect evidence i.e. on logical analysis of the results of study of syntopical samples. Further studies are needed to corroborate this indirect evidence by direct methods of investigation, for example, by molecular taxonomical analyses. The first (preliminary) data on phylogeography of *V. piscinalis* s.l. from the Baltic Sea basin demonstrate that there are at least two cryptic species (groups of haplotypes) that are geographically separated though in some regions, including northern Germany, they can occur sympatrically (Filippenko, 2012). Possibly, one of these haplogroups corresponds to *V. ambigua.*

It is difficult to outline the range of *V. ambigua* exactly because most western European malacologists do not distinguish between this species and *V. piscinalis* s. lato. Beyond the ex-USSR territory localities of *V. ambigua* were registered in Scandinavia (Norway, Sweden, see Westerlund, 1873) and north Germany (Glöer & Diercking, 2010). Possibly, a shell of this species is depicted by Germain (1931: 672, fig. 740), who referred it to an "intermediate form between forms *alpestris* Blauner and *pulchella* Studer". It means that the range of *V. ambigua* may cover France as well. In Ukraine, the species has been registered from the Dnieper River basin (Anistratenko & Anistratenko, 2001). In western Siberia, *V. ambigua* is known from the waterbodies belonging to the Irtysh River basin (Vinarski *et al*., 2007). Westerlund (1886) also mentioned probable findings of this species in central Asia ("Turkestan") and even in north Africa but these recordings are very doubtful from the zoogeographical point of view.

Most probably, the species range covers north, central and eastern Europe as well as the southern part of western Siberia.

A brief comparison between *V. ambigua* and some other European species of *Valvata* of similar shell shape is desirable. There are some traits which allow these species to be distinguished. In *Valvata alpestris* the umbilicus is wider than in *V. ambigua* and the first whorls are clearly visible (Fig. 8). The umbilicus of *V. studeri* is similar to that of *V. ambigua* but the umbilicus is obscured in part by the last whorl. In addition, the surface of *V. studeri* shell is smooth, while in *V. ambigua* it is finely ribbed. Shell width in *V. macrostoma* is nearly equal to shell height, whereas in shells of *V. ambigua* height exceeds width. Typically, the spire of *V. macrostoma* is much shorter than that of *V. ambigua*.

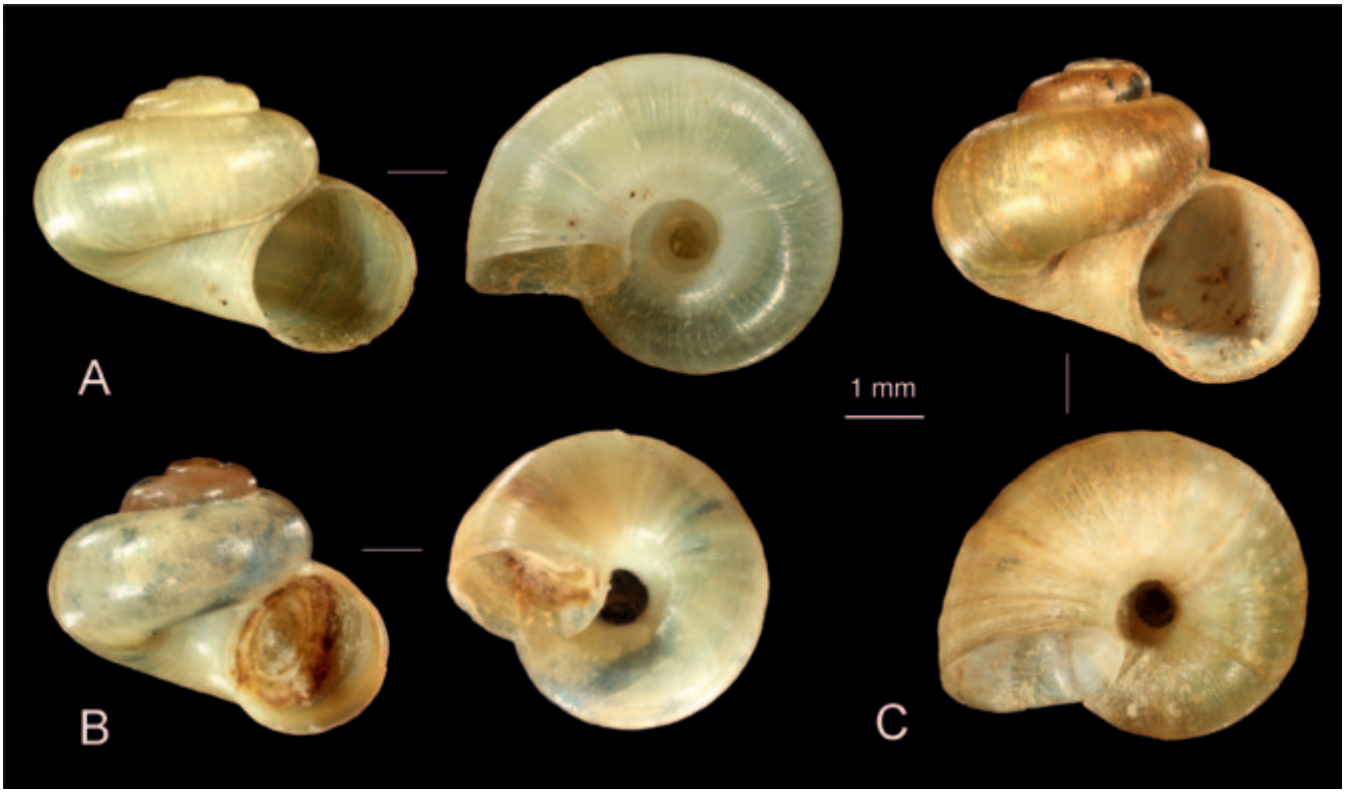

Figure 8 Comparison of *V. ambigua* with other species of similar shell shape. A *V. alpestris*. B *V. studeri*. C *V. ambigua*. Scale bars 1 mm.

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