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Population structure of forest land snails (Gastropoda) in southern Finland

Irene Routio & Matti Valta

***Routio**, Irene, Zoological Museum, Biodiversity Unit, FI-20014 University of Turku.*
irene.routio@elisanet.fi.
***Valta**, Matti,* luontosade.valta@elisanet.fi

Land snails have been divided into four different groups for this study: living adults, deceased adults, living juveniles and deceased juveniles. The three areas studied in southern Finland differed from each other in the quantity of land snail species and individuals present. The collected material can be inspected in many ways. The percentages of living and dead land snails, appearance frequencies of species and other results of the study are made apparent through charts and figures. Even results within a species have fascinating differences.

Introduction

The population structure of land snails can be observed in several different ways, from many different perspectives: by species, by species group, by comparing the relationships between different species (Routio 2010). The snails can, of course, be observed through biotopes (Routio 2009, Routio & Valta 2014a), by verifying differences between areas (e.g. archipelago – continental Finland) (Routio & Valta 2011), or by seasons (Routio & Valta 2016). They can also be studied by observing the populations of different years, throughout a longer period, or the impact that the quality of the soil or weather conditions have on the populations.

Snail communities react to clearances of forest, differences caused by the erosion of the terrain and differences between, for example, maintained and unmaintained meadows (Routio & Valta 2014b). The follow-up findings the writers made regarding the snail populations at a maintained ancient cite, the Kuusisto Bishop's Castle Ruins near Turku, were also interesting (Routio 2008).

In Finland, observations have been made based on living adults and young individuals (Routio & Valta 2016), and on the portions of living and dead ones in populations (Hutri & Mattila 1986, Routio 2010, Routio & Valta 2011). In Europe, the population ecology of land snails has been researched in several ways for a long time (Wäreborn 1969, Cameron & Pokryszko 2005, Gärdenfors 1987, Jurickova & Kucera 2005, Kappes 2005, Polley 1973, von Proschwitz 1991 & 2001, Suominen et al. 2002, Walden 1981). The results are, however, not directly applicable to Finland.

The soil samples show an interesting combination of living adults, living young, dead adults and dead young snails. These can be looked at as a whole. The shells of small forest species will remain in the soil for 2–4 years. The shells of larger, hard-shelled, cultural species will decompose in 4–6 years (Routio & Valta 2022). Both types of land snails have approximately the same life expectancy. We will first look at the relationship between old and young ones, then the portions of the living and the dead, frequency, and finally in short, the populations of different species.

Methods

As research subjects, we have chosen three different forest areas in southwestern Finland (V, Ab) and Uusimaa (U): The Suomusjärvi, Kisko, Karjalohja area (from here on out ”Kisko”, coord. ETRS-TM35FIN 6694:3217), The Ruissalo island in Turku (coord. 6711:2394) and the Kustavi municipality in the west (coord. 6724:1911).

Barren pine forests, peatland forests, and on the other hand, yards and parks, were left out of the observation. Samples where no snails were found were not included. The Kustavi municipality had 11 of these, which was by far the most. This study includes only those terrestrial samples which contained living land snails or their shells.

The sample radius was three meters, vertical depth 5 centimetres. 15 litres of soil and litter was collected from the sample area. Snails were separated from the sample and the species were identified indoors using a microscope. The samples have been collected between May-October in 1993–2022. From each area, a total of 76 soil samples were collected, put together 228 samples, or 3 420 litres.

Known as potentially carnivorous, even cannibalistic, *Zonitoides nitidus*, is exceptional from other land snails in its life habits (Frömming 1954). In this observation, it has been left aside, even though it is the most common land snail, for example, in the Ruissalo island (Routio & Valta 2011). In this research, the species was present to some extent in moist grove forests, but it is not a proper forest species. It is numerous in strand black alder forests and bird cherry bushes. It can even be found in masses on the strands of reedy ponds, in the vicinity of soft water. Species usually found in similar biotopes, *Succinea putris* and *Oxyloma* species, were almost completely absent from the soil samples.

The shell of a snail grows continuously and transforms. Every individual that excepts from a fully-grown, old snail, has been interpreted as a young one. The shell of a young snail is smaller and undeveloped when compared to that of an adult one. For instance, young snails of the family *Clausilidae* have deficient and incomplete teeth around the mouth opening. The same difference can, naturally, be seen in dead individuals. Identifying the species of young snails is not as difficult as one might expect.

Results

Three areas, populations

Wetland species *Zonitoides nitidus* was found in six samples, put together 47 individuals. The species has been excluded from this observation.

It turned out that the Kisko area forests are leafy, the ones in Kustavi more barren, and the nutritional value of forests in Ruissalo is somewhere between these two. There were 36 (26) species of land snails found in Kustavi, 36 (30) in Ruissalo and 38 (36) in Kisko. The actual forest species are in parentheses. There was a total of 1 659 individuals in Kustavi, 3 300 in Ruissalo and 5 223 in Kisko. The populations of the most common species can be seen in Tables 1a, 1b and 1c. The red numbers are exceptions to the average value.

Nesovitrea hammonis is by far the most common and populous land snail species in Kustavi and Kisko. *Cochlicopa lubrica* is the most common one in Ruissalo. It is common and populous everywhere. *Vallonia pulchella* and *Columella edentula* are rare in the east, in Kisko. In the west, in Kustavi, the species *Aegopinella pura*, *Goniodiscus rotundatus*, *Perforatella bidentata*, *Cochlodina orthostoma*, *Vitrea crystallina*, and *Carychium* species were completely absent.

Many species have great variation in their prevalence by area: *Punctum pygmaeum* was met 14,9 % in Ruissalo, 10,5 % in Kustavi, and only 6,7 % in Kisko. The prevalence of *Cochlodina laminata* was 4,9 % in Kustavi, 1,0 % is Kisko and 0,9 % in Ruissalo. The same relations can be seen in the sample areas of the species: Kustavi 7,2 %, Ruissalo 2,4 %, and Kisko 2,9 %. The prevalence of *Vallonia costata* has great variation, as well: Kustavi 5,4 %, Kisko 5,3 % and Ruissalo 0,5 %.

Nesovitrea petronella, *Fruticicola fruticum* and *Vertigo substriata* were rare in all the areas in which they were found, but the frequencies are high. This means they are common, but few in number. The population structure of *Arianta arbustorum*, *Euconulus alderi*, *Vallonia costata* and *Aegopinella pura* is the opposite: they were found

Table 1 a. The Kustavi land snails in soil samples. Species from the most common to the most rare. 20 species. 76 sample areas. N = 1 659. Samples taken in 2014–2022. The **red numbers** are exceptions to the average value.

Species	Freq. by sample area x/76	Adults			Juveniles			Adults & juveniles total	% whole material	Ind. / sample area	% sample area
		living	dead	total	living	dead	total				
Nesovitrea hammonis	51	197	73	270	74	33	107	377	22,7	7,4	67,1
Clausilia bidentata	35	100	19	119	57	25	82	201	12,1	5,7	46,1
Punctum pygmaeum	24							175	10,5	7,3	31,6
Vitrina pellucida	28	62	36	98	20	17	37	135	8,1	4,8	36,8
Nesovitrea petronella	24	59	37	96	15	14	29	125	7,5	2,0	31,6
Discus ruderatus	23	35	9	44	44	12	56	100	6,0	4,3	30,3
Vallonia costata	9	65	10	75	10	5	15	90	5,4	10,0	11,8
Euconulus fulvus	26	43	16	59	16	6	22	81	5,3	3,1	34,2
Cochlodina laminata	11	24	5	29	31	19	50	79	4,8	7.2	14,5
Cochlicopa lubrica	26	35	20	55	15	2	17	72	4,3	2,8	34,2
Vertigo pusilla	11							54	3,3	4,9	14,5
Vallonia pulchella	8	13	11	24	1	3	4	28	1,7	3,5	10,5
Zonitoides nitidus	6	17	6	23	3	2	5	28	1,7	4,7	7,9
Fruticicola fruticum	11	3	8	11	8	4	12	23	1,4	2,1	14,5
Columella edentula	5	16	-	16	5	-	5	21	1,3	4,2	6,6
Euconulus alderi	8	12	1	13	5	2	7	20	1,2	2,5	10,5
Vertigo substriata	10	14	1	15	2	-	2	17	1,0	1,7	13,2
Cochlicopa lubricella	8	11	4	15	2	-	2	17	1,0	2,1	10,5
Columella aspera	3	5	2	7	2	-	2	9	0,5	3,0	3,9
Euomphalia strigella	5	4	2	6	1	-	1	7	0,4	1,4	6,6
Total ind.		715	260	975	311	144	455	1659	100 %		
%		73,4	26,7		68,4	31,6					
%				68,2			31,8				

Table 1 b. The 20 most abundant land snail species of the Ruissalo island. 76 sample areas, n = 3 300. Samples collected in 1993–2022. The **red numbers** are exceptions to the average value.

Species	Freq. by sample area x/76	Adults			Juveniles			Adults & juveniles total	% whole material	Ind. / sample area	% sample area
		living	dead	total	living	dead	total				
Cochlicopa lubrica	51	250	85	335	228	181	409	744	22,7	14,6	67,1
Nesovitrea hammonis	52	279	146	425	135	76	211	636	19,4	12,2	68,4
Punctum pygmaeum	47	244	94	338	109	42	151	488	14,9	10,4	61,8
Euconulus fulvus	50	142	75	217	122	87	209	426	13,0	8,5	65,8
Clausilia bidentata	40	42	22	64	102	22	124	188	5,7	4,7	52,3
Discus ruderatus	37	35	28	63	81	33	114	177	5,4	4,8	48,7
Vertigo substriata	24	46	29	75	31	12	43	118	3,6	4,9	31,6
Vallonia pulchella	12	38	21	59	28	6	34	93	2,8	7,8	15,8
Vitrina pellucida	29	38	27	65	11	17	28	93	2,8	3,2	38,2
Columella edentula	11	37	19	56	14	12	26	82	2,5	7,5	14,5
Nesovitrea petronella	29	30	8	38	16	9	25	63	1,9	2,2	38,2
Columella aspera	15	20	5	25	27	4	31	56	1,7	3,7	19,7
Cochlodina laminata	13	8	-	8	6	16	22	31	0,9	2,4	17,1
Vertigo pusilla	9	10	11	21	3	-	3	24	0,7	2,7	11,8
Vertigo lilljeborgi	2	4	13	17	1	2	3	20	0,6	10,0	2,6
Vallonia costata	6	5	8	13	5	-	5	18	0,5	3,0	7,9
Goniodiscus rotundatus	2	4	4	8	6	2	8	16	0,4	8,0	2,6
Trochulus hispidus	11	8	-	8	-	4	4	12	0,3	1,1	14,5
Euconulus alderi	2	4	2	6	1	3	4	10	0,3	5,0	2,6
Cochlicopa lubricella	2	3	-	3	1	1	2	5	0,2	2,5	2,6
Total ind.		1247	597	1844	927	529	1456	3300	100 %		
%		67,6	32,4		63,7	36,3					
%				55,9			44,1				

Table 1 c. The forest land snails in the Kisko area. Including 25 species. 76 sample areas, n = 5 223. Samples collected in 1998–2013. The **red numbers** are exceptions to the average value.

Species	Freq. by sample area x/76	Adults			Juveniles			Adults & juveniles total	% whole material	Ind. / sample area	% sample area
		living	dead	total	living	dead	total				
Nesovitrea hammonis	64	338	280	618	216	139	355	973	18,6	15,2	84,2
Cochlicopa lubrica	46	150	110	260	136	144	280	540	10,3	11,7	61,5
Euconulus fulvus	45	117	86	203	92	97	189	392	7,5	8,7	60,8
Punctum pygmaeum	40	161	131	292	42	40	82	374	7,2	9,4	52,6
Discus ruderatus	45	60	45	105	115	113	228	333	6,4	7,4	60,8
Nesovitrea petronella	44	66	90	156	64	76	140	296	5,7	6,7	57,9
Vallonia costata	22	122	80	202	56	19	75	277	5,3	12,6	28,9
Carychium tridentatum	15	101	89	190				190	3,6	12,7	19,7
Clausilia bidentata	40	58	20	78	39	59	98	176	3,4	4,4	52,6
Vitrina pellucida	35	38	58	96	24	39	63	159	3,0	4,5	46,1
Cochlicopa lubricella	26	63	51	114	17	22	39	153	2,9	5,9	34,2
Acanthinula aculeata	10	92	18	104	27	14	41	151	2,9	15,1	13,2
Vertigo pusilla	21	49	69	118	14	18	32	150	2,9	7,1	27,2
Vertigo substriata	31	72	32	104	27	12	39	143	2,7	4,6	40,8
Euconulus alderi	5	57	42	99	20	23	43	142	2,7	28,4	6,6
Aegopinella pura	5	26	31	57	24	23	47	104	2,0	20,8	6.6
Trochulus hispidus	8	14	39	53	24	23	43	96	1,9	12,0	10,5
Fruticicola fruticum	20	9	14	23	25	28	53	76	1,5	3,8	26,3
Columella aspera	18	25	24	49	20	2	22	71	1,4	3,9	23,7
Macrogastra plicatula	16	25	12	37	12	11	23	60	1,2	3,8	21,1
Cochlodina laminata	18	23	9	32	13	7	20	52	1,0	2,9	23,7
Arianta arbustorum	2	6	11	17	20	14	34	51	1,0	25,5	2,6
Carychium sp	5	2	1	3	20	16	36	39	0,7		
Vallonia pulchella	7	22	5	27	8	3	11	38	0,7	5,4	9,2
Columella edentula	15	12	18	30	2	1	3	33	0,6	2,2	19,7
Goniodiscus rotundatus	4	17	2	19	11	2	13	32	0,6	8,0	5,3
Total ind.		1725	1367	3086	1068	945	2009	5101			
%		55,9	44,3		53,2	47,0					
%				60,5			39,5				

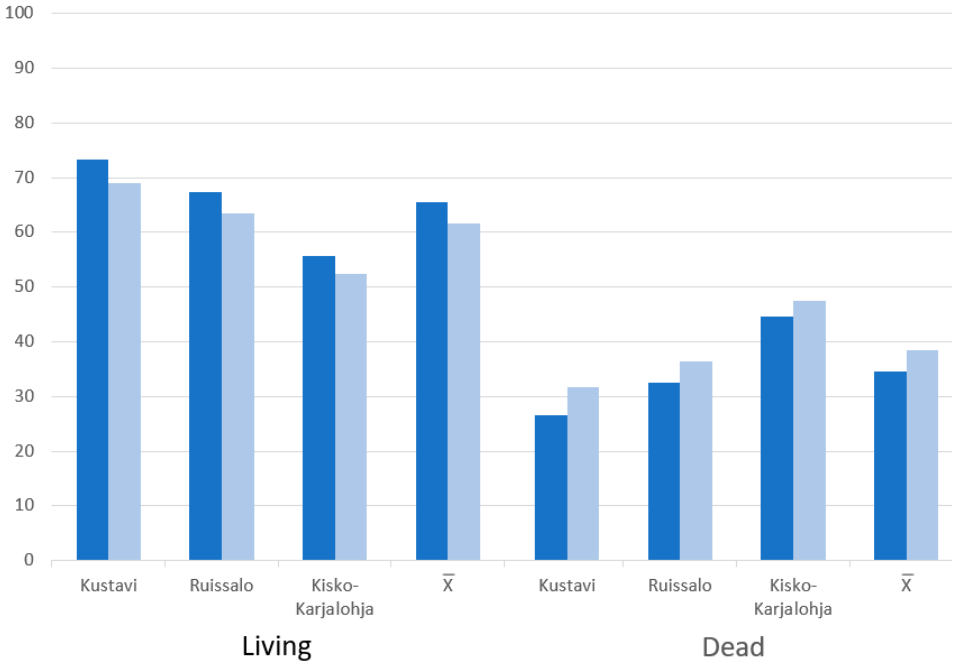
in few sample areas, but in abundance in those. *Vallonia pulchella* and *Acanthinula aculeata* were also found in few sample areas, but not as abundantly as the previously mentioned ones. *Euconulus fulvus* is common, but few in number throughout the research area.

Living and dead

Land snail populations have a percentage of living individuals, combining old and young ones, of 73,4–55,7 %. The corresponding percentage of dead ones is 44,3–26,6 %. There is 3–4 % more adult than young snails. When looked at as individual species, the same relations are true for most. In the west, in Kustavi, there are relatively more living ones than in Ruissalo and Kisko. When comparing the relative portions of living and dead, the species with the most living ones were individual/sample areas *Acanthinula aculeata* 11,1/3,0, *Goniodiscus rotundatus* 6,3/1,7 and *Vallonia costata* 7,1/3,3. Average values for the whole material were 4,9/3,2.

When disregarding individuals that are dead over whatever reason, the relations of the living adults and young ones can be seen in Table 3. In Kustavi the relation is instable at 74,8/58,4 %, but in Ruissalo and Kisko it is balanced, at 65,2/66,9 % and 55,6/56,8 %. The species with the most prominent representation of young individuals is *Columella aspera*, 51/90,9 %. The very common species *Nesovitrea hammonis* and *Punctum pygmaeum* have an even relation of approximately 50/50 %.

The portion of dead ones was the lowest in Kustavi, 24,4 %. The portion was 34,1 % in Ruis-



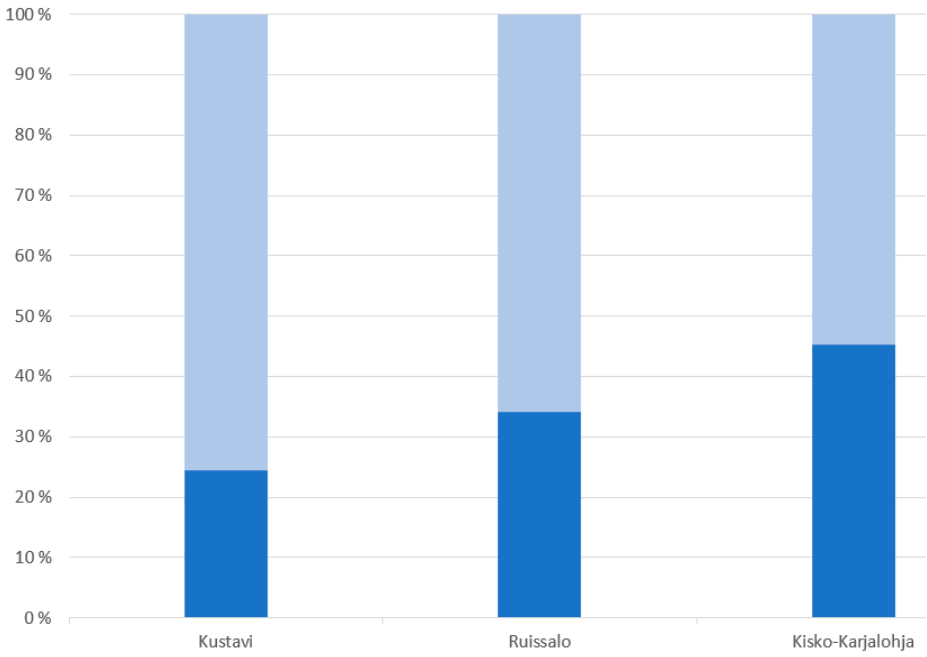
◄ **Fig. 1. The living and dead individuals in all material and the average. n = 11 420. *Zonitoides nitidus* has been excluded.**

Table 2. The frequencies and percentages of living and dead individuals of 24 land snail species in relation to frequence. 228 sample areas. n = 9 326. The **red numbers** are exceptions to the average value.

Species	Sample areas 3 x 76 = 228			Freq. x/228	Living	Dead	Living % / sample area	Dead % / sample area
	Kis-Kar	Ruissalo	Kustavi					
Nesovitrea hammonis	64	52	51	167	1239	747	7,4	4,5
Cochlicopa lubrica	46	51	26	123	814	542	6,6	4,4
Euconulus fulvus	45	50	26	121	532	367	4,4	3,0
Punctum pygmaeum	40	47	24	87	556	307	6,4	3,5
Discus ruderatus	45	37	26	105	370	240	3,5	2,3
Nesovitrea petronella	44	29	24	97	250	234	2,6	2,4
Vallonia costata	22	6	9	37	263	122	7,1	3,3
Clausilia bidentata	40	40	35	115	398	167	3,5	1,5
Vitrina pellucida	35	29	28	92	193	194	2,1	2,1
Cochlicopa lubricella	26	2	8	36	97	78	2,7	2,2
Acanthinula aculeata	10	1	1	11	122	33	11,1	3,0
Vertigo pusilla	21	9	11	30	76	98	2,5	3,3
Vertigo substriata	31	24	10	65	192	86	3,0	1,3
Euconulus alderi	5	2	8	15	99	73	6,6	4,9
Aegopinella pura	5	1	-	6	54	55	9,0	9,1
Trochulus hispidus	8	11	4	23	51	67	2,2	2,9
Fruticicola fruticum	20	28	11	31	35	54	1,1	1,7
Columella aspera	18	5	3	36	99	37	2,8	1,0
Macrogastra plicatula	16	-	-	16	37	23	2,3	1,4
Cochlodina laminata	18	13	11	42	105	56	2,5	1,3
Arianta arbustorum	2	3	-	5	31	26	15,5	13,0
Vallonia pulchella	7	12	8	27	110	49	4,1	1,8
Columella edentula	15	11	5	31	86	50	2,8	1,6
Goniodiscus rotundatus	4	2	-	6	38	10	6,3	1,7
Total	587	465	329		5847	3715		
Mean x							4,9	3,2

Table 3. Portions of the living adult and young individuals in a land snail population in relation to each other. n = 6063. The **red numbers** are exceptions to the average value.

	%	%	%	%	%	%
Nesovitrea hammonis	73,0	69,2	65,6	68,0	54,7	60,8
Clausilia bidentata	**84,0**	69,5	65,6	**82,3**	**74,4**	39,8
Vitrina pellucida	63,3	54,0	58,5	**39,3**	**39,6**	**38,1**
Punctum pygmaeum			72,2	72,2	55,1	51,2
Nesovitrea petronella	61,5	51,7	78,9	64,0	42,3	45,7
Discus ruderatus	79,5	78,6	55,6	71,1	57,1	50,4
Vallonia costata	**86,7**	66,7	38,5		60,4	74,7
Euconulus fulvus	72,9	72,7	65,4	58,4	57,6	48,7
Cochlodina laminata	**82,8**	62,0			71,9	65,0
Cochlicopa lubrica	63,6	88,2	74,6	55,7	57,7	48,6
Vallonia pulchella	54,2	**25,0**	64,4	**82,4**	**81,5**	72,7
Columella edentula			66,1	53,8	40,0	
Euconulus alderi			66,7		57,6	46,5
Vertigo substriata			61,3	72,1	69,2	69,2
Columella aspera			**80,0**	**87,1**	**51,0**	**90,9**
Carychium tridentatum					53,2	
Cochlicopa lubricella					55,3	43,6
Acanthinula aculeata					**88,5**	**65,9**
Vertigo pusilla					41,5	43,8
Aegopinella pura					45,6	51,1
Trochulus hispidus					**26,4**	55,8
Fruticicola fruticum					39,1	47,2
Macrogastra plicatula					65,8	54,2
Goniodiscus rotundatus					**89,5**	**84,6**
mean %	**74,0**	58,4	65,2	66,9	**55,6**	**56,8**
	Adults	Juvelniles	Adults	Juveniles	Adults	Juveniles
	Kustavi		Ruissalo		Kisko-Karjalohja	
24 landsnail species	Living					



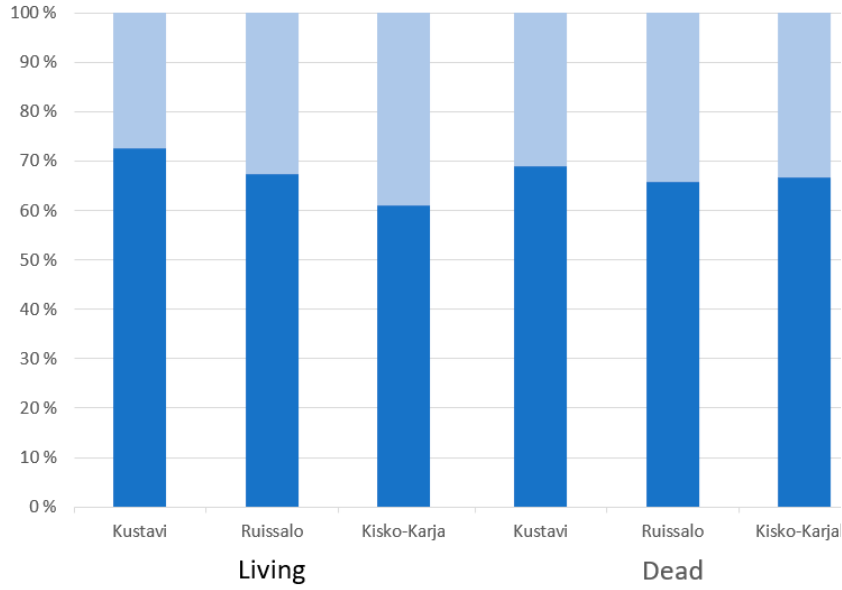
◄ **Fig. 2. The relation between living and dead individuals in the forest species material. n = 10 060.**

salo, and 45,3 % in Kisko. An explanation can be found in the quality of the soil, for example the pH value. In Finland, the shells take a longer time to decompose in a soil with a high pH value, than in a soil where the pH value is low (Routio & Valta 2022).

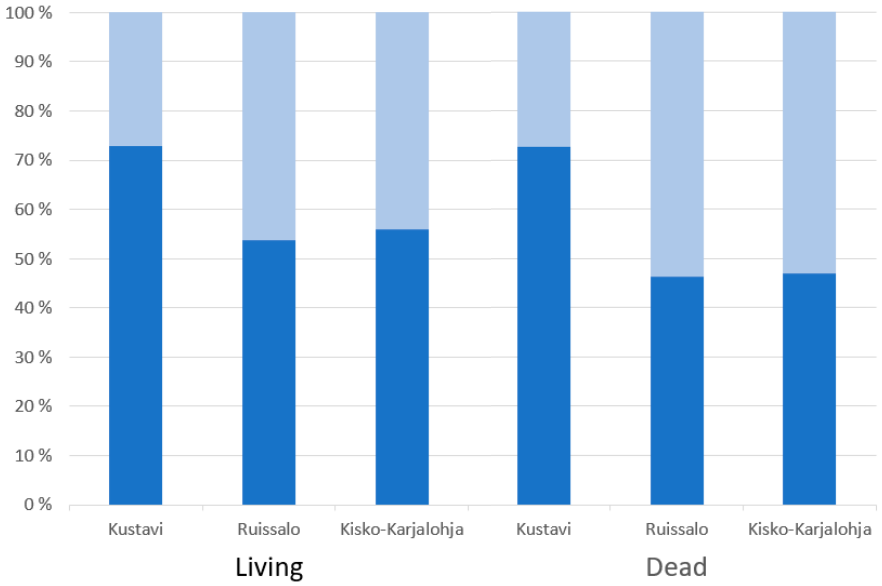
It is possible to create a correction factor for each species that would take into account the different decomposing speed of the shell, and a factor that would compensate the effect of the pH value. This way the population of each species would be counted by a mathematical formula. This is the next level and challenge of snail research.

Characters of species shortly

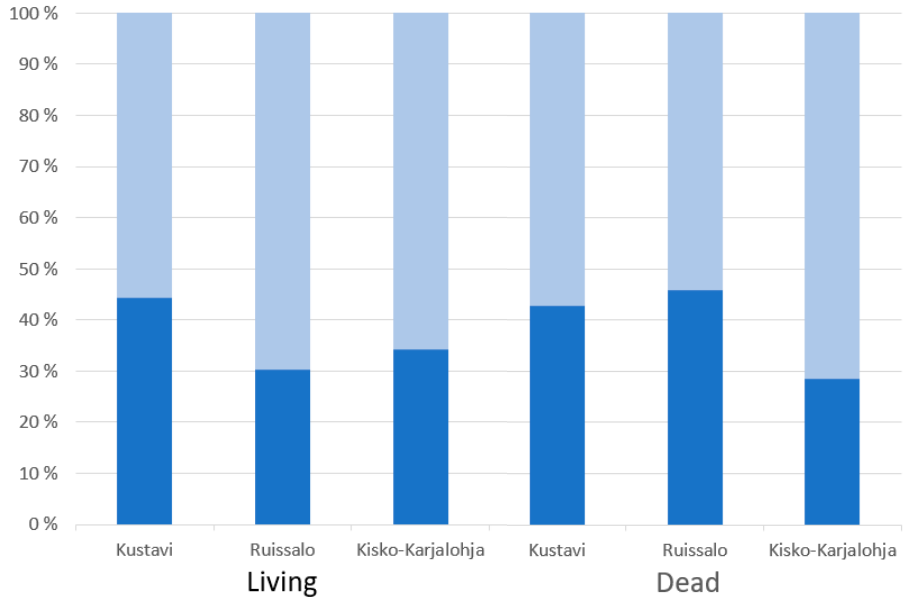
Here are figures (Figs. 3–7) of some of the most populous species generally, in all the material. We can see clear differences between species and different areas.



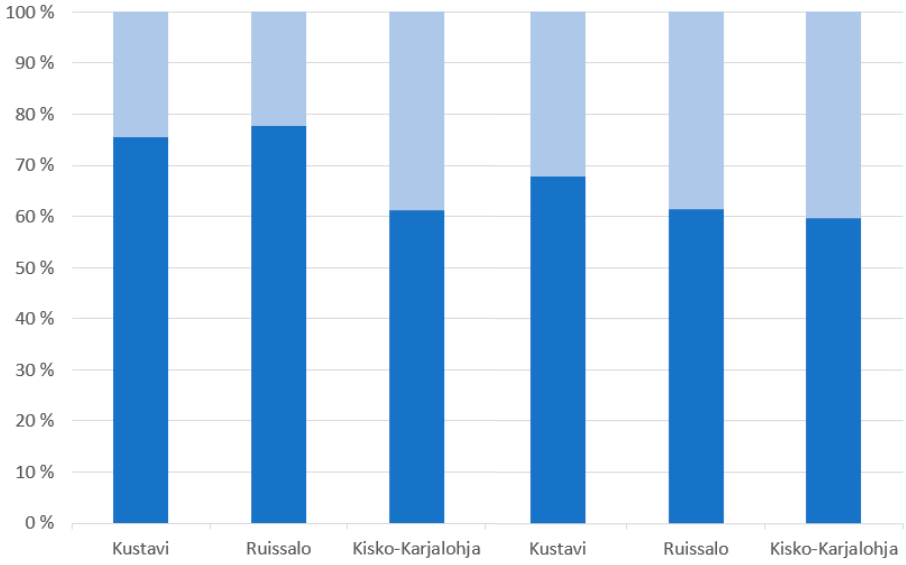
◄ **Fig. 3.** ***Nesovitrea hammonis*** **is the most common and populous species met in this study. It prospers in all sample areas with a balanced population structure. n = 1 986.**



◄ **Fig. 4. In** ***Euconulus fulvus*** **there is a correlation between the living and the dead. The high number in Kustavi is a sign of the species' weak reproductive ability. n = 899.**



◄ **Fig. 5. In *Discus ruderatus* the portions of adult individuals are low everywhere. The young ones are very prominent in this species. This is an exceptional species-specific characteristic. n = 505.**



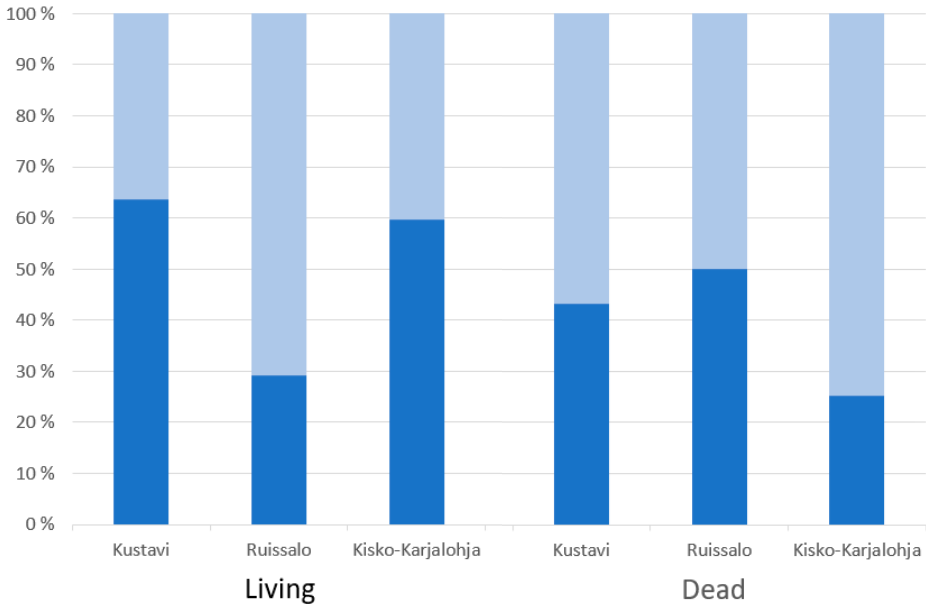
◄ **Fig. 6. In *Vitrina pellucida* the adults are in high portion, 77,6–61,3 % in living individuals, and also in dead ones, 67,9–59,8 %. This is an eminently species-specific characteristic. n = 387.**

Observations

All species observed here are perennial and live up to 3–4 years. Vitrina pellucida is mentioned to be annual in Finnish literature (Valovirta et al. 1986). The species would only hibernate as an egg. In southwestern Finland, this is hardly the case, as adult individuals are already met in early spring.

In southern Europe, some species have two generations per year, but in Finland these same species only have one per year. In the hot, sunny summers in southern Europe the snails procreate rapidly whenever it rains (Polley 1973). In Finland, summer rains and most of all wet nightly mists stabilize the variations in population structures. Naturally, procreation is mostly impacted by quantity of nutrition and profitable microclimate circumstances.

The possible warming of the climate may alter the time of procreation and populational structure of land snails in the future. Land snails are adaptable, however. Even in the clearance areas of damp coniferous forests, 70 % of the species will prosper for decades, provided that large,



◄ Fig. 7. The *Clausilia bidentata* populations are doing better in some areas than in others. This kind of variation is typical of the Clausilidae family. n = 565.

overshadowing ferns stay alive. 30 % of the species will be replaced by new ones, while the overall number of species remains the same (Routio & Valta 2012).

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