Extended essay

Biology

The effect of the pH of the soil on the population size of *Helix pomatia.*

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Word count: 3888

Abstract

The aim of this investigation is to state the effect of the pH of the soil on the population size of *Helix pomatia* . To determine this, three locations from Świętokrzyski National Park were chosen: "Święty Krzyż", "Łysica" and "Zapusty" reserve, which differed mainly by the pH of the soil. Firstly, 10 samples with area 0.25m^2 from each investigated location were carefully searched through in order to state the density of the *Helix pomatia* population in a particular location and then the population size was calculated. The samples of soil from all investigated areas were collected and pH of the soil was measured in two ways: by mixing soil with distilled water and with 1mol/dm^3 potassium chloride solution. The results support hypothesis and show that the pH does have an effect on *Helix pomatia* population size – the greater the pH the greater the population size. In the area with the lowest pH_{KCl} equal 3.33 no snail was found. Such correlation may be caused by the fact that snails need calcium carbonate as some parts of their body are made of it and the presence of calcium carbonate in the soil makes it alkaline. The acidity of the soil may also cause damage to *Helix pomatia*'s epiphragm as well as to eggshells and result in increased mortality among matured individuals and not yet hatched snails causing the decrease in population size. This study shows the importance of protecting areas like "Święty Krzyż" and "Zapusty" reserve from malacological point of view.

Word count: 249

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1. Research question

What is the effect of the pH of the soil on the population size of *Helix pomatia*?

2. Introduction

In January 2013 I heard in the news about the problem with building a bypass route near Poznań, because it would cross the natural habitat of an endangered species of snail, *Vertigo moulinsiana*. It caused conflicts between ecologists and local authorities, however they are working on a solution now (TVN24 2013). This situation directly led me to come up with the idea for the topic of my extended essay. I live in the buffer zone of the Świętokrzyski National Park, therefore I have been having an easy access to one of the most valuable (in a scientific and cultural way) areas in the country since I was born. This fact became a major factor that contributed to my interest in the world of nature; the way how it works has always seemed to be very mysterious to me. What intrigues me the most is the ecological aspect of interactions between animals and their surroundings. Change in the environment can sometimes have detrimental effects on the populations or even the existence of the whole species in case of endangered organisms as it could have happened near Poznań. I have decided to investigate one of the abiotic factors – pH of the soil and examine its effect on the population size of one of the species of snails – *Helix pomatia.* This could also be a great opportunity to explore the location where I live and get a broader knowledge about the protected area within the Świętokrzyski National Park.

2.1. Helix pomatia

Scientific classification of *Helix pomatia* (Herczek and Gorczyca 2000)

- Kingdom: Animalia
- Phylum: Mollusca
- Class: Gastropoda
- Clade: Pulmonata
- Order: Styllommatophora
- Family: Helicidae
- Genus: *Helix*
- Species: *pomatia*

Helix pomatia is one of the biggest snails in Europe. It is widespread in Poland mainly due to the fact that it was a part of friars' cuisine and thus was commonly raised in medieval times in gardens near monasteries. Body of *Helix pomatia* consists of head with tentacles, foot and visceral mass (where organs are located) contained in a shell. Sense organs include tentacles and statocysts that are "sacs" filled with fluid in which there are particles of calcium carbonate and when they press on the walls of these "sacs" that are lined with sensory cells, a snail can orientate in space (Herczek and Gorczyca 2000, p 19). A shell consists of three layers: outer (periostracum) –made of conchiolin, medium (ostracum) – made of calcareous plates arranged perpendicularly (calcium carbonate is absorbed via nutrition and water), inner (hypoostracum) – made of pearl (Dogiel 1986). A shell of *Helix pomatia* is big, with 40-45mm height and slightly conical, almost spherical shape. Colour of the shell varies from creamy, beige to brown with visible texture and sometimes blurred dark brown bands. An umbilicus is narrow, visible, partially or almost completely covered with an inner lip. An outer lip is thick, light, yellowish-white. The habitats of *Helix pomatia* are warm and humid areas including forests, shrubbery, parks, gardens and cemeteries (Wąsowski and Penkowski 2003, p 56; Herczek and Gorczyca 2000). Temperature, humidity and chemical composition of the soil are the main factors affecting the presence of *Helix pomatia* (Herczek and Gorczyca 2000, p 29). Their activity increases when the level of air humidity is high – during warm, rainy days. When the weather conditions are not suitable they close the aperture with layer of dried mucus. *Helix pomatia* are herbivores; they eat herbs such as stinging nettle, common dandelion, tussilago, arctium as well as fruits and vegetables. *Helix pomatia* are victims of many predators such as european hedgehog, common frog, common toad, some of the rodents, eurasian magpie, common raven, hooded crow, not to mention humans. *Helix pomatia* are hermaphrodites. The breeding season starts in May and during this time individuals' feet adjoin in a vertical position and right before copulation one individual stabs another with a love dart. Love dart is a kind of thorn made of calcium carbonate created by snails belonging to family *Helicidae*. In June *Helix pomatia* dig a small hole in the humid, soft soil and lay several dozens of eggs there (Herczek and Gorczyca 2000). Each egg has a diameter about 6mm and is enclosed with calcareous eggshell (Wąsowski and Penkowski 2003, p 56). After up to 30 days *Helix pomatia* hatch from the eggs. Snails live about 6 years and they become physically mature after three years. Their hibernation starts in September or October, depending on weather conditions and ends in April. They dig a hole in the ground and spend this period approximately dozen centimetres underground with aperture of their

shells closed with epiphragm. Epiphragm is a cover made of calcium carbonate and protects snails from cold and drying (Herczek and Gorczyca 2000).

2.2. Key terms

"Population – a group of organisms of the same species which live in the same area at the same time."(Damon, McGonegal, and others 2007, p 113)

"Population density – number of individuals belonging to a population per unit area.

Population size – number of individuals belonging to a population at the same time" (Kłos, Kofta, and others 2002, p 192).

"Community – a group of populations living and interacting with each other in an area" (Damon, McGonegal, and others 2007, p 113).

2.3. Soil

"Soil is a thin surface layer of low thickness, which is influenced by both the atmosphere and organic life. Soil includes mineral and organic particles, air and water. Soil formation is affected by soil-forming factors (weathered rock, altitude, topography, climate, water, vegetation, animal organisms) characteristic of a given area" (Kosakowski, Kowalik, and others 2006, p 121). First step of this formation is weathering of parent rock that stem from the activity of wind, temperature differences and dissolving by water and acids. Then living organisms settled on the ground absorb minerals from it and provide organic matter creating humus (Hurvic 1967, p 469). One of the features of the soil is pH, which depends on the composition of the soil such as presence of acids, salts, colloids and clay minerals and the activity of the living organisms. Acidic pH of the soil is the result of the presence of salts derived from strong acids and weak bases and acids that provide hydrogen ions to the soil (Uniwersytet Łódzki). "Acids formed in soil as a result of the biological processes include: nitric (V) acid, sulphuric (VI) acid, acetic acid, oxalic acid, carbonic (IV) acid and humic acids (…). Salts of strong acids and weak bases when undergoing hydrolysis cause the acidic pH of the soil. The salts include: potassium alum [$KAl(SO_4)_2 \cdot 12H_2O$], aluminum (III) chloride ($AlCl_3$), iron (II) sulphate (VI) ($FeSO_4$)" (Uniwersytet Łódzki). Alkaline and neutral soils are the ones that contain calcium carbonate and potassium and magnesium salts (Hurvic 1967, p 469). Outside factors (mainly precipitation) influence significantly the properties of soil and this is reflected in the change in pH. pH of the soil is very important for living organisms, especially plants and bacteria and for many biological, chemical and physical

processes occurring within soil (Uniwersytet Łódzki; Hurvic 1967). "Acidity of the soil is the concentration of hydrogen ions in the soil solution."(Uniwersytet Łódzki). There are two kinds of acidity of soil:

- Actual – depends on the free hydrogen ions present in soil. Measured in a mixture of soil with distilled water. It is influenced by the presence of calcium carbonate, organic acids and carbonic acid (Uniwersytet Łódzki).
- Potential – it is measured in a mixture of soil with neutral salt (e.g. KCl) or salt undergoing hydrolysis and depends on the hydrogen ions that move to the soil solution as a result of the reaction with salt and hydrolysis. In this case pH is lower, than in the above as the greater amount of hydrogen ions can move to the solution (Uniwersytet Łódzki).

3. Hypothesis

Knowing that calcium carbonate is present in *Helix pomatia's* body and shell and is as well a protection for eggs, I assume that the greater the pH of the soil the greater the population size of *Helix pomatia*. Acidic environment may damage the calcareous parts of *Helix pomatia*'s body, because calcium carbonate reacts with acids. *Helix pomatia,* to construct their shells, need calcium carbonate, which can be absorbed from the soil, and presence of calcium carbonate in the soil increases its pH.

4. Variables

Independent variable: pH of the soil

Dependent variable: population size of *Helix pomatia*

Control variables:

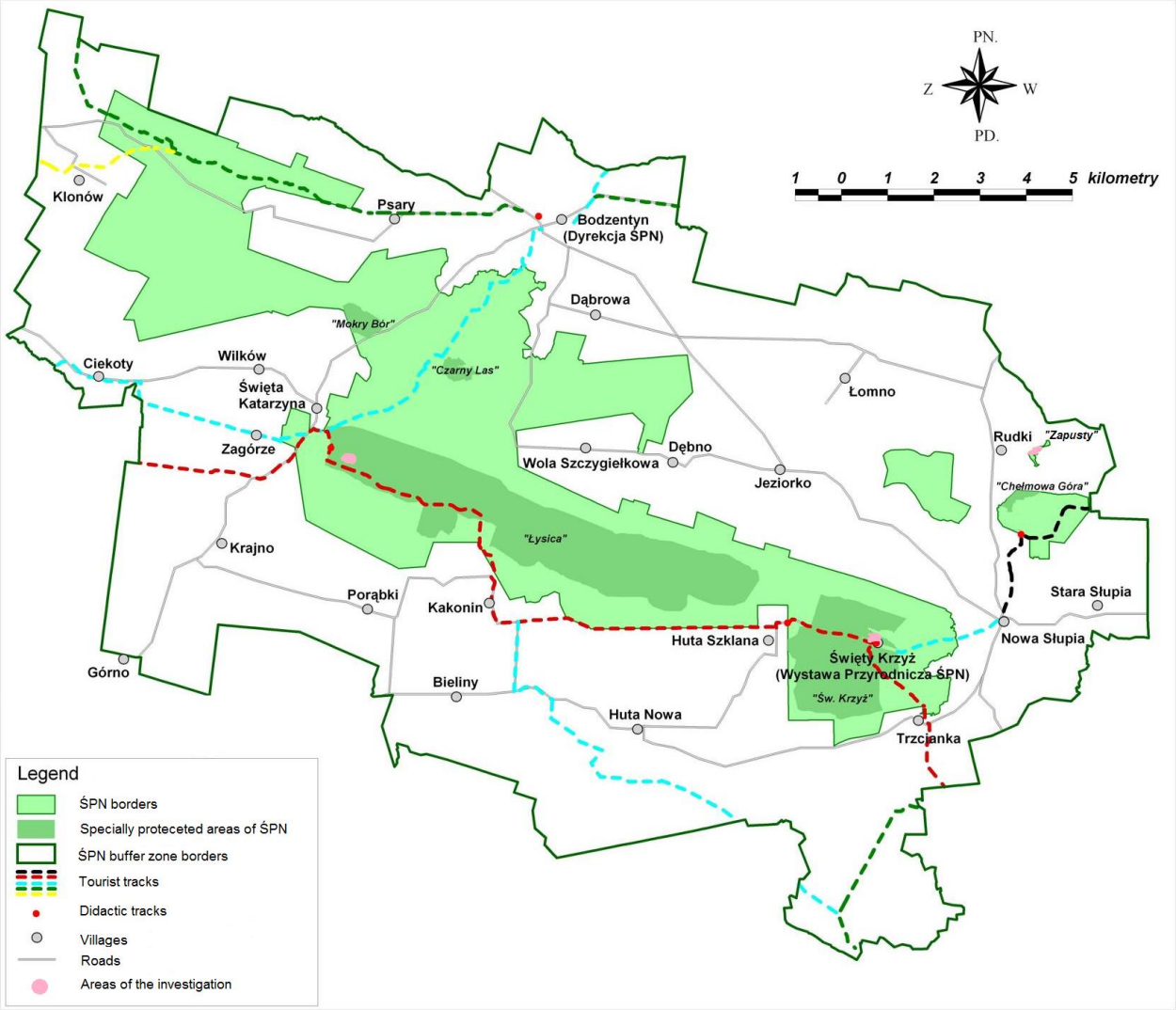
- Temperature of the air: 20-23ºC
- Area of the investigated location (about 200m^2)
- Number of samples investigated in each location – 10
- Size of each sample (0.25m^2)
- Time of the day: 11.00-15.00
- Time of the year: 31.07. – 02.08.
- Type of investigated areas – forest

- Area of the Świętokrzyski National Park

5. Locations of the investigation

The locations chosen are all within the area of Świętokrzyski National Park thus generally the conditions such as climate are similar. The investigated difference between the locations is the pH of soil which depends on the chemical composition of the soil. Here are the brief descriptions of investigated locations. "Łysica" reserve is located on the highest mountain in Świętokrzyskie Mountains – Łysica with 612m a.s.l. "Święty Krzyż" reserve is on mountain Łysa Góra with 595 m a.s.l. which is a part of the same mountain chain as Łysica called Łysogóry (Duława and Bronowski 2010). On the top of Łysa Góra there is Benedictine monastery from 12th century and other later buildings, where Świętokrzyski National Park's and religious institutions are located (Ossowska). These mountains are composed of upper cambrian quartz sandstone, slate and mudstone and the stone runs are also present (Adamczyk, Buchholz, and others 2013). Fir-beech forest is growing there (Ossowska and Świątkowski). "Zapusty" reserve is located on a hill composed of limestone and that makes it an exceptional place in Świętokrzyski National Park (Adamczyk, Buchholz and others). Dry-ground forests with hornbeams and oaks and xerothermic grasses grow there (Barga-Więcławska 2011). Mean annual amount of precipitation in Łysogóry equals 800-850mm, whereas in lower located "Zapusty" it equals 550-600mm (Cieśliński and Kowalkowski 2000, p 105). The warmest month with the greatest amount of precipitation is July and according to weather station on the top of Łysa Góra the mean annual temperature is 5.8ºC (Cieśliński and Kowalkowski 2000, p 137).

Map. 1 Map of the Świętokrzyski National Park showing the investigated locations (Świętokrzyski Park Narodowy, http://www.swietokrzyskipn.org.pl/o_parku/mapa/).



6. Materials

- Protective gloves
- Wooden frame with dimensions: 50cm x 50cm
- Camera
- Distilled water
- 1mol/dm^3 potassium chloride solution
- Scale (±0.1g)
- pH-meter (±0.01pH)
- 2 beakers (capacity: 250ml)

- Graduated cylinder (±0.5ml, capacity: 50ml)
- 10 numbered sticks
- 30 labelled jars with capacity about 250ml
- Mortar
- Sieve
- Spoon
- Stopwatch (±0.01s)
- Plastic spoon
- Thermometer (range: –30.0-50.0±0.5ºC)

7. Method

7.1. Method for estimating the population size of *Helix pomatia*

Method used for estimating the population size of *Helix pomatia* was based on the Oekland's method frequently applied in malacological researches (Barga-Więcławska 2011; Dzięczkowski 1988). To state the population size of *Helix pomatia* on the previously described locations the following activities were undertaken. Wooden frame with dimensions: 50cm x 50cm (covering a square with the area 0.25m^2) was placed in the 10 randomly chosen places on the particular area. Each sample was marked by placing a stick with the number of a sample in the ground in the left top corner of the frame in order not to investigate the same sample more than once. Area within a frame was carefully searched through (which is visible on pictures 7 and 8 in the appendix) and all of the *Helix pomatia* individuals as well as other snails with size greater than 5mm were counted. The species *Helix pomatia* was identified basing on the description presented in the introduction.

The investigation took place during summer; in "Łysica" reserve on 31st July 2013, in "Święty Krzyż" reserve on 1st August 2013, in "Zapusty" reserve on 2nd August 2013. In all cases the research was conducted between the 11.00 and 15.00, the weather was sunny, slightly windy and the temperature of the air was measured by thermometer (±0.5ºC) and ranged from 20ºC to 23ºC. During the whole period of the research as well as a few days earlier no precipitation occurred.

Data from each sample gave the number of *Helix pomatia* individuals per 0.25m^2. Data from all 10 samples was used to calculate the mean density of *Helix pomatia* population

on the given area. Then by multiplying the density by the area the population size was estimated.

7.2. Method for stating the pH of the soil

From every sample (method for choosing and marking samples is described in the above paragraph) approximately 5 spoonfuls of soil from the depth up to 5cm were collected in the labelled jars. The method of determining the pH of the soil was based on the procedure presented by Uniwersytet Gdański (2013).The sample of the soil was left for a couple of days to get dry, then triturated in the mortar and sieved. 10.0g of such prepared soil was weighed using a scale with uncertainty 0.1g and placed in a beaker (capacity: 250ml). Then 25ml of distilled water was measured using a graduated cylinder (±0.5ml) and poured into the beaker. The mixture was stirred with plastic spoon and left for 10min (measured by stopwatch) and also stirred several times during this period. After that time a suspension was stirred again and the pH-meter with uncertainty 0.01 was placed in it and the pH of the suspension was recorded. pH of each suspension was measured 3 times. The same procedure was repeated, but instead of distilled water a 1 mol/dm^3 solution of potassium chloride was used. The whole procedure was repeated for all of the samples from the same area. Then the mean pH_{H2O} and the mean pH_{KCl} for each investigated area were calculated.

8. Data collection

Tab. 1 Raw data about snails from each sample from "Łysica" reserve.

Number of a sample	*Helix pomatia*			Qualitative data	Other snails*		
	Number of living indivi-duals	Number of empty shells	Together		Number of living indivi-duals	Number of empty shells	Together
1	0	0	0	-	0	0	0
2	0	0	0	-	0	0	0
3	0	0	0	-	0	0	0
4	0	0	0	-	0	0	0
5	0	0	0	-	0	0	0
6	0	0	0	-	0	0	0
7	0	0	0	-	0	0	0
8	0	0	0	-	0	0	0
9	0	0	0	-	0	0	0
10	0	0	0	-	0	0	0

*Only snails with size greater than 5mm are considered.

Tab. 2. Data about the investigated area in "Łysica" reserve.

Temperature in [ºC] ±[0.5ºC]	Time of the investigation	Weather	Description of the area
23.0	11.00 – 15.00 31.07.2013	Sunny; little windy; no precipitation	South side of the peak of the mountain "Łysica", near stone run, about 15m from tourist track; fir-beech forest, very thick layer of leaf litter on the ground, many stones and great amount of dead wood.

Pic. 1. Investigated area in “Łysica” reserve.

Tab. 3 pH of the soil measured in distilled water in “Łysica” reserve.

Number of the sample	pH of the soil ±0.01pH			Average pH of the soil from one sample ±0.01pH
	I trial	II trial	III trial	
1	4.02	4.00	4.09	4.04
2	3.90	3.84	3.87	3.87
3	3.88	3.82	3.89	3.86
4	3.91	3.85	3.88	3.88
5	3.78	3.70	3.76	3.75
6	4.23	4.25	4.24	4.24
7	3.86	3.87	3.86	3.86
8	3.94	3.98	3.96	3.96
9	4.02	4.02	4.05	4.03
10	3.89	3.90	3.92	3.90
Average pH of the soil in “Łysica” reserve ±0.01pH				3.94

Tab. 4 pH of the soil measured in 1 mol/dm^3 solution of potassium chloride in "Łysica" reserve.

Number of the sample	pH of the soil ±0.01pH			Average pH of the soil from one sample ±0.01pH
	I trial	II trial	III trial	
1	3.48	3.51	3.50	3.50
2	3.47	3.47	3.49	3.48
3	3.16	3.13	3.14	3.14
4	3.24	3.26	3.28	3.26
5	2.90	2.90	2.92	2.91
6	3.54	3.52	3.51	3.52
7	3.36	3.37	3.30	3.34
8	3.56	3.55	3.57	3.56
9	3.38	3.31	3.32	3.34
10	3.23	3.24	3.26	3.24
Average pH of the soil in "Łysica" reserve ±0.01pH				3.33

Tab. 5 Raw data about snails from each sample from "Święty Krzyż" reserve.

Number of a sample	*Helix pomatia*			Qualitative data about *Helix pomatia*	Other snails*		
	Number of living indivi-duals	Number of empty shells	Together		Number of living indivi-duals	Number of empty shells	Together
1	1	0	1	Brown shell, snail moving on the leaf	1	1	2
2	0	0	0	-	0	1	1
3	0	0	0	-	0	0	0
4	1	0	1	Brown shell with a snail body completely hidden in	0	0	0
5	0	0	0	-	0	1	1
6	1	0	1	Brown shell with mucus cover on the aperture	0	0	0
7	0	0	0	-	1	4	5
8	0	0	0	-	0	1	1
9	0	0	0	-	0	0	0
10	0	0	0	-	0	0	0

*Only snails with size greater than 5mm are considered.

Tab. 6. Data about the investigated area in “Święty Krzyż” reserve.

Temperature in [ºC] ±[0.5ºC]	Time of the investigation	Weather	Description of the area
20.0	11.00 – 15.00 01.08.2013	Slightly cloudy; little windy; no precipitation	North slope of the mountain “Łysiec”, behind the abandoned building; fir-beech forest on the stone run, leaf litter with a medium thickness and dead wood on the ground.

Pic. 2. Investigated area in “Święty Krzyż” reserve.

Tab. 7. pH of the soil measured in distilled water in “Święty Krzyż” reserve.

Number of the sample	pH of the soil ±0.01pH			Average pH of the soil from one sample ±0.01pH
	I trial	II trial	III trial	
1	5.10	5.11	5.08	5.10
2	5.24	5.22	5.20	5.22
3	5.23	5.20	5.19	5.21
4	5.82	5.87	5.90	5.86
5	5.05	5.06	5.03	5.05
6	4.98	5.00	5.03	5.00
7	7.27	7.29	7.27	7.28
8	7.10	7.15	7.12	7.12
9	4.90	4.88	4.89	4.89
10	5.88	5.81	5.83	5.84
Average pH of the soil in “Święty Krzyż” reserve ±0.01pH				5.66

Tab. 8. pH of the soil measured in 1 mol/dm^3 solution of potassium chloride in "Święty Krzyż" reserve.

Number of the sample	pH of the soil ±0.01pH			Average pH of the soil from one sample ±0.01pH
	I trial	II trial	III trial	
1	4.50	4.54	4.54	4.53
2	4.68	4.75	4.85	4.76
3	4.76	4.76	4.73	4.75
4	5.29	5.35	5.37	5.34
5	4.50	4.58	4.54	4.54
6	4.65	4.60	4.61	4.62
7	6.57	6.66	6.64	6.62
8	6.52	6.55	6.56	6.54
9	4.44	4.45	4.46	4.45
10	5.22	5.18	5.16	5.19
Average pH of the soil in "Święty Krzyż" reserve ±0.01pH				5.13

Tab. 9. Raw data about snails from each sample from "Zapusty" reserve.

Number of a sample	*Helix pomatia*			Qualitative data	Other snails*		
	Number of living indivi-duals	Number of empty shells	Together		Number of living individuals	Number of empty shells	Together
1	0	1	1	Beige shell	0	0	0
2	1	0	1	Beige shell with mucus cover on the aperture	0	4	4
3	1	0	1	Beige shell	0	0	0

				with mucus cover on the aperture			
4	0	0	0	-	1	3	4
5	0	0	0	-	0	2	2
6	0	0	0	-	0	3	3
7	1	1	2	Light beige shell with mucus cover on the aperture/ beige shell	0	0	0
8	0	0	0	-	1	2	3
9	0	0	0	-	0	1	1
10	1	0	1	Brown shell with mucus cover on the aperture	0	1	1

*Only snails with size greater than 5mm are considered.

Tab. 10. Data about the investigated area in “Zapusty” reserve.

Temperature in [ºC] ±[0.5ºC]	Time of the investigation	Weather	Description of the area
23.0	11.00-14.00 02.08.2013	Sunny; little windy; no precipitation	North-west slope of hill “Zapusty”, maple-hornbeam forest on stone run with thin layer of leaf litter.

Pic. 3. Investigated area in “Zapusty” reserve.

Tab. 11. pH of the soil measured in distilled water in “Zapusty” reserve.

Number of the sample	pH of the soil ±0.01pH			Average pH of the soil from one sample ±0.01pH
	I trial	II trial	III trial	
1	7.52	7.50	7.49	7.50
2	7.89	7.86	7.94	7.90
3	7.85	7.84	7.90	7.86
4	7.89	7.95	7.96	7.93
5	8.00	8.11	8.09	8.07
6	7.89	7.92	7.93	7.91
7	8.05	8.03	8.00	8.03
8	8.03	8.01	8.02	8.02
9	8.47	8.50	8.49	8.49
10	8.08	8.06	8.03	8.06
Average pH of the soil in “Zapusty” reserve ±0.01pH				7.98

Tab. 12. pH of the soil measured in 1 mol/dm^3 solution of potassium chloride in "Zapusty" reserve.

Number of the sample	pH of the soil ±0.01pH			Average pH of the soil from one sample ±0.01pH
	I trial	II trial	III trial	
1	7.00	6.97	6.95	6.97
2	7.55	7.59	7.50	7.55
3	7.31	7.32	7.40	7.34
4	7.42	7.40	7.42	7.41
5	7.44	7.42	7.42	7.43
6	7.54	7.55	7.50	7.53
7	7.66	7.60	7.65	7.64
8	7.56	7.55	7.56	7.56
9	7.97	7.92	7.92	7.94
10	7.68	7.76	7.77	7.74
Average pH of the soil in "Zapusty" reserve ±0.01pH				7.51

9. Data processing

To calculate the density of *Helix pomatia* population in a sample the number of living individuals found in a sample was divided by the area of a sample which is 0.25m^2.

e.g. calculating the density of *Helix pomatia* population in a first sample from "Święty Krzyż":

$$\frac{1}{0.25m^2} = \frac{4}{1m^2}$$

To calculate the mean density of *Helix pomatia* population in one of the investigated areas the densities from all samples were added and then divided by the number of samples (=10).

e.g. calculating the mean density of *Helix pomatia* population in "Święty Krzyż":

$$\frac{4+0+0+4+0+4+0+0+0+0}{10} = 1.2$$

To calculate the population size of *Helix pomatia* in one of the investigated locations the mean population density was multiplied by area (=200m^2).

e.g. calculating the population size of *Helix pomatia* in "Święty Krzyż:
1.2/m^2 × 200m^2 = 240

In the same way the size of the community of other snails in each of the investigated locations is calculated.

Tab. 13. Density and size of *Helix pomatia* population in all investigated locations.

Location		"Łysica"	"Święty Krzyż"	"Zapusty"
Population density per m^2 in each sample	1	0	4	0
	2	0	0	4
	3	0	0	4
	4	0	4	0
	5	0	0	0
	6	0	4	0
	7	0	0	4
	8	0	0	0
	9	0	0	0
	10	0	0	4
Mean population density per m^2		0	1.2	1.6
Population size on area 200m^2		0	240	320

Tab. 14. Density and size of the community of other snails in all investigated locations.

Location		"Łysica"	"Święty Krzyż"	"Zapusty"
Community density per m^2 in each sample	1	0	4	0
	2	0	0	0
	3	0	0	0
	4	0	0	4
	5	0	0	0
	6	0	0	0
	7	0	4	0
	8	0	0	4
	9	0	0	0
	10	0	0	0
Mean community density per m^2		0	0.8	0.8
Community size on area $200m^2$		0	160	160

Fig. 1 The graph showing the population size of *Helix pomatia* against the pH of soil.

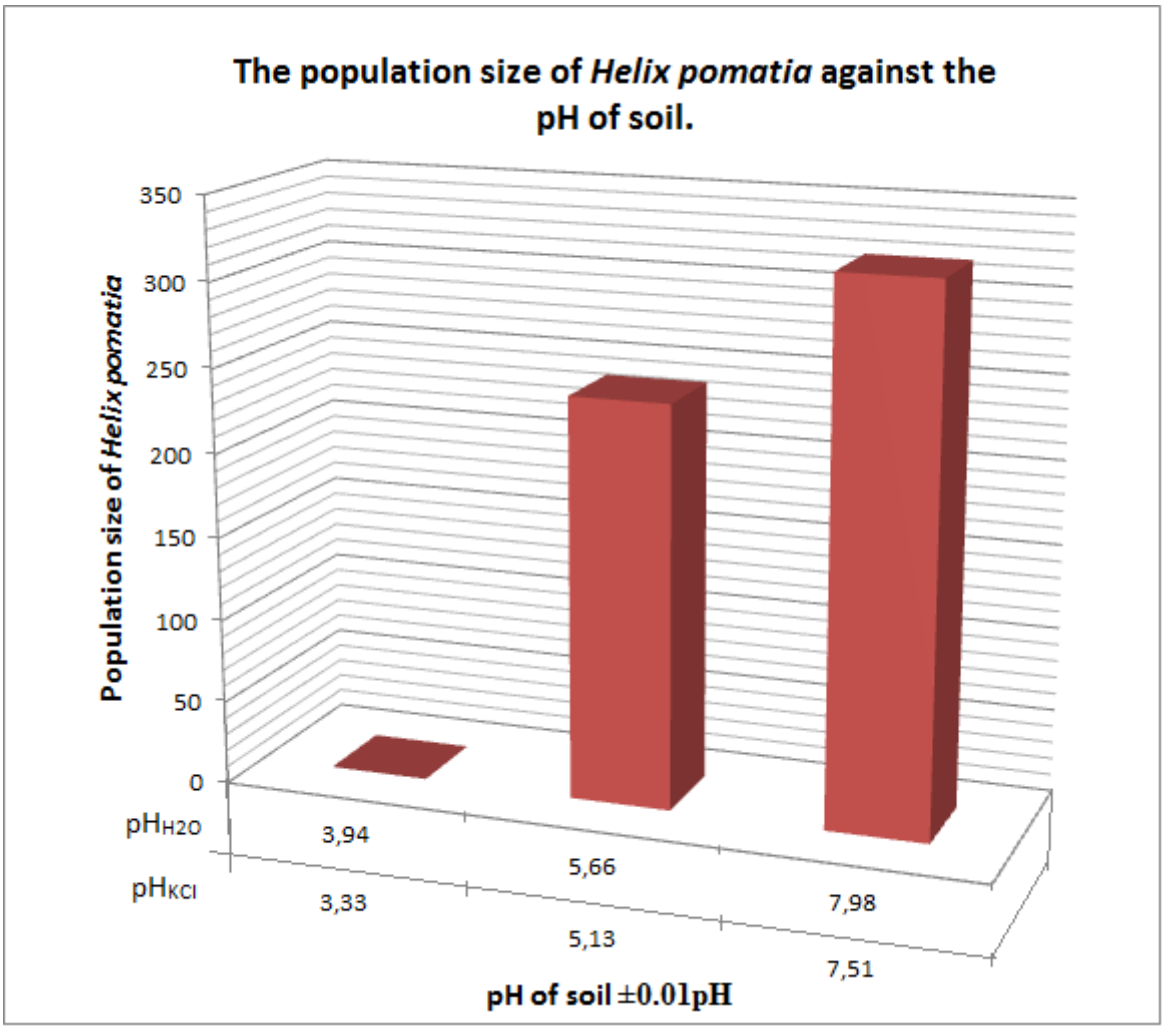
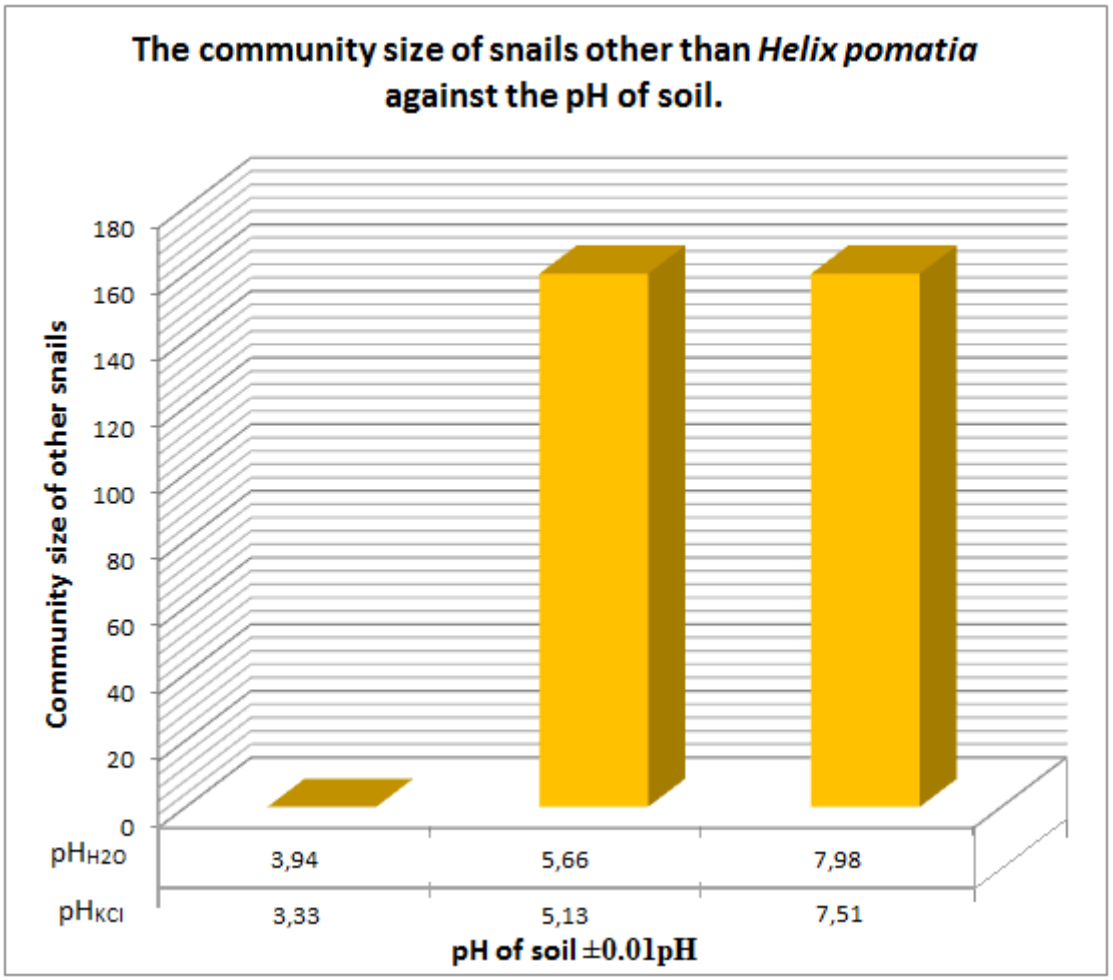


Fig. 2. The graph showing the community size of snails other than *Helix pomatia* against the pH of soil.



10.Data analysis

According to fig. 1 the biggest population of *Helix pomatia* (320 individuals) was found in "Zapusty" reserve, where the pH of the soil was the greatest (pH_{H2O} = 7.98, pH_{KCl} = 7.51); smaller population (240 individuals) – in "Święty Krzyż" reserve, where the pH was lower (pH_{H2O} = 5.66, pH_{KCl} = 5.13); not a single *Helix pomatia* individual was found in "Łysica", where the pH was the lowest (pH_{H2O} = 3.94, pH_{KCl} = 3.33). Referring to tables 1, 5 and 9 the most of the empty shells (both *Helix pomatia's* and other snails') was noticed in "Zapusty" and none in "Łysica". The presence of empty shells indicates how many individuals used to live on the area. According to the figure 2 in Łysica no other snails was found, whereas in "Zapusty" and in "Święty Krzyż" the same size (160 individuals) of the

other than *Helix pomatia* snails community was stated, however it has to be emphasised that only snails with size greater than 5mm were considered during the investigation.

There was also a difference in the colour of the *Helix pomatia* shells between individuals from "Zapusty" and "Święty Krzyż" reffering to tables 5 and 9 (this is also visible on picture 6 in the appendix). Generally in "Zapusty" *Helix pomatia* have lighter colour of the shell. This suggests that the composition of the matrix in individuals in those two locations differ owing to the fact that the colour of the shell depends on the type of proteins that snails' matrix consists of (Herczek and Gorczyca 2000).

Alkaline pH in Zapusty is mainly the result of the presence of limestone in the ground, which is composed of calcium carbonate. *Helix pomatia* during their growth need $CaCO_3$ to create a shell (Barga-Więcławska 2011) as well as some parts inside their bodies such as love dart or statocysts, therefore the more the calcium carbonate in the soil the more beneficial it is for snails, especially the ones with shells like *Helix pomatia*; however some scientists disagree and claim that since calcium carbonate is absorbed via nourishment, it is the containment of calcium carbonate in plants eaten by *Helix pomatia* that has a greater influence on the absorption of $CaCO_3$ than the quantity of this compound in the soil (Dzięczkowski 1988; Brehm 1968). On the other hand, plants absorb minerals from the soil so the type of plants growing in a particular area and the compounds they contain depend on the chemical composition and pH of soil. But calcareous ground has also other advantages apart from providing needed compound – such ground can gain heat faster and then keep it longer increasing the air temperature, which is very important as temperature of the environment is an essential factor contributing to snails' existence (Herczek and Gorczyca 2000, p 29; Brehm 1968, p 137).

"Łysica" and "Święty Krzyż" have similar environment; in both cases soil is based upon quartz sandstone and areas are located higher than "Zapusty" thus climate there is cooler with a greater amount of precipitation. In both locations pH of soil was acidic, but in "Święty Krzyż" it was higher. This may be caused by the fact that this reserve contains a built-up area and decaying buildings are the source of different compounds affecting soil, for example calcium carbonate and as it was stated earlier it is beneficial for snails and contributes to increase in the pH of the soil (Barga-Więcławska 2011). This fact may also explain such a great variation in pH of the soil within samples from "Święty Krzyż". The layer of leaf litter in "Łysica" was very thick, which may also be the reason for low pH there as many biological processes creating humus that occur within leaf litter result in production of acids. Jadwiga

Barga-Więcławska (2011) states pH = 4.5 as a critical value for snails to exist. pH in Łysica is much lower (pH_{KCl} = 3.33) and that is why no *Helix pomatia* individual as well as any other snail was found. In case of "Święty Krzyz" the other reason apart from higher pH (pH_{KCl} = 5.13) may influence the presence of *Helix pomatia*. This species may have been brought here by friars (Barga-WIęcławska 2011), because, as it was stated in the introduction, raising *Helix pomatia* near monasteries was a common practice in medieval time. Greater amount of precipitation in "Święty Krzyż" may result in greater humidity of that place and so be the factor contributing to the fact that only there any active (not closed in a shell with a layer of dry mucus) *Helix pomatia* individual was found.

Low pH means that there are more acids than alkali salts, so snails may have less calcium carbonate to absorb. Moreover acids can react with calcium carbonate and therefore may damage parts of snails. Statocysts and love dart are not exposed directly to the soil and calcareous part (ostracum) of the shell is under the periostracum so it is also protected from detrimental effects of exposure to the acidic soil. It has to be taken into consideration that *Helix pomatia* lay eggs with calcareous cover, burry them in the ground and they stay there for about a month. During that time the reaction may occur and damage the eggshells and thus stop the procreation. Adults *Helix pomatia* individuals also spend several months dug under the ground with the calcareous epiphragm on the aperture. If it was destroyed by the acid it would result in the death of the individuals as epiphragm protects them from cold and drying. This may lead to decrease in population size.

Another factor supporting my hypothesis is the result shown in figure 2. The size of the other snails' community is the same in "Zapusty" and in "Święty Krzyż" so the competition for *Helix pomatia* was the same in both locations. Taking this fact into consideration the role of pH of the soil seems to be more important.

The weather during the investigation was sunny and warm and there was no precipitation. It was dry and that is why almost all of the snails have shells closed with mucus cover. Also there was found a greater amount of empty shells than of living individuals and no slug was found. This is due to the fact that the activity of snails increases in the wet environment; when the humidity is high.

The presence of *Helix pomatia* in Świętokrzyskie Mountains was confirmed by Adolf Riedel (1988) and also recently by Jadwiga Barga-Więcławska (2011). The latter research showed the existence of *Helix pomatia* in "Zapusty" and in "Święty Krzyż", but not exactly in

the same place as in my investigation, however in a nearby location. This difference may be explained by the migration of the population.

Jadwiga Barga-Więcławska (2008, 2011) claims that the pH of the soil does have the effect on the existence of snails and their population sizes and that the greatest amount of species is found in the areas with pH of the soil ranging from 6.1 to 7.5. This thesis is confirmed by my investigation. She also emphasises the importance of presence of calcium carbonate. On the other hand Andrzej Dzięczkowski (1988) states that the type of soil has a tremendous effect on the snails' existence, however pH is not a dominant factor – the most important is humidity. He argues that it is the combination of many different environmental factors that has the greatest influence on the amount of snails in the area.

11. Conclusion

Taking everything into consideration it can be stated that pH affects the population size of *Helix pomatia*. Generally, the greater the pH the greater the population size of *Helix pomatia*. pH of the soil influences the existence of snails in both direct and indirect way. Directly, acidic pH may damage calcareous eggshells of the *Helix pomatia* offspring and protective epiphragm of adult individuals. In both cases it causes death of the individuals and reduces the population size. Indirectly, pH of the soil affects the nutrition of *Helix pomatia* as it determines the type of plants growing on the area and therefore basic pH is the most beneficial. Hypothesis is supported.

This investigation showed how strongly different components of environment are connected and that changing one of them may severely influence the others. It also confirms, from the malacological point of view, the importance of keeping "Święty Krzyż" and "Zapusty" reserves protected.

12. Evaluation

It is impossible to isolate only one factor that will be an independent variable when considering the field investigation. Because of that it cannot be stated with full convenience that pH of the soil influences the size of the population of *Helix pomatia* as it may as well be limited by a combination of different environmental factors. Although I was trying to keep other differences to minimum there were some variations, especially between "Zapusty" and other areas, for instance in climate. Therefore to reduce the influence of other environmental factors on the results of the investigation, more locations should have been investigated, at

least three locations with low pH (3.5-4.0), three with medium pH (5.5-6.0) and three with higher pH (7.5-8.0).

One of the main factors affecting the population size of snails is humidity and it was not controlled in this research so there is no data that will show whether the investigated locations differed by this factor and if so to what degree. It should have been measured by hygrometer.

To better understand the effect of the pH of the soil on the population size of *Helix pomatia* composition of the soil should have been investigated, especially calcium carbonate level as it influences pH and is an important component of *Helix pomatia's* body.

Taking into consideration other snails and their possible effect on the population size of *Helix pomatia* – it was difficult to determine because only snails greater than 5mm were considered and many species have smaller size. To count also these very small snails, soil from the whole area of each sample should have been sieved by using sieve with 0.5mm mesh.

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14. Appendix

Pic. 4. *Helix pomatia* in a natural habitat in „Święty Krzyż".

Pic 5. Dry mucus cover on the aperture of *Helix pomatia's* shell.

Pic. 6. *Helix pomatia* individuals; upper is from “Zapusty”, lower is from “Święty Krzyż”

Pic. 7. Random sample during research.

Pic. 8. Me during field investigation.

Pic. 9. Collecting soil samples.

Pic. 10.Measuring the pH of soil.