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LUCILLA SINGLEYANA (PILSBRY, 1890) (GASTROPODA: PULMONATA: PUNCTIDAE) IN RECENT FLOOD DEBRIS IN THE BESKIDY MTS (SOUTHERN POLAND)

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ABSTRACT: Mollusc thanatocoenoses are common components of flood debris in river valleys. Several localities with such sediments, found in the Beskidy Mts, were studied in detail. Their thanatocoenoses comprise a very rich fauna of molluscs, especially land snails. Almost three hundred specimens of *Lucilla singleyana* (Pilsbry) were found in the whole investigated material; more than 150 adult shells were selected for biometrical analysis. *L. singleyana* has been recorded from several European countries, but its localities are few and isolated. Its geographical range is probably much wider and may extend throughout Central and Western Europe, except high mountains, but, being a small subterranean snail, it is difficult to find. Detailed examination of mollusc shells in flood debris seems to be the best way to ascertain the geographical range of the species.

KEY WORDS: flood debris, biometrics, gastropods, *Lucilla singleyana*, Beskidy Mts, Southern Poland

INTRODUCTION

The land gastropod fauna of Poland comprises about 175 species (WIKTOR 2004). Some of them are common and widespread Holarctic or European taxa. Others have a more restricted distribution; they inhabit particular geographical regions or specific habitats; they are rare species recorded only from single localities. The taxonomic composition of the recent terrestrial malacofauna of Poland was established during the post-glacial period (Holocene – the last 10,000 years), as a result of migrations caused by climatic and environmental changes. During the last few hundred years, the faunal composition was much modified because of human activity. In this period, especially during the last two centuries, numerous new species immigrated into Europe. *Lucilla singleyana* (Pilsbry, 1890) was one of them. The snail was first reported and described in 1889 from several localities in North America (PILSBRY 1948). The first specimens were found in Europe in 1943, but were identified and described only six years later (KUIPER 1949). In Poland, the occurrence of *L. singleyana* was noted only in two synanthropic localities: the botanical garden in Wrocław and Puszczykowo near Poznań (KOSIŃSKA 1979, RIEDEL 1988, WIKTOR 2004).

The shell of *L. singleyana* is discoidal, nearly flat. The number of whorls varies from 3.5 to 4 (occasionally 4.5 or even 5). The whorls are well-rounded, slowly and regularly increasing. They are separated by a rather deep suture. The umbilicus is very broad and completely open. The mouth is round and its edge sharp, without a lip. The shell is thin, translucent and glossy. Gentle, irregular growth-lines are visible on some specimens (Fig. 1).

The habitats and ecology of *L. singleyana* are poorly known. It is probably a subterranean snail, living relatively deep in the soil. It has been recorded from several European countries (Table 2), but it is always very rare. Live individuals and empty shells of *L. singleyana* are very difficult to find. They are rarely found in flood debris or in artificial, anthropogenic habitats (greenhouses, botanical gardens) (RIEDEL & WIKTOR 1974, KERNEY et al. 1983, WIKTOR 2004).

Accumulations of organic remains in the recent fluviatile sediments are composed of plant detritus, fragments of wood, sometimes also of fruit, leaves, conifer needles and plant seeds. Mollusc shells are often important components of these accumulations. Recent flood debris is deposited during floods along

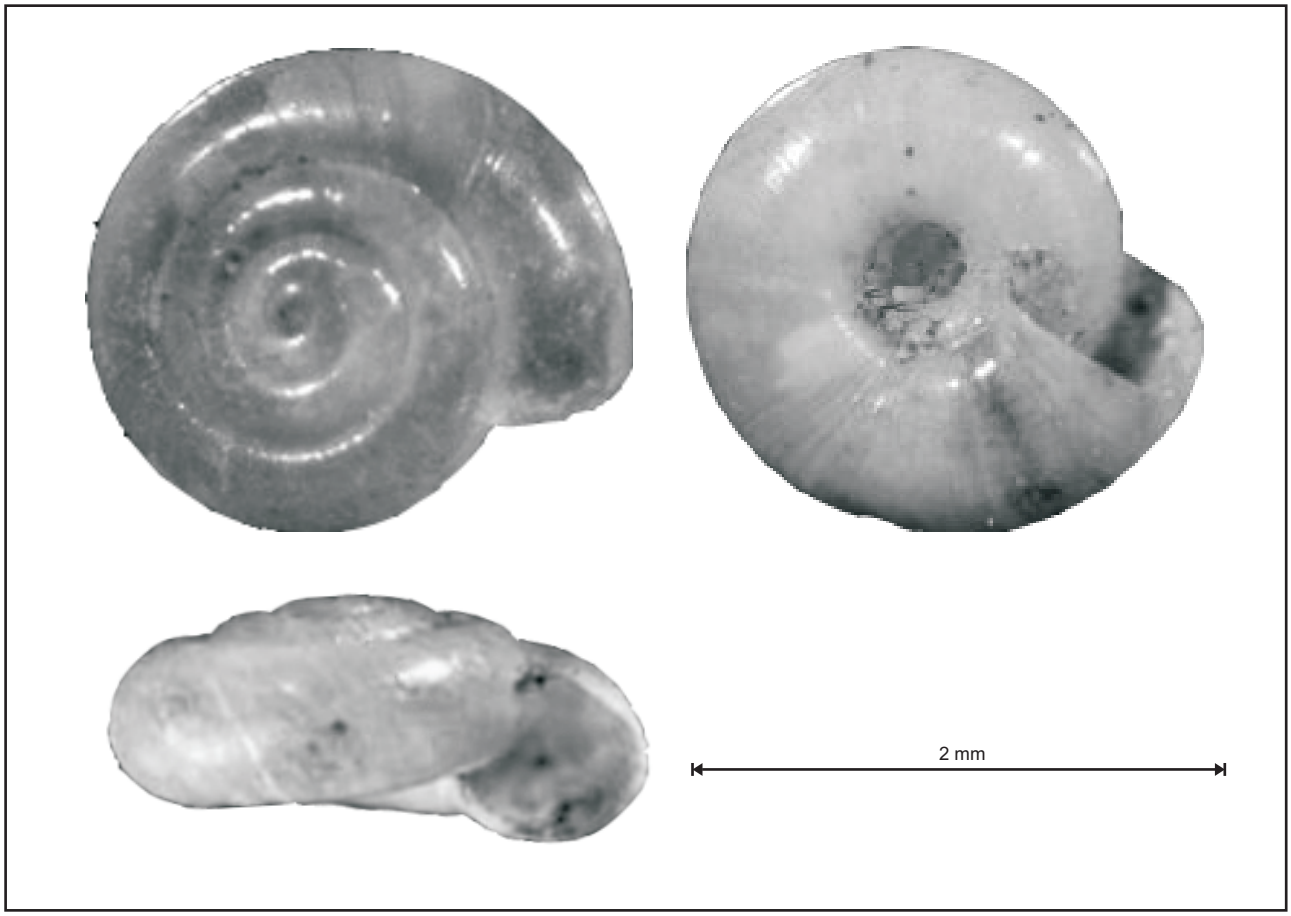

Fig. 1. Shell of *Lucilla singleyana* (Pilsbry, 1890)

river valleys, mainly on floodplains, as lateral bars indicating the maximum extension of floodwater. Rarely can it be observed in the outer part of meanders or behind dams, weirs and other obstacles. Mollusc thanatocoenoses include species which are widespread in the whole catchment basin, and reflect habitat diversity, taxonomic diversity, as well as the flood course and intensity. Such thanatocoenoses have been collected and described by many authors for over a hundred years (KOTULA 1882, KLEMM 1973, KÖRNIG 1987, S. W. ALEXANDROWICZ 1997, 2000, ČEJKA 2000a, W. P. ALEXANDROWICZ 2002, RODZINKA 2005 and many others). Identification of species and reconstruction of their distribution are the main subjects of these studies. Accumulations of mollusc shells in flood debris can be used to characterise the composition of mollusc fauna of river valleys and surrounding areas. On the other hand, mollusc thanatocoenoses reveal the presence of some usually rare species which are very difficult to find in their habitats using other methods. One of such taxa is *L. singleyana*, identified in mollusc assemblages collected in a few river valleys in the Beskidy Mts. The species has been found in similar sediments in the Danube river valley near Bratislava, Slovakia (ČEJKA 2000b).

MATERIAL AND METHODS

Detailed malacological studies of thanatocoenoses deposited during summer floods were carried out in numerous localities in the Beskidy Mts and their foothills. Samples of flood debris of 3–4 kg each were taken, dried and sieved to select all identifiable mollusc shells and their fragments. Standard methods of Quaternary malcology (LOŽEK 1964, S. W. ALEXANDROWICZ 1987, 1999) were used to analyse the material. Mollusc assemblages from flood debris of 11 localities were subject to ecological analysis. The analysis focused on similarities and differences between the ecological characteristics of particular thanatocoenoses and types of habitats developed on the valley bottoms, surrounding slopes and entire catchment areas. They

provided a basis to reconstruct the distance over which the mollusc shells were transported during the flood.

The whole analysed material comprised 277 specimens of *L. singleyana* (0.7% of the total number of snail and bivalve shells found in the analysed thanatocoenoses). The number of shells varied among the localities, from 3 (Mszana Dolna) to 97 (Kłodne). Three sites (Rzyczanka, Kłodne and Biecz) yielded more than 30 adult shells (4 or more whorls) each. These populations were used in the biometrical analysis. The greatest breadth (B) and height (H) of the shells were measured to the nearest 0.1 mm. The shape index (H/B ratio) was calculated, as well as basic statistical indices; they were presented in diagrams and histograms.

RESULTS

Numerous empty shells of *L. singleyana* were found in 11 localities distributed mainly in the valleys of large rivers in the western part of the Beskidy Mts (Fig. 2).

I – Rzyczanka Stream Valley (Rzyki village near Andrychów) – flood debris was accumulated on stream terraces (ca. 3 m above the mean stream level) during the summer flood following a heavy rainfall in July 1999. The mollusc assemblage represented a relatively narrow part of the valley, surrounded by more or less wooded slopes. The valley bottom was partly overgrown by alder and willow and partly cultivated. The shell material contained 37 species represented by 1,860 specimens. The assemblage was dominated by shade-loving and mesophile snails: *Discus rotundatus* (O. F. Müller), *Perforatella vicina* (Rossmässler) and *Cochlicopa lubrica* (O. F. Müller). Forty-five specimens of *L. singleyana* were found there (W. P. ALEXANDROWICZ 2002) (Fig. 2).

II – Skawa River Valley (Bystra Podhalańska) – a rich mollusc assemblage (58 species and nearly 13,000 specimens) was deposited on the terrace 1.5 m above the river level in July 1991. Mesophile species (*Cochlicopa lubrica* (O. F. Müller), *Nesovitrea hammonis* (Ström) and *Punctum pygmaeum* (Draparnaud)), accompanied by forest snails such as *Aegopinella pura* (Alder), *Vitrea diaphana* (Studer) and meadow taxa (*Cecilioides acicula* (O. F. Müller), *Vallonia pulchella* (O. F. Müller)) were the main components of the assemblage. Hygrophile and water molluscs occurred occasionally. The valley bottom was wide, flat and overgrown by bushes or gently cultivated. Four shells of *L. singleyana* were identified in the material (Fig. 2).

III – Raba River Valley (Mszana Dolna) – debris accumulated during the great summer flood of July 1997 ca. 2 m above the river channel contained a rich thanatocoenosis, comprising more than 2,100 specimens, representing 45 species of snails and bivalves. The fauna was dominated by mesophile species: *Vitrina pellucida* (O. F. Müller), *Punctum pygmaeum* (Draparnaud) and *Cochlicopa lubrica* (O. F. Müller), while molluscs representing the remaining ecological groups were few. The valley bottom was relatively narrow and completely overgrown by bushes. Only three specimens of *L. singleyana* were found in this locality (Fig. 2).

IV – Dunajec River Valley (Kłodne) – flood debris was deposited in July 1991 on a flat part of the terrace about 1.5 m above the river level. The assemblage contained 62 mollusc species and more than 2,300 specimens. It was dominated by forest and mesophile taxa (*Vitrea crystallina* (O. F. Müller), *Fruticicola fruticum*

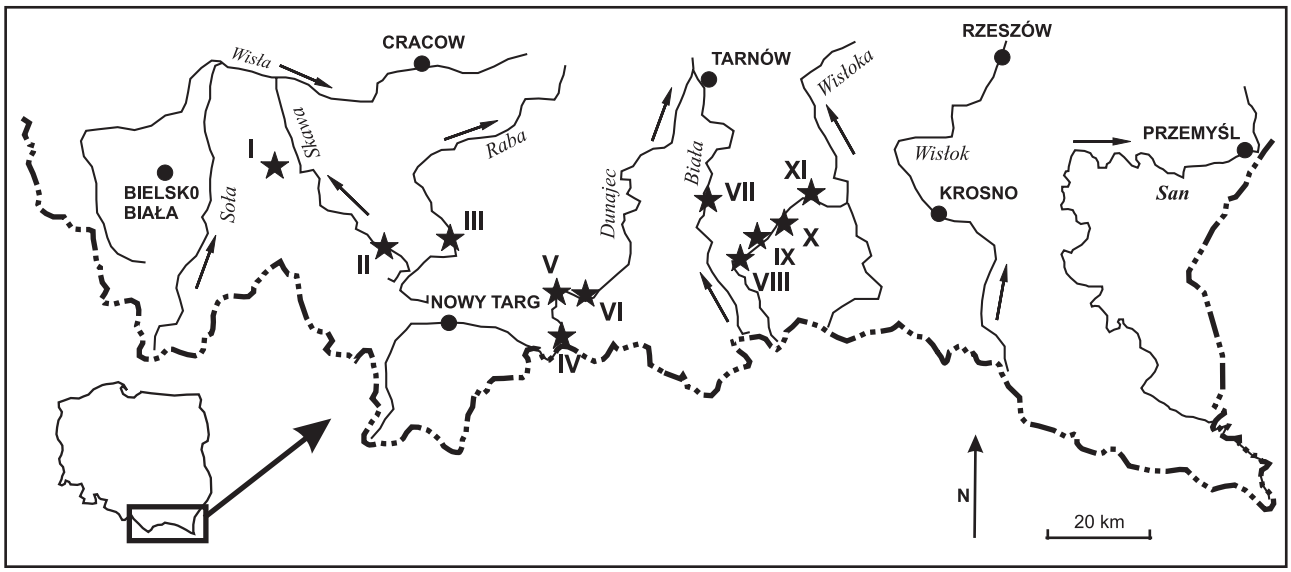

Fig. 2. Localities of analysed flood deposits in the Beskidy Mts: asterisks – localities described in text

(O. F. Müller), *Vitrina pellucida* (O. F. Müller), *Punctum pygmaeum* (Draparnaud), *Cochlicopa lubrica* (O. F. Müller). Shade-loving species preferring wet habitats (*Perforatella bidentata* (Gmelin), *P. vicina* (Rossmässler) and *P. umbrosa* (C. Pfeifer)) were frequent. Wet meadows and bushes covered the valley bottom. Nearly a hundred specimens (97) of *L. singleyana* were collected from these sediments (Fig. 2).

V – Dunajec River Valley (Zabrzeż) – a rich mollusc assemblage (61 taxa, 3,432 shells) was sampled from flood debris associated with the inundation in July 1991 near Zabrzeż. Mesophile (*Cochlicopa lubrica* (O. F. Müller), *Nesovitrea hammonis* (Ström), *Carychium tridentatum* (Risso) and open-country species (*Vallonia pulchella* (O. F. Müller), *V. costata* (O. F. Müller), *Pupilla muscorum* (Linneaus)) were the main components of this assemblage. The thanatocoenoses were accumulated on a flat, partly grassy and partly alder and willow-overgrown terrace, 1.5 m above the river. The fauna included twenty-five specimens of *L. singleyana* (Fig. 2).

VI – Dunajec River Valley (Łącko) – a relatively poor mollusc assemblage was collected from flood debris deposited in July 1991. Mesophile and meadow snails were the main components of this fauna. The thanatocoenoses formed on a grassy, partly bush-covered terrace. Only four specimens of *L. singleyana* were found (Fig. 2).

VII – Biała River Valley (Ciężkowice) – mesophile snails (*Cochlicopa lubrica* (O. F. Müller), *Vitrea contracta* (Westerlund)) and forest species preferring wet habitats (*Perforatella bidentata* (Gmelin), *P. vicina* (Rossmässler), *Macrogastra ventricosa* (Draparnaud), *Vestia gulo* (E. A. Bielz)) were the main components of the thanatocoenosis. Flood debris was accumulated on a flat and relatively wide terrace of the Biała River Valley near Ciężkowice in 2004. The rich mollusc assemblage (59 species and nearly 3,000 specimens) comprised only five shells of *L. singleyana* (Fig. 2).

VIII – Ropa River Valley (Gorlice) – a rich mollusc assemblage (53 species and 1,204 specimens) was collected from flood debris accumulated in July 2004 on a relatively narrow terrace of the Ropa River, ca. 2 m above the mean water level. The thanatocoenosis was dominated by forest and mesophile snails (*Acanthinula aculeata* (O. F. Müller), *Isognomostoma isognomostoma* (Schröder), *Chilostoma faustinum* (Rossmässler), *Carychium tridentatum* (Risso), *Cochlicopa lubrica* (O. F. Müller) and many others). Meadows and bushes covered the valley bottom, while the surrounding slopes were mostly forested. Fifteen shells of *L. singleyana* were collected in this locality (Fig. 2).

IX – Ropa River Valley (Zagórzany) – a mollusc assemblage was found after the inundation in July 2004. It included 49 species and more than 1,000 specimens. Species typical of wet forests (*Perforatella bidentata* (Gmelin), *P. vicina* (Rossmässler)) and mesophile snails (*Nesovitrea hammonis* (Ström), *Carychium tridentatum* (Risso), *Vitrina pellucida* (O. F. Müller) and others) were the two main components of this assemblage. Open-country, hygrophile and water molluscs occurred sporadically. The narrow valley bottom was overgrown by alder and willow. Ten specimens of *L. singleyana* were found in Zagórzany (Fig. 2).

X – Ropa River Valley (Libusza) – a rich and diverse (57 species, nearly 1,400 specimens) thanatocoenosis

Table 1. Statistical indices of populations of *Lucilla singleyana*: N – number of specimens, x – arithmetic mean, s – standard deviation, x_s – range limits of the standard deviation, b – standard error, x_b – range limits of the standard error, Mn – minimum value, Mx – maximum value

Locality	N	x	s	$x_{s-} – x_{s+}$	b	$x_{b-} – x_{b+}$	Mn	Mx
Shell breadth (B)								
Biecz	32	1.97	0.112	1.75–2.19	0.02	1.93–2.01	1.80	2.25
Kłodne	65	1.98	0.115	1.76–2.21	0.014	1.95–2.01	1.75	2.20
Rzyczanka	30	1.96	0.097	1.77–2.15	0.018	1.92–1.99	1.80	2.15
Whole population	157	1.97	0.107	1.76–2.18	0.0085	1.96–1.98	1.75	2.25
Shell height (H)								
Biecz	32	0.98	0.07	0.84–1.12	0.012	0.95–1.00	0.90	1.20
Kłodne	65	0.96	0.079	0.81–1.12	0.01	0.94–0.98	0.75	1.10
Rzyczanka	30	0.97	0.07	0.83–1.11	0.013	0.94–0.99	0.80	1.10
Whole population	157	0.96	0.079	0.81–1.11	0.0063	0.95–0.97	0.75	1.20
Shape index H/B								
Biecz	32	2.02	0.08	1.86–2.18	0.014	1.9–2.05	1.87	2.21
Kłodne	65	2.06	0.095	1.87–2.25	0.012	2.04–2.08	1.89	2.33
Rzyczanka	30	2.04	0.094	1.86–2.22	0.017	2.01–2.07	1.89	2.25
Whole population	157	2.06	0.102	1.86–2.26	0.0082	2.04–2.08	1.87	2.33

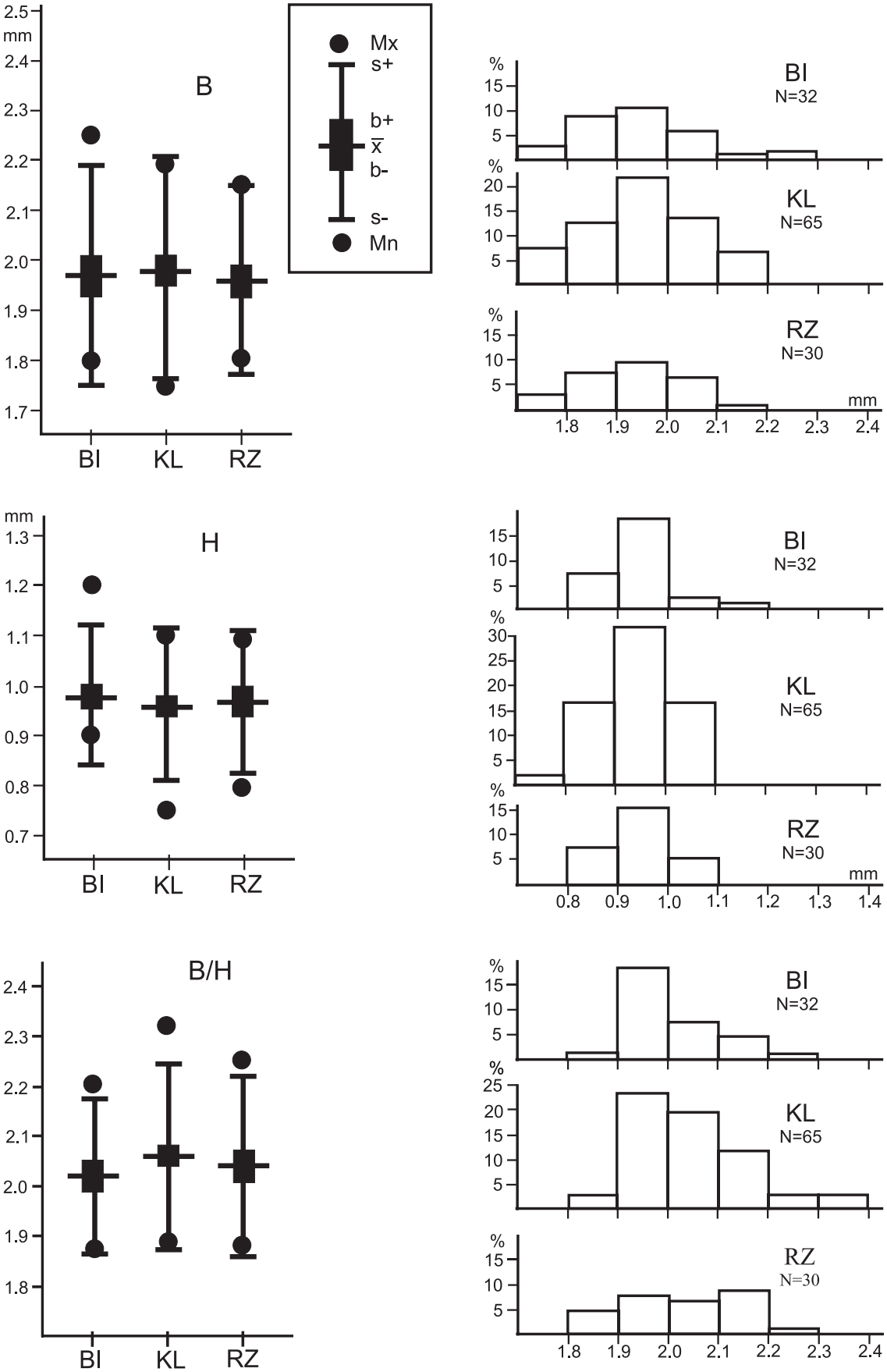

Fig. 3. Biometric characteristics of populations of *Lucilla singleyana* from Biecz (BI), Kłodne (KL) and Rzyczanka (RZ). B – shell breadth, H – shell height, B/H – shape index, for other explanations see Table 1

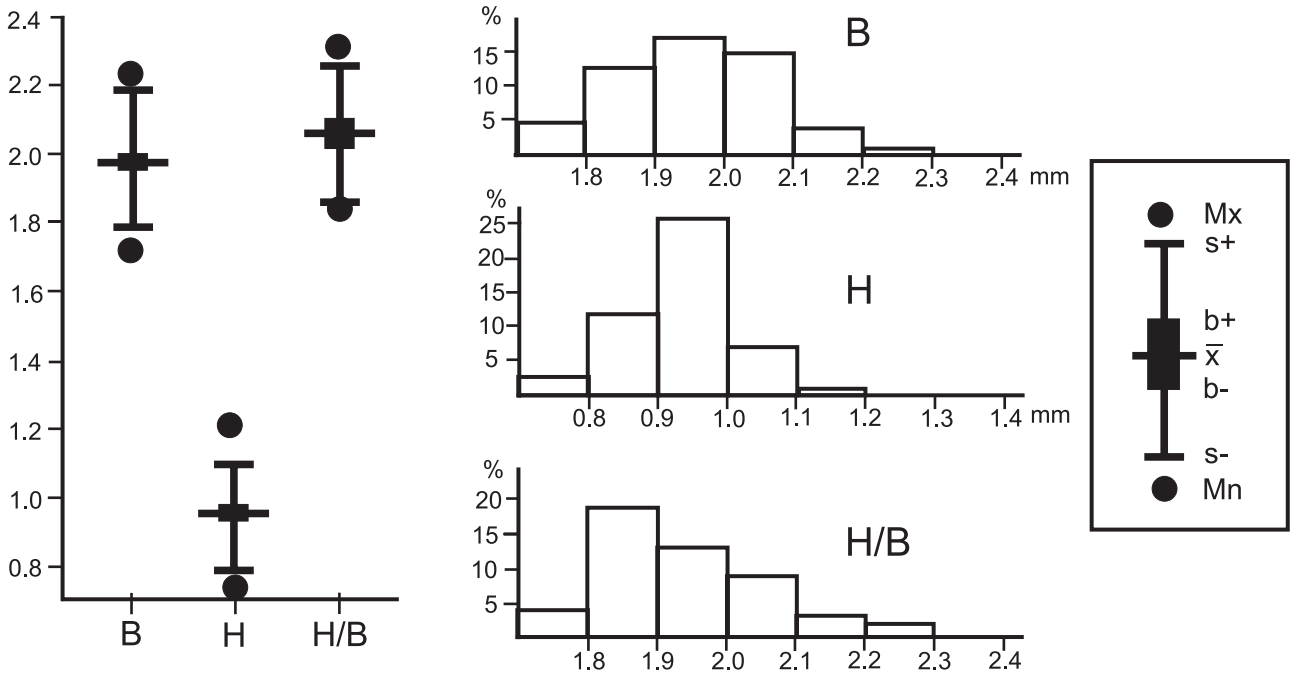

Fig. 4. Biometric characteristics of the whole material of *Lucilla singleyana* from the Beskidy Mts. For explanations see Table 1 and Fig. 3

was accumulated 3.5 m above the river channel in July 2004. The fauna comprised mainly forest (*Isognomostoma isognomostoma* (Schröder), *Alinda biplicata* (Montagu)) and mesophile (*Laciniaria plicata* (Draparnaud), *Euconulus fulvus* (O. F. Müller), *Cochlicopa lubrica* (O. F. Müller)) taxa. The valley bottom was relatively wide and covered by meadows and locally by bushes. Nine shells of *L. singleyana* were found there (Fig. 2).

XI – Ropa River Valley (Biecz) – thanatocoenoses were deposited in July 2003 and July 2004. They comprised very rich assemblages (53 and 65 species, with 1,430 and 7,490 specimens, respectively). Mesophile taxa (*Euconulus fulvus* (O. F. Müller), *Cochlicopa lubrica* (O. F. Müller), *Punctum pygmaeum* (Draparnaud) and others) accompanied by forest species preferring moist habitats, such as *Perforatella bidentata* (Gmelin) and *P. vicina* (Rossmässler), were the most important components of both assemblages. The valley bottom was partly overgrown by bushes and partly covered by grassland and even cultivated. Fifty-eight specimens of *L. singleyana* were found in the flood debris of 2004, while only two shells were collected from the older thanatocoenosis (Fig. 2).

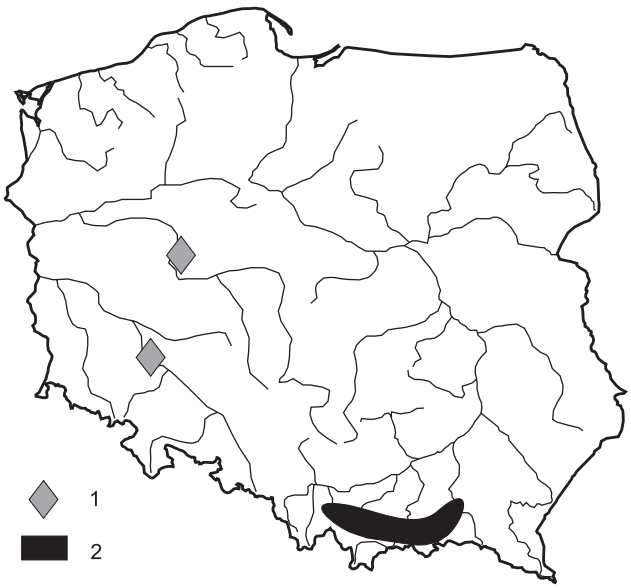

Fig. 5. Occurrence of *Lucilla singleyana* in Poland: 1. older localities, 2. new localities

The biometric analysis included the following statistical indices: arithmetic mean (x), standard deviation (s), standard error (b) as well as range limits of the standard error (x_b) and standard deviation (x_s) at a confidence level of 0.05 (95%), calculated as: $x_b=x\pm1.96b$ and $x_s=x\pm1.96s$. The analysed material derived from three localities: Biecz (BI), Kłodne (KL) and Rzyczanka (RZ). The number of measured specimens was 32, 65 and 30, respectively. Statistical indices of the populations are presented in Table 1. Morphometric shell characters (breadth, height and shape index) in individual localities show similar values (Fig. 3). Shells from Kłodne are somewhat more conical (higher values of shape index) than those from the remaining sites. However, the difference is not significant at the confidence level of 0.05 (Fig. 3). The largest shells derive from Biecz (maximum breadth and height: 2.25 and 1.20 mm, respectively), while the smallest ones are those from Kłodne (1.75 and 0.75 mm, respectively) (Fig. 3, Table 1). Statistical indices were also calculated for all the adult shells (153 specimens) found in the above-described localities. The

Table 2. Distribution of *Lucilla singleyana* in Europe

Country	Region	References
Austria	Salzburg region, Carinthia, Lower Austria and Danube Valley near Vienna	KLEMM (1973), FLASAR (1977), KREISSL & STUMMER (1986), FRANK (1986, 1992, 2006), JAUERING (1995), FRANK & RABEDER (1996)
Belgium	South-Western Belgium	FLASAR (1977), KERNEY et al. (1983)
Czech Republic	environs of Hradec Kralove	FLASAR (1977), JUŘIČKOVÁ (1998), HORSÁK et al. (2004), ŠEFROVA & LAŠTŮVKA (2005)
France	several localities in French mainland and in Corsica	FLASAR (1977), KERNEY et al. (1983), KERNEY & CAMERON (1999), CUCHERAT & DEMUYNCK (2006), BOULORD et al. (2007)
Germany	several localities distributed in whole territory	SCHMID (1964, 1969, 1997), KADOLSKY (1967), FLASAR (1977), KERNEY et al. (1983), HALDEMANN (1990), STRÄTZ (2001)
United Kingdom	localities in southern and central part of England and in channel islands	FLASAR (1977), CHATFIELD (1977), KERNEY et al. (1983), NORRIS (1991), KERNEY (1999), ANDERSON (2005), WATSON & DALLWITZ (2005)
Hungary	Northern Hungary, Balaton region	PINTÉR (1976), VARGA (1977, 1987), AKOS & VARGA (2005), DOMOKOS & MAJOROS (2008)
Italy	several localities in whole Apenninic Peninsula	PEZZOLI (1985), FERRERI et al. (2005)
Luxemburg	whole country	as in Belgium and the Netherlands
Netherlands	several localities distributed in whole territory	KUIPER (1949, 1956), CLERX (1968), SCHMID (1970), GITTENBERGER at al. (1970), BANK (1980a, b), BOSVELD (2005a, b), NECKHEIM (2006)
Norway	Southern Norway	OLSEN (2002)
Poland	Wrocław (botanical garden), Puszczykowo near Poznań, Rzyczanka Valley (Carpathians)	KOSIŃSKA (1979), RIEDEL (1988), W. P. ALEXANDROWICZ (2002), WIKTOR (2006)
Romania	Western Romania	DOMOKOS & MAJOROS (2008)
Slovakia	Bratislava region, Danube Valley	ČEJKA (2000a, b), ŠTEFFEK (2003), ČEJKA et al. (2006)
Spain	mainland Spain, Balearic Islands	ALTIMIRA (1969), ALTONAGA (1989), ALTABA (1994), HERMIDA et al. (1994)
Sweden	Southern Sweden	VON PROSCHWITZ (1996)
Switzerland	Northern part of Alps	KUIPER 1956, TURNER et al. (1998)
Ukraine	single localities in Western Ukraine	SVERLOVA & GURAL (2005)

population of *L. singleyana* is composed of relatively small and flat specimens (mean breadth – 1.97 mm, mean height – 0.96 mm, mean shape index – 2.06) (Fig. 4, Table 1). The breadth, height, as well as the shape index were characterised by unimodal distributions corresponding to normal ones (Fig. 4). The two main features (B and H) have been mentioned by several authors (PILSBRY 1948, KUIPER 1956, RIEDEL & WIKTOR 1974, KERNEY et al. 1983, JAUERING 1995, KERNEY & CAMERON 1999, WIKTOR 2004, WATSON & DALLWITZ 2005, FRANK 2006 and others) and can be used to compare data from different regions. Shells of *L. singleyana* from the river valleys of the Beskidy Mts seem to be distinctly smaller than the specimens from Western Europe. Most of the above-mentioned authors report the size of the shells as 1.8–2.5 mm (B) and 0.9–1.2 mm (H) (without biometric analysis), while in the studied population the measurements are within 1.75–2.22 mm (B) and 0.70-1.20 mm (H), respectively. However, it is quite difficult to compare details, because only ranges of shell size, or even single measurements, have been published by the cited authors.

CONCLUSIONS

Since the first record of *L. singleyana* in Europe (KUIPER 1949: North Brabant in the Netherlands) only few shells have been found in several European countries. The distribution of the species in Europe is presented in Table 2. The snail is found in two categories of localities. One includes synanthropic habitats, especially greenhouses and botanical gardens (MEEUSE & HUBERT 1949, RIEDEL & WIKTOR 1974, FLASAR 1977, HORSÁK et al. 2004, WIKTOR 2006). Natural (river valleys) (ČEJKA 2000a, b, W. P. ALEXANDROWICZ 2002, ŠTEFFEK 2003) or quasi-natural habitats (castle ruins) (JAUERING 1995, KREISSL & STUMMER 1986) constitute the other category. *L. singleyana* is commonly regarded as alien in Europe. According to this scenario it immigrated into Europe from North America, probably in the late 19th c. or at the beginning of the 20th c., and first inhabited anthropogenic habitats such as greenhouses (MEEUSE & HUBERT 1949, HORSÁK et al 2004). Since the late 20th c., shells of *L. singleyana* have been found in natural habitats. They are especially frequent in flood debris and in castle ruins (FRANK 1986, KREISSEL & STUMMER 1986, HALDEMANN 1990, JAUERING 1995, ČEJKA 2000a, b, W. P. ALEXANDROWICZ 2002). On the other hand, *L. singleyana* has been found in Pliocene and Pleistocene deposits in a few localities in Austria (RABEDER 1981, FRANK & RABEDER 1996) and southern Slovakia (LOŽEK 1964). Its youngest Pleistocene locality is associated with Eopleistocene (Waalian and Cromerian Interglacials, about 1,000,000–700,000 years ago) (LOŽEK 1964), where the species must have become extinct later. Its reintroduction in Europe in the 20th c. was associated with human impact, particularly with the increase in international, transatlantic trade. The development of artificial habitats such as greenhouses or botanical gardens facilitated the colonisation of Europe.

The populations of *L. singleyana* from the river valleys of the Beskidy Mts develop in natural habitats. Their morphometric analysis shows that their shells are somewhat smaller than most specimens from other regions of Central and Western Europe. The analysed populations probably contain a limited number of individuals but seem to be quite stable. Empty shells of the species were found in deposits accumulated in different years in the same places. In Poland *L. singleyana* had been previously found only in two localities: Puszczykowo near Poznań and the botanical garden in Wroclaw (KOSIŃSKA 1979, RIEDEL 1988, WIKTOR 2004). Malacological studies of thanatocoenoses from flood debris in the Beskidy Mts revealed several new localities scattered between the Soła and Wisłok Rivers (Fig. 5). The geographical range of *L. singleyana* is probably considerably wider and may extend throughout Central and Western Europe; the snail has isolated localities in several countries (Table 2). Shells of *L. singleyana* are usually very difficult to find. The snail lives underground and is conchologically quite similar to other species, especially to *Vitrea contracta* (Westerlund) and juvenile *Vallonia pulchella* (O. F. Müller). Systematic examination of snail shells in flood debris seems to be the best way of ascertaining the geographical range of *L. singleyana* and its habitat requirements.

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