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THE HABITAT OF MASK SNAIL *ISOGNOMOSTOMA ISOGNOMOSTOMOS* SCHRÖTER IN LATVIA

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Latvia is a north edge of *Isognomostoma isognomostomos* distributional range in Europe where their populations are isolated from the rest distribution area. The aim of this research was to test which ecological factors are associated with the occurrence of *I. isognomostomos*; describe the structure of land snail communities and evaluate the position of mask snail in snail communities. The research was carried out in Nature Park „Daugavas loki" that lies in South-East part of Latvia. The probability of snail *I. isognomostomos* occurrence based on 20 predictors was assessed with a binomial logistic regression. To test the influence of predictor variables on the structure of snail communities, the Canonical Correspondence Analysis (CCA) was used. The main result showed that of the 20 ecological factors only ten significantly predicted the likelihood of snail occurrence: *Tilia cordata*, *Quercus robur*, *Betula pendula*, *Ulmus glabra*, *Fraxinus excelsior, Populus tremula,* total number of deciduous trees, of bushes, of fallen deadwood and coverage of moss layer. In Latvia *I. isognomostomos* inhabit broad-leaved forests and mixed spruce forest in ravines at an average altitude of 188.2 m above sea level. The number of snail species in communities range from 28 to 39. In land snail communities, mask snail is subdominant or subrecedent. Abundance of *I. isognomostomos* is low - from one to three specimens per m².

Key words: *Isognomostoma isognomostomos*, occurrence, ecology, snail communities, distributional range, Latvia.

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INTRODUCTION

Mask snail (*Isognomostoma isognomostomos*) is distributed in Highlands of Eastern, Central and Western Europe. Latvia is a north edge of its distributional range in Europe and snail populations are peripheral and isolated from the rest of the main distribution (Fig.1). Some isolated populations of mask snail are located in Belgium, Poland, Lithuania and elsewhere in Europe. (Shileiko 1978, Kerney et al. 1983, Neubert 2011, Kuznecova & Skujienė 2012). Snails occur in forests that lie between 300 and 1800 meters above sea level. They live under the fallen deadwood, under bark of fallen deadwood, between stones, on mosses and under the litter (Shileiko 1978, Kerney et al. 1983).

In Latvia, *Isognomostoma isognomostomos* was found for the first time in 1991 (Pilāte et al. 1994). Currently, three locations of mask snail are recorded in valley of river Daugava in southeast Latvia (Rudzīte et al. 2010, Pilāte et al. 2014). The nearest locations of mask snail to Latvia are known in the central part of Lithuania and Russia (Kaliningrad region) (Neubert 2011, Kuznecova & Skujienė 2012). In Latvia, mask snail is a protected species (Cabinet… 2000, 2004). It is included in the Red Data Book of Latvia in 3rd category as a rare species (Spuris 1998). However, in the Red List of Threatened Species of the International Union for Conservation of Nature (IUCN) it is considered to be Least Concern (LC) (Neubert 2011).

Isognomostoma isognomostomos inhabit beech forests, oak-hornbeam forests, ash forests, birch woods and mixed forest, in which *Picea abies* is dominant among the conifers (Shileiko 1978, Kerney et al. 1983, Pfleger 1984, Falkner et al. 2001, Beckmann & Kobialka 2007). The occurrence of snail in forest depends on herb layer, fallen timber, soil pH, persistent moisture and shading. However, the effect of those ecological factors on likelihood of snail occurrence has been known only in the main area of snail distribution, whereas there is a lack of empirical studies for the north edge of its distribution. The mask snail in the main area of distribution is found mainly in beech forests and oak-hornbeam forests. Beech (*Fagus sylvatica*) does not growing in nature of Latvia and is found only in cultivation, because Latvia is located outside the northern boundary of this species natural distribution. Also hornbeams (*Carpinus betulus*) are found only in South-West Latvia as solitarily specimens and groups in forests, rarely in pure stands (Priedītis 2014). Therefore, the aim of this research was to evaluate which ecological factors are associated with the presence or absence of *I. isognomostomos* in north edge of its distribution. We used a binomial logistic regression to test the hypothesis that likelihood of *I. isognomostomos* occurrence is related to 20 predictor variables. To evaluate the position of *I. isognomostomos* in land snail communities we investigated the structure of communities in study sites. We expected that likelihood of *I. isognomostomos* occurrence is affected by tree species composition, habitat structures and soil pH.

MATERIALS AND METHODS

Study area and sites

The research was carried out in Nature Park „Daugavas loki" that lies in South-East part of Latvia and is Natura 2000 site with area 12 372 hectares (Fig. 1). Study area is one of the warmest climatic regions in Latvia with continental climate (Bāra (ed.) 2010). The annual mean air temperature in nature park is +5.4°C, whereas in January -6.6°C and in July +17.6°C with mean range 24.2°C. Frost-free period lasts 236 days and vegetation period 187 days. The circulation of Atlantic air mass is dominant in the Nature Park, resulting in high air humidity, high cloudiness and precipitation – a mean of 730-760 mm per year. The territory of Nature Park has pronounced relief where the river Daugava forms a well-established valley. In the territory, the absolute height of the surface is 188.2 m above sea level. Forests cover is 58% of the territory where most prevalent are coniferous forests with the dominant species – pine (*Pinus sylvestris*).

The research was carried out in three ravine forests, of which Naujene ravine (RAV-1) is located on the right bank of the River Daugava, whereas the ravine of the Lazdukalns brook (RAV-2) and the ravine of the Eitvinišķi brook (RAV-3) are located on the opposite bank of river (Fig. 1). The forest stand is natural origin and the trees are of different age. The ravines are up to 1 km long, 30 – 50 m deep and their slope is 45° - 50° (Table 1).

Collection of samples

Samples were collected in August and September 2012. On both sides of ravine RAV-1 and RAV-2, six 40-meter long transects were marked parallel to the slope in the top, middle and lower part of ravine. In ravine RAV-3, three 90-meters long transects were marked on one side. One litter sample was taken from square meter every 10 meter along each transects with a hand and sifted into a litter sieve (10 mm). Each sample were air-dried and then sifted through a set of soil sieves (5 mm, 3 mm, 2.5 mm, 2 mm and 1 mm). Overall, a total of 95 square areas were examined. Each soil fraction was examined by magnifying glasses, binocular and tweezers. Snail species were identified according to Rudzīte et al. (2010).

Ecological factors

Ecological factors were recorded at a radius of five meters from the center of each square area. Overall, a total of 20 following ecological factors were recorded: tree species (*Tilia cordata, Quercus robur, Alnus incana, Betula pendula, Ulmus glabra, Fraxinus excelsior, Acer*

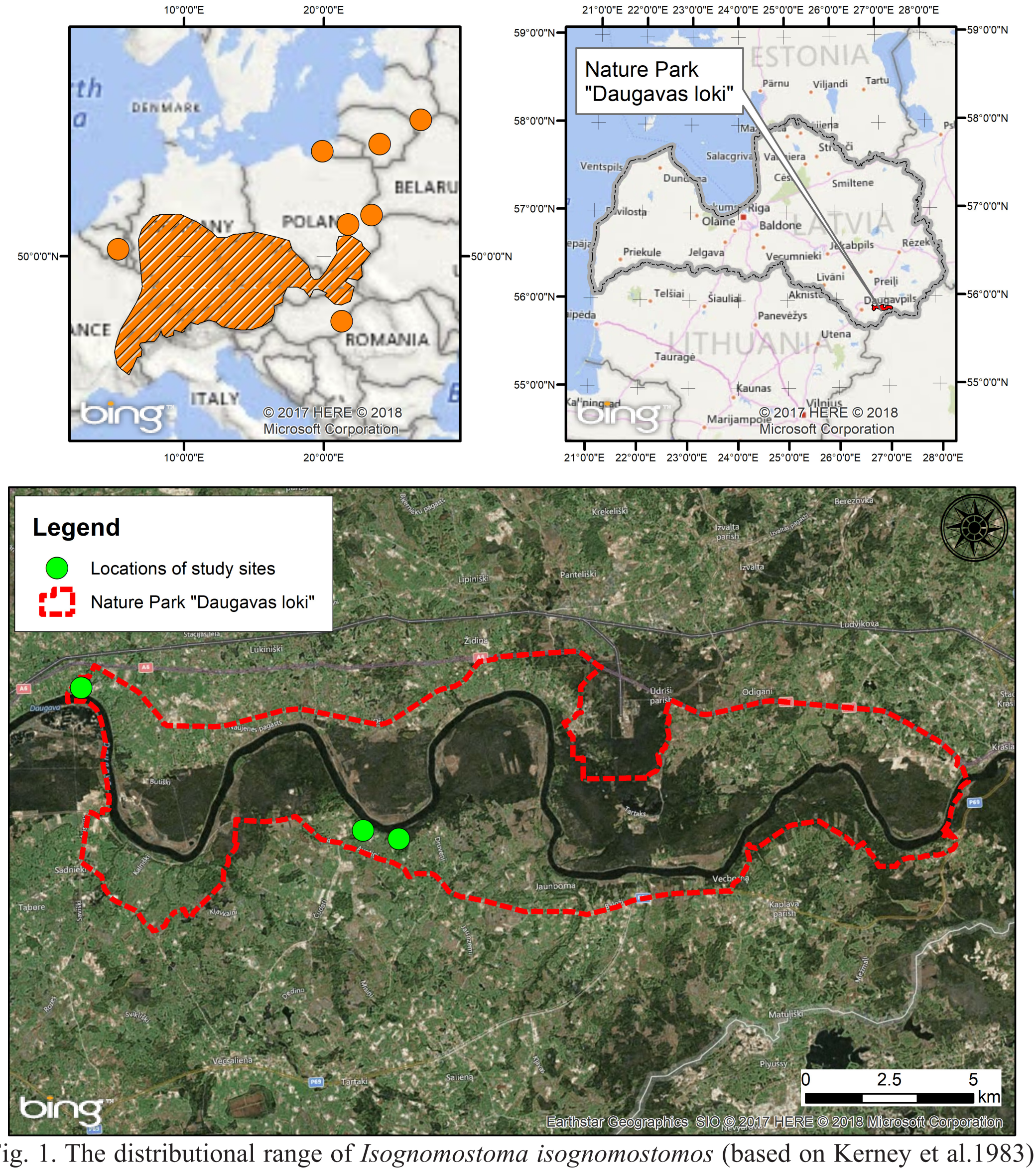

Fig. 1. The distributional range of *Isognomostoma isognomostomos* (based on Kerney et al.1983); study area and locations of study sites.

Table 1. Characteristics of study sites

Study site	Naujene ravine (RAV-1)	Ravine of Lazdukalns brook (RAV-2)	Ravine of Eitvinišķi brook (RAV-3)
Habitat	Broad leaved forest	Broad leaved forest	Mixed spruce forest
Plant association (Laiviņš 2014, Auniņš et al. 2013)	Alno-Ulmion	Tilio-Acerion	Melico-Piceetum
Dominating tree species	*Acer platanoides*, *Ulmus glabra*	*Acer platanoides*, *Tilia cordata*	*Picea abies*
Dominanting brushwood species	*Corylus avellana*, *Padus avium*	*Corylus avellana*, *Padus avium*	*Corylus avellana*
Dominating herb species	*Aegopodium podagraria*, *Anemone nemorosa*, *Pulmonaria obscura*	*Aegopodium podagraria*, *Anemone nemorosa*, *Mercurialis perennis*	*Galeobdolon luteum*, *Oxalis acetosella*
Age of forest (years)	60-90	70-100	80
Habitat area (ha)	7.5	8.1	2.7
Ravine length (m)	~ 600	~ 1000	~ 1000
Ravine depth (m)	40-50	30-40	30
Inclination angle (°)	30-45	45-50	30
Exhibition of ravine sloops	SW	NE	NW

platanoides, Populus tremula, Picea abies, Pinus sylvestris), total number of deciduous trees, of large dimension (>25 cm diameter) deciduous trees, of conifers, of fallen deadwood, of bushes, coverage of herb-layer, coverage of moss layer, coverage of litter layer, tree crown cover and soil pH (Table 2). Soil pH level was measured according to ISO 10390:1994 (International Organization for Standardization).

Statistical data analysis

The probability of snail *I. isognomostomos* occurrence based on 20 predictors was assessed with a binomial logistic regression. The tree species were treated as dichotomous variables (0 absences and 1 presence of species) and others as continuous variables. To cluster this set of variables into a smaller set of 'artificial' variables (called principal components) the principal components analysis (PCA) was applied.

Linearity of the continuous variables with respect to the logit of the dependent variable was assessed via the Box-Tidwell (1962) procedure. A Bonferroni correction was applied (Tabachnick & Fidell 2014). Based on this assessment, all continuous independent variables were found to be linearly related to the logit of the dependent variable. There was six studentized residual with a value greater than 2.5 standard deviations that was removed from the analysis.

Kruskal – Wallis with Mann – Whitney post hoc tests were used to determine if there are difference in snail species abundance between ravines. Statistical data analysis was carried out using SPSS Statistics version 23 (IBM Corporation, Chicago, Illinois).

To test the influence of predictor variables on the structure of snails communities, the Canonical Correspondence Analysis (CCA) was processed using PC-ORD-5 for Windows 4.5 software package.

Table 2. Descriptive statistics of the environmental factors on the study sites RAV-1, RAV-2 and RAV-3. Explanations: CV – coefficient of variation

Variables	RAV-1			RAV-2			RAV-3			CV%
	Total	Range	Mean ± SD	Total	Range	Mean ± SD	Total	Range	Mean ± SD	n=95
Lime *Tilia cordata* Mill.	25	0-8	0.71 ± 1.81	75	0-10	2.5 ± 2.92	4	0-3	0.13 ± 0.57	4,9
Oak *Quercus robur* L.	7	0-2	0.2 ± 0.53	1	0-1	0.03 ± 0.18	3	0-2	0,1 ± 0,4	0,17
Gray alder *Alnus incana* (L.)	9	0-2	0.26 ± 0.61	29	0-11	0.97 ± 2.24	-	-	.	1,84
Birch *Betula pendula* Roth.	1	0-1	0.03 ± 0.17	3	0-1	0.03 ± 0.31	46	0-7	1.53 ± 1.89	1,61
Elm *Ulmus glabra* Huds.	141	0-14	4.03 ± 3.16	59	0-10	1.97 ± 3.01	-	-	-	9,2
Ash *Fraxinus excelsior* L.	14	0-2	0.4 ± 0.7	-	-	-	2	0-1	0.07 ± 0.25	0,23
Maple *Acer platanoides* L.	97	0-15	2.8 ± 3.7	68	0-12	2.27 ± 3.06	19	0-4	0.63 ± 0.96	8,98
Aspen *Populus tremula* L.	10	0-3	0.3 ± 0.86	6	0-2	0.2 ± 0.61	2	0-1	0.07 ± 0.25	0,41
Spruce *Picea abies* (L.)	1	0-1	0.03 ± 0.17	4	0-1	0.13 ± 0.35	187	1-14	6.23 ± 2.58	10,38
Pine *Pinus sylvestris* L.	-	-	-	-	-	-	2	0-1	0.07 ± 0.25	0,02
Total number of deciduous trees	308	2-22	8.8 ± 5.23	241	3-18	8.03 ± 4.55	76	0-8	2.53 ± 2.03	25,27
Large dimension (>25 cm diameter) deciduous trees	123	0-10	3.5 ± 2.42	84	0-11	2.8 ± 3.08	56	0-7	1.87 ± 1.74	4,84
Conifers	1	0-1	0.03 ± 0.17	4	0-1	0.13 ± 0.35	189	1-14	6.3 ± 2.62	10,62
Fallen deadwood	130	0-10	3.7 ± 2.28	204	1-15	6.8 ± 3.61	223	3-15	7.43 ± 2.75	11,03
Bushes	248	2-17	8.27 ± 3.93	321	0-42	10.7 ± 7.94	470	1-30	15.7 ± 7.46	54,91
Coverage of herbaceous layer, (%)	-	18-75	41.71 ± 16.97	-	5-55	24.2 ± 11.84	-	20-87	52.33 ± 20.51	406,32
Coverage of moss layer, (%)	-	6-83	23.77 ± 21.05	-	3-48	19.03 ± 11.18	-	6-97	47.8 ± 28.94	611,18
Coverage of litter layer in plot (%)	-	10-55	26.63 ± 14.48	-	10-90	56.6 ± 22.22	-	45-95	78.53 ± 12.82	749,68
Tree crown cover in plot (%)	-	20-90	55.86 ± 20.2	-	20-88	63.67 ± 18.58	-	15-80	41.47 ± 15.81	412,47
Soil pH (KCl)	-	6-6.98	6.53 ± 0.23	-	5.79-6.91	6.52 ± 0.31	-	4.76-6.73	5.66 ± 0.5	0,29

Table 3. The likelihood of mask snail *Isognomostoma isognomostomos* occurrence in species habitat based on 20 predictors

Predictors	B	SE	Wald	df	p
Intercept	18.850	11.615	2.634	1	0.105
Lime *Tilia cordata* Mill. (1)	**-10.857**	**3.442**	**9.951**	**1**	**0.002**
Oak *Quercus robur* L. (1)	**6.854**	**2.726**	**6.323**	**1**	**0.012**
Gray alder *Alnus incana* (L.) (1)	-2.201	1310	2.824	1	0.093
Birch *Betula pendula* Roth. (1)	**-5.971**	**2.484**	**5.776**	**1**	**0.016**
Elm *Ulmus glabra* Huds. (1)	**-6.670**	**2.577**	**6.698**	**1**	**0.010**
Ash *Fraxinus excelsior* L. (1)	**-5.299**	**2.335**	**5.152**	**1**	**0.023**
Maple *Acer platanoides* L. (1)	1.373	1.029	1.779	1	0.182
Aspen *Populus tremula* L. (1)	**-6.856**	**2.953**	**5.391**	**1**	**0.020**
Spruce *Picea abies* (L.) (1)	4.546	2.532	3.225	1	0.073
Pine *Pinus sylvestris* L. (1)	-2.703	2.857	0.895	1	0.344
Total number of deciduous trees	**-0.589**	**0.221**	**7.108**	**1**	**0.008**
Large dimension (>25 cm diameter) deciduous trees	0.067	0.320	0.044	1	0.833
Conifers	0.083	0.402	0.043	1	0.837
Fallen deadwood	**0.812**	**0.286**	**8.067**	**1**	**0.005**
Coverage of herbaceous layer, %	0.013	0.033	0.151	1	0.698
Coverage of moss layer, %	**-0.116**	**0.045**	**6.713**	**1**	**0.010**
Coverage of litter layer, %	0.010	0.029	0.117	1	0.732
Tree crown cover, %	0.016	0.027	0.349	1	0.555
Soil pH (KCl)	-0.638	1.380	0.214	1	0.644
Coverage of bushes, %	**0.423**	**0.144**	**8.595**	**1**	**0.003**

The number of species (species richness), number of individuals (abundance), dominance structure and two indices of biological diversity (Shannon-Wiener (H') and Simpson's (D)) were used to describe communities (Odum 1971, Drozd 2010). Species dominance was classified according to Tischler's scale (Tischler 1949): eudominant (E) – 10 % $\leq D_i \leq$ 100 %; dominant (D) – 5 % $\leq D_i <$ 10%; subdominant (Sd) – 2% $\leq D_i <$ 5%; recedent (R) – 1 % $\leq D_i <$ 2%; subrecedent (Sr) – 0 % $< D_i <$ 1%. Dominance was calculated as follows:

$$D_i = n_i / N^* 100\%$$

where n_i – abundance of species i, N – total abundance in sample.

Frequency classes were calculated according to Schwerdtfeger (1975):

$F = 100^* b/a$, where a – total number of examined square areas in one rave, b – square areas, where species was recorded.

Frequency classes were categorized according to Tischler (1949): class I – 0% - 20%, class II – 20.1% - 40%, class III – 40.1% - 60%, class IV – 60.1% - 80%, class V – 80.1% - 100%.

RESULTS

The likelihood of mask snail *Isognomostoma isognomostomos* occurrence

Table 2 summarizes data of the ecological factors on the study sites. The composition of tree species was not equal in examined ravines. The relatively high number of elms and maples was recorded in RAV-1, whereas high number of spruces was recorded in RAV-3. Also, RAV-3 had the highest number of fallen deadwood, bushes, coverage of moss layer and coverage of litter layer. In RAV-2, we recorded the largest number of limes, the smallest number of maples and even less number of elms. There were no spruces and pines in RAV-1 and RAV-2 as well as gray alders and elms were not found in RAV-3. We found that the highest coefficient of variation had coverage of herbaceous layer, coverage of moss layer, coverage of litter layer and tree crown.

The logistic regression model was statistically significant, $X^2(20)$ = 40.639, p = 0.004. The model explained 75.3% (Nagelkerke R^2) of the variance in *I. isognomostomos* occurrence and

Table 4. Number of sample plots, species richness, abundance, Shannon–Wiener diversity index, Simpson's index, eudominant and dominant in study sites

	RAV-1	RAV-2	RAV-3	Total
Sample plots	35	30	30	95
Species richness	28	39	30	41
Mean ± SD	8.1 ± 2.99	16,2 ± 4.15	13 ± 4.22	12.5± 5.17
Range	2–14	7-27	5-20	2-27
Total abundance	771	2047	3105	5929
Mean specimens/m² ± SD	22 ± 15.41	68.23 ± 41.74	103.5 ± 77.3	62.35±60.19
Range	2–63	9–161	19–305	2-305
Shannon – Wiener diversity index	3.89	4.23	3.67	-
Simpson's index	0.09	0.08	0.12	-
Number of eudominant	3	2	2	-
Number of dominant	5	4	4	-

correctly classified 90.9% of cases. Sensitivity was 91.9%, specificity was 90.2%, positive predictive value was 87.1% and negative predictive value was 93.8%. Of the 20 predictor variables only ten were statistically significant: *Tilia cordata*, *Quercus robur*, *Betula pendula*, *Ulmus glabra*, *Fraxinus excelsior, Populus tremula,* total number of deciduous trees, of fallen deadwood, of bushes and coverage of moss layer (as shown in Table 2).

Species richness and composition

Altogether, we found 5929 specimens of 41 snail species that represent 18 families (Aciculidae, Bradybaenidae, Clausiliidae, Cochlicopidae, Discidae, Ellobiidae, Enidae, Euconulidae, Gastrodontidae, Helicidae, Hygromiidae, Oxychilidae, Pristilomatidae, Punctidae, Succineidae, Valloniidae, Vertiginidae and Vitrinidae). The number of snail species range from 28 to 39 (mean=32). The most abundant species was *Punctum pygmaeum.*

Table 4 summarizes data that describe land snail communities and number of sample plots by study sites, whereas the composition and frequency classes of snail species in study sites is presented in Table 5.

RAV-1 had the least number of species and low abundance, where *Eumphalia strigella, Laciniaria plicata* and *Macrogastra plicatula* were eudominant, whereas *Aegopinella nitidula, Macrogastra ventricosa, Perforatella bidentata, Fruticola fruticum, Helix pomatia* were dominant. We found 23 specimens of *I.isognomostomos* on the study site, where it was subdominant and had II frequency class.

RAV-2 had the largest number of snail species with high Shannon-Wiener diversity index. *Carychium tridentatum* and *Punctum pygmaeum* were eudominant, whereas *C. minimum, Cochlodina laminata*, *Laciniaria plicata* and *Macrogastra ventricosa* were dominant. We found 76 specimens of *I.isognomostomos* on the study site, where it was subdominant and had III frequency class.

RAV-3 had the lowest Shannon-Wiener diversity index. *Nesovitrea petronella* and *Punctum pygmaeum* were eudominant, whereas *Carychium minimum, C.tridentatum*, *Nesovitrea hammonis* and *Vertigo substriata* were dominant. We found 18 specimens of *I.isognomostomos* on the study site, where it was subrecedent and had II frequency class.

Jaccard's similarity index showed that species composition in RAV-2 and RAV-3 were more similar (Ja=73%) than in other location pairs. Also, Kruskal – Wallis with Mann – Whitney post hoc tests confirmed that RAV-2 and RAV-3 are similar ($p>0.05$) whereas RAV-1 and RAV-2; RAV-1 and RAV-3 significantly differ at species abundance ($p<0.05$).

Table 5. The structure of land snail communities in study sites RAV-1, RAV-2 and RAV-3

Species	Acronym	RAV-1			RAV-2			RAV-3			CV% n=95
		A/m²	SD	F	A/m²	SD	F	A/m²	SD	F	
Aegopinella nitidula (Draparnaud, 1805)	AEG NIT	1.77	D	III	0.97	R	III	0.03	Sr	I	172
Aegopinella pura (Alder, 1830)	AEG PUR	0.8	Sd	II	2.43	Sd	IV	0.03	Sr	I	232
Arianta arbustorum (Linnaeus, 1758)	ARI ARB	0.2	Sr	I	0.03	Sr	I				394
Bulgarica cana (Held, 1836)	BUL CAN	0.03	Sr	I	0.2	Sd	I				376
Carychium minimum O. F. Müller, 1774	CAR MIN	0.09	Sr	I	5.23	D	IV	7.87	D	III	239
Carychium tridentatum (Risso, 1826)	CAR TRI	0.54	Sd	I	7.07	E	IV	9	D	III	180
Cepaea hortensis (O. F. Müller, 1774)	CEP HOR	0.03	Sr	I	0.93	R	III				258
Clausilia dubia Draparnaud, 1805	CLA DUB				0.2	Sr	I				722
Clausilia pumila C. Pfeiffer, 1828	CLA PUM				1.6	Sd	IV				260
Cochlicopa lubrica (O. F. Müller, 1774)	COC LUB	0.09	Sr	I	1.8	Sd	V	3.03	Sd	IV	150
Cochlicopa lubricella (Rossmässler, 1834)	COC LUBR	0.03	Sr	I	0.07	Sr	I	3.2	Sd	IV	223
Cochlodina laminata (Montagu, 1803)	COC LAM	0.91	Sd	III	3.9	D	V	2.07	R	IV	151
Cochlodina orthostoma (Menke, 1828)	COC ORT	0.09	Sr	I	0.1	R	I				475
Columella aspera Walden, 1966	COL ASP				0.07	Sr	I	1.13	R	III	269
Columella edentula (Draparnaud, 1805)	COL EDE	0.03	Sr	I	0.57	Sr	II	1.23	R	III	196
Discus ruderatus (W. Hartmann, 1821)	DIS RUD				0.03	Sr	I	1.07	R	III	300
Euconulus fulvus (O. F. Müller, 1774)	EUC FUL				0.17	Sr	I	3.13	Sd	III	320
Euomphalia strigella (Draparnaud, 1801)	EUO STR	2.94	E	IV	0.9	R	III	0.43	Sr	I	156
Fruticicola fruticum (O. F. Müller, 1774)	FRU FRU	1.2	D	III	0.97	R	III	0.47	Sr	II	147
Helix pomatia Linnaeus, 1758	HEL POM	1.17	D	III							248
Isognomostoma isognomostomos (Schröter, 1784)	ISO ISO	0.66	Sd	II	2.53	Sd	IV	0.6	Sr	II	180
Laciniaria plicata (Draparnaud, 1801)	LAC PLI	3.66	E	IV	3.93	D	V	0.07	Sr	I	180
Macrogastra plicatula (Draparnaud, 1801)	MAC PLI	2.57	E	IV	2.47	Sd	V	0.1	Sr	I	129
Macrogastra ventricosa (Draparnaud, 1801)	MAC VEN	1.74	D	III	4.53	D	V	0.37	Sr	II	151
Merdigera obscura Held, 1838	MER OBS				0.07	Sr	I				720
Nesovitrea hammonis (Ström, 1765)	NES HAM				0.1	Sr	I	8.2	D	V	227
Nesovitrea petronella (L. Pfeiffer, 1853)	NES PET	0.03	Sr	I	0.5	Sr	I	11.73	E	V	192
Perforatella bidentata (Gmelin, 1791)	PER BID	1.43	D	II	2.03	Sd	IV	0.47	Sr	II	182
Platyla polita (W. Hartmann, 1840)	PLA POL	0.23	R	I	2.5	Sd	V	0.17	Sr	I	222
Pseudotrichia rubiginosa (Rossmässler, 1838)	PSE RUB	0.77	Sd	III	1.47	Sd	III	0.03	Sr	I	208
Punctum pygmaeum (Draparnaud, 1801)	PUN PYG	0.14	Sr	I	13.97	E	IV	28.87	E	IV	176
Succinea oblonga (Draparnaud, 1801)	SUC OBL				0.07	Sr	I	0.3	Sr	I	436
Succinea putris (Linnaeus, 1758)	SUC PUT	0.31	R	II	0.07	Sr	I				287
Trochulus hispidus (Linnaeus, 1758)	TRO HIS	0.2	Sr	I	0.87	R	II	0.2	Sr	I	243
Vallonia costata (O. F. Müller, 1774)	VAL COS				1.03	R	II	3.93	Sd	III	293
Vertigo alpestris Alder, 1838	VER ALP				0.07	Sr	I				720

Species	Acronym	RAV-1			RAV-2			RAV-3			CV% n=95
		A/m²	SD	F	A/m²	SD	F	A/m²	SD	F	
Vertigo pusilla O. F. Müller, 1774	VER PUS				0.87	R	I	3.13	Sd	IV	215
Vertigo substriata (Jeffreys, 1833)	VER SUB							6.53	D	V	273
Vitrea crystallina (O. F. Müller, 1774)	VIT CRY	0.17	Sr	I	2.47	Sd	IV	4.47	Sd	III	183
Vitrina pellucida (O. F. Müller, 1774)	VIT PEL	0.2	Sr	I	1.23	R	III	1.63	R	III	183
Zonitoides nitidus (O. F. Müller, 1774)	ZON NIT				0.23	Sr	I				633

Explanations: A/m² – mean abundance per m², SD – structure of dominance, F – frequency classes, D – dominant; E – eudominant; Sd – subdominant, Sr – subrecedent R – recedent; CV – coefficient of variation.

We were not be able to reduce the variables to a smaller number of components (Bartlett's test of sphericity, p > 0.05). The CCA model (Fig. 2) explained 18% of species variation and 77% of the variation in the species-environment relation. The first canonical axis as well as all axes together were significant (p<0.05).

DISCUSSION

Results of present study show that *I. isognomostomos* has not stochastic occurrence in study sites. The variation of ecological factors is probably the main reason for this. Tree species (presence or absence) were stronger associated

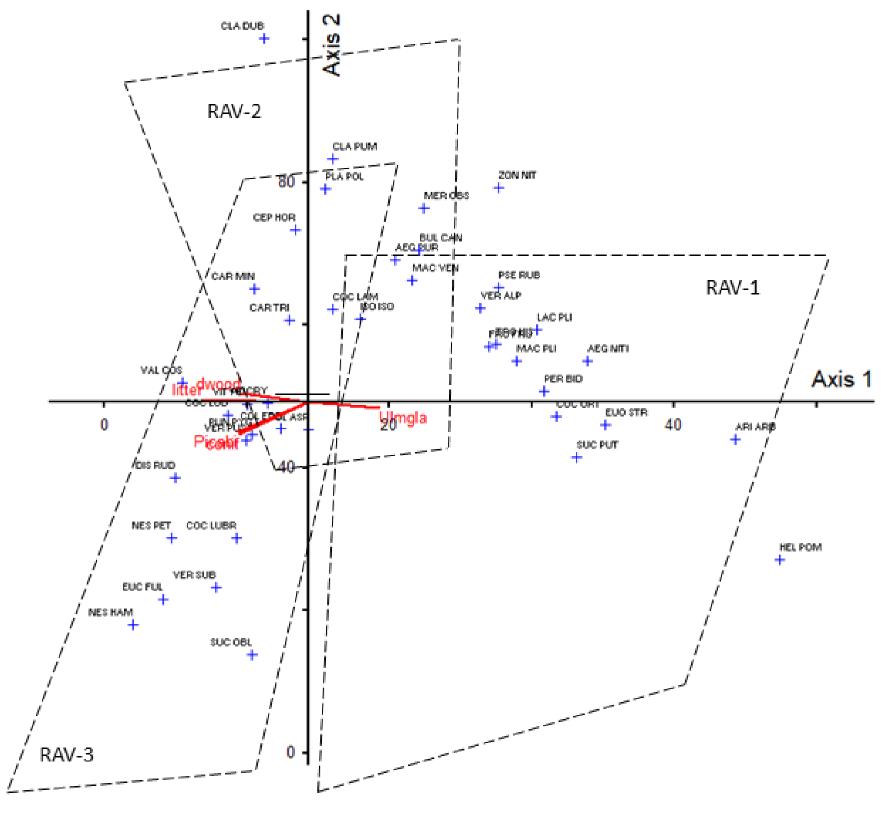

Fig. 2. Ordination diagram (CCA analysis. Eigenwalues: Axes 1 - 0.236, Axes 2 - 0.124, Axes 3 - 0.144) of the distribution of snail species recorded on the study sites (RAV-1, RAV-2, RAV-3), related to the study sites ecological factors. Ecological factors: conif - conifers, dwood - fallen deadwood, litter - coverage of litter layer, Picabi - *Picea abies,* Ulmgla - *Ulmus glabra*.

with likelihood of *I. isognomostomos* occurrence than other habitat structures in study sites. The main findings suggest that the most of leaf tree species are negatively associated (except oak – positively associated) with likelihood of *I. isognomostomos* occurrence, whereas conifer tree species have not impact at all. Our results only partly coincide with data presented by Falkner et al. (2001). As there are no beech forests and oak-hornbeam forests in Latvia, we expected that likelihood of *I. isognomostomos* occurrence will depends on not just from oak (which represents Fagaceae family and includes *Fagus sylvatica*), but on other deciduous tree species, because, in Europe, *I. isognomostomos* is found in ash forests, birch woods and mixed spruce forest. Perhaps, the occurrence of *I. isognomostomos* is associated with other environmental factors, for example as soil fertility or soil composition that not studied in this research.

Description of *Isognomostoma isognomostomos* habitat

In Latvia, *I. isognomostomos* inhabit forests of ravines with at an average altitude of 188.2 m above sea level. For example, in Poland, it is found in Białowieża Forest within 134–202 m (Cameron & Pokryszko 2004). In the main area of distribution, snail inhabits mainly high-altitude regions (300 – 1800 m) (Shileiko 1978, Kerney et al. 1983, Pfleger 1984, 1995, Alexandrowicz & Alexandrowicz 2006, Maltz 2011). Although *I. isognomostomos* is montane-Carpathian species (Kerney et al. 1983), it also may be found in lowland where habitats have pronounced relief. The mask snail in the main area of distribution is found mainly in beech forests and oak-hornbeam forests (Kerney et al. 1983, Pfleger 1984, Falkner et al. 2001, Beckmann & Kobialka 2007). In Latvia, *I. isognomostomos* inhabit 60–100 years old forests and the forest stands is of natural origin. There are broad-leaved forests of ravines where the most abundant tree species are elm, maple and lime, whereas ash, oak, aspen and other deciduous tree species occur rarely (Table 2). Spruce, pine and birch represent mixed coniferous forests.

Land snail communities in the habitat of *Isognomostoma isognomostomos*

In Latvia, the number of species in snail communities in habitats of *I. isognomostomos* range from 28 to 39. All snail species in broad-leaved forests are represented relatively equally. In mixed spruce forest, the Shannon-Wiener diversity index is low, but the dominance of a species is more pronounced. In the present study we found 22 snail species that occurred in all study sites. We found that Clausiliidae species: *Laciniaria plicata* and *Macrogastra plicatula* were dominant or eudominant in broad-leaved forests whereas in mixed spruce forest they were subrecedent and rare. If structure of snail community is similar then *Carychium minimum*, *C. tridentatum* and *P. pygmaeum* species occur as dominant or eudominant in broad-leaved forests and mixed spruce forest (Table 5).

If species that are not occurring in Latvia are not taken into account, then the structure of snail communities in Latvia has the same snail species as *I. isognomostomos* localities in Europe (Pfleger 1995, Szybiak 2000, Cameron & Pokryszko 2004, Alexandrowicz & Alexandrowicz 2006, Maltz 2011, Kuznecova & Skujienė 2012). The number of dominant species varies from 1 to 6. We found six in Latvia protected snail species in *I. isognomostomos* localities: *Bulgarica cana*, *Clausilia dubia*, *C. pumila*, *Cochlodina orthostoma*, *Merdigera obscura* and *Platyla polita*. They account for 35% of the total number of protected terrestrial snail species (Cabinet… 2000, 2004). Almost all of these species are found in *I. isognomostomos* habitats in broad-leaved forests. In Latvia, according to dominance index mask snail is subdominant in broad-leaved forests, whereas in mixed spruce forest – subrecedent. Abundance of *I. isognomostomos* is low – from one to three specimens per m² (Tab. 5). In other sites of distributional area, mask snail abundance in communities are variable and species dominance range from recedent to dominant (Pfleger 1995, Szybiak 2000, Maltz 2011, Alexandrowicz & Alexandrowicz 2006).

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