Donna Bilkovic Janet Walby August 9, 1992 General Ecology

INFLUENCE OF pH ON THE DISTRIBUTION AND ABUNDANCE OF FRESHWATER SNAILS

ABSTRACT

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We compared snail populations with pH as a limiting factor in two acidic and two alkaline lakes in Northern Michigan. We estimated populations by the depletion method to determine whether the snails differed in abundance and diversity. The two acidic lakes contained no snails as opposed to the basic lakes which had relatively large snail populations. No species overlap existed between these alkaline lakes. We concluded that pH was a limiting factor in snail distribution.

INTRODUCTION

The niche of a freshwater organism has many dimensions which include abiotic and biotic factors. "In freshwater environments, abiotic factors tend to overshadow biotic ones, especially in temperate climates (Aldridge1983)." The pH of surrounding freshwater can be one of these abiotic factors. "The pH of soil in terrestrial environments or of water in aquatic ones is a condition which can exert a powerful influence on the distribution abundance of organisms (Jewell 1929)." Freshwater snails need specific pH levels for the formation and development of the shell. The mantle of the snail, which is the skin that lies next to and underneath the shell, is responsible for making the shell. The mantle takes up fluids containing Ca++ and HCO3- from the body and external medium. The mantle's cells excrete Ca and H₃CO₃ to the extrapallial fluid. This fluid separates into two phases, one of which is the CaCO₃ shell (Figure 3), (Wilbur and Yonge 1964). "Under the conditions leading to acid accumulation...the CaCO₃ of the shell will act as a buffer. The result is an etching or erosion of the inner shell surface (Wilbur and Yonge 1964)." Based on the premise that pH levels will influence the development of snails, we propose to find different snail fauna and abundance when comparing acidic and basic lakes.

DESCRIPTION OF AREAS SAMPLED

We sampled four lakes in the Upper Penninsula that were known to have varying pH levels (N. Tuchman, pers. comm.). In this study we incorporated two acidic lakes, Johnson Lake (pH 4.46) and McNearny Lake

(pH 3.86), and two basic lakes, Piatt Lake (pH 7.08) and Carp Lake (pH 8.09), (Table 1). All of the lakes sampled had sandy bottoms and vegetation around the shoreline. Johnson Lake (T43N, R6W, Sec. 26) was a small lake (16 hectares) with few houses. There was guite a bit of vegetation around the shore and the sandy bottom included some black soil. McNearny Lake (T47, R5W, Sec. 32) was surrounded by homes and activity was apparent by the presence of the residents' boats. McNearny Lake was also one of the smaller lakes we sampled (50 hectares). The shoreline was surrounded by shrubs and soil deposits also existed on this lake bottom. Piatt Lake (T46N, R6W, Sec. 35) was relatively larger (102 hectares). Human activity at this lake was evident from the presence of houses and boats. Piatt Lake had sandy beaches and a unique feature in that it had adjoining ponds which flowed into the lake and were rich in lillies and weeds. Carp Lake (T44N, R6W, Sec.22) was surrounded by a sandy beach; this sandy substrate continued into the lake bottom. There were many rocks scattered across the bottom of this larger lake (137 hectares).

MATERIAL AND METHODS

We obtained a water sample from each lake in a 50 mL polyurethane

bottle. These samples were analyzed for calcium and pH levels by Michael Grant at the UMBS chemical lab. Both of us collected snails in a 10 x 5 meter guadrat at the same time to ensure that we thoroughly covered the quadrat. We scanned the quadrat and collected all snails found underneath lily pads and on the lake bottom in 15 successive five minute samples. Glass bottom buckets were used to increase visibility. The samples from each of the five minute intervals were counted separately and recorded to observe the successive depletion of the population. We proceded with this method twice at each lake. The above method describes the depletion estimate from which population estimates can be determined. This method consists of taking repeated sampling of a population so that a constant fraction of the remaining population will be taken in each sample. "This fraction can be estimated by regression of the number taken in ith sample (Y) against the total taken in all previous samples (X). The slope of the regression line is the estimate of the fraction of the remaining population taken with each sample. The X intercept of the line is the estimate of the total population size" (Zippin 1958). We estimated snail species populations for only the species in which we captured more than ten representatives were found. Also, we determined a snail population for the total number of snails found within

the quadrats. From these population estimates we found the mean of the samples captured on the two separate sample days.

RESULTS

From the water samples of each lake we found the calcium levels to be proportionally related to the pH levels (Figure 2). Mean population estimates for snails in Piatt Lake (pH 7.08, Ca=10.4 mg/L) and Carp Lake (pH 8.09, Ca=72.3 mg/L) were 491.71 and 201.38, respectively (Table 1 and Table 3). We found no snail fauna in either Johnson (pH 4.46, Ca=1.3 mg/L) or McNearney Lake (pH 3.86, Ca=0.8 mg/L) after searching each for 90 minutes (Table 1). Figure 1 displays differences between mean population estimates of the lakes. In Piatt Lake, the two most abundant species had mean population estimates of 322.89*Physella ancillaria* and 67.13 *Ferrissia paralleia*, (Table 2). *Amincola limosa*, population estimate=180.12, and *Valvata sincera*, population estimate=21.25, (Table 2) were the only two species for which population estimates were made at Carp Lake.

DISCUSSION

The effects of pH levels were most obviously seen in comparing Johnson Lake (ph 4.46) and McNearny Lake (pH 3.08) with the basic lakes, Piatt (pH 7.08) and Carp Lake (pH 8.09), (Figure 1). There was no snail species found in the acidic lakes while relatively large snail populations existed in the basic lakes. The trend of increasing snail fauna with increasing pH did not continue when comparing Piatt Lake with Carp Lake, (Table 1 and Table 3). Even though Carp Lake had a higher pH, it contained less snails than Piatt Lake. This may suggest that pH is determining the abundance or presence of snails when the lakes are highly acidic, but there may be no difference once a certain pH level is reached (Figure 1). Jewell (1929) found that "the most acid waters in which molluscs were found was pH 6.1 in case of snails and pH 5.7 for Pisidium. This approximates the point at which the deposition of lime shells would theoretically cease to be possible."

There was no species overlap in the quadrats or in the shells found on the beaches of Piatt Lake and Carp Lake . From the shells on the beach, we recovered and identified *Gyraulus Torquis circumstriatus* at Piatt Lake. At Carp Lake we found five other shells of species not already mentioned: *Stagnicola emarginata, Sphaerium simile, Sphaerium striatinum,* Planorbella Campanulata campanulata and Planorbella Pleisoma trivolvis. This suggests that species diversity varies proportionally with pH levels. "...the restriction of species to specific types of habitats is the general rule (Burch 1989)."

No snails were found in extremely acidic waters and snail species differed between the basic lakes; therefore, our data support the idea that pH levels do limit the abundance and distribution of freshwater snails. However, it is important to keep in mind the other dimensions of an organisms niche. As described earlier, calcium is important in the formation of a snail's shell. Calcium levels in the lakes will also have an effect on snail distribution and abundance. The calcium and pH levels rose proportionally in the lakes that we surveyed, (Figure 2). It would be difficult to exclude one factor in order to study the other. Calcium levels may have been the determining factor of snails presence instead of the pH level. Boycott (1934) also found in his survey that a number of molluscs do not live in freshwater below a specific calcium level.

Varying vegetation will also affect snail distribution. Piatt Lake contained more vegetation than Carp Lake. The ponds connected to Piatt Lake also provided this lake with more algae slime which freshwater snails eat (Boycott 1919). Aldridge (1983) found that "...food availability is an important determinant of snail distribution patterns." Water lilies also provide favorable habitats for snails. Boycott (1919) observed that water lilies afford particularly favorable nurseries for the eggs and young.

Temperature could also alter the abundance and distribution of freshwater snails. "Many animals, including molluscs, migrate downshore or into the sublittoral during the autumn...(Wilbur and Yonge 1964)." The size of the lakes can help determine the temperature. For example a smaller, and shallower lake will provide a snail with a higher temperature. At the same time, a smaller lake could also provide a snail with less vegetation and possibly make food and shelter limiting resources. All of the factors mentioned above influence the niche of freshwater snails, but we conclude that pH levels do play a significant role in determining snail distribution and abundance.

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FIGURE 1





APPENDIX

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11 0 216 46656 0 11 1 25 625 25 11 1 241 50081 241 12 0 216 46656 0 12 2 26 676 52 12 2 242 58564 484 13 1 216 46656 216 13 0 28 784 0 13 1 244 59536 244 14 1 217 47089 217 14 0 28 784 0 14 1 245 60025 245 15 0 218 47524 0 15 0 28 784 0 15 0 246 60516 0 TOTAL 218 2613 513455 19030 TOTAL 28 309 7389 328 TOTAL 246 2922 643742 24486 MEAN 14.5333333 174.2 MEAN 1.86666667 20.6 MEAN 16.4 194.8 922 643742	10	0	216	46656	0	10		25	825		10	0	241	58081	4/0
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13 1 216 46656 216 13 0 28 784 0 13 1 244 59536 244 14 1 217 47089 217 14 0 28 784 0 14 1 245 60025 245 15 0 218 47524 0 15 0 28 784 0 14 1 245 60025 245 15 0 218 47524 0 15 0 28 784 0 15 0 246 60516 0 0 0 15 0 246 60516 0 0 0 15 0 246 2922 643742 24486 MEAN 14.5333333 174.2 MEAN 1.86666667 20.6 MEAN 16.4 194.8 94.8 SLOPE -0.3251325 SLOPE -0.2430637 SLOPE -0.3144075 94.8 94.8 97.865727 97.865727 97.865727 97.97572 97.97572 97.977428 <t< td=""><td>12</td><td>0</td><td>216</td><td>46656</td><td>0</td><td>12</td><td></td><td>26</td><td>876</td><td>52</td><td>12</td><td>2</td><td>242</td><td>58584</td><td>484</td></t<>	12	0	216	46656	0	12		26	876	52	12	2	242	58584	484
14 1 217 47089 217 14 0 28 784 0 14 1 245 60025 245 15 0 218 47524 0 15 0 28 784 0 15 0 246 60025 245 15 0 218 47524 0 15 0 28 784 0 15 0 246 60025 245 TOTAL 218 2613 513455 19030 TOTAL 28 309 7389 328 TOTAL 246 2922 643742 24486 MEAN 14.5333333 174.2 MEAN 1.86666667 20.6 MEAN 16.4 194.8 SLOPE -0.3251325 SLOPE -0.2430637 SLOPE -0.3144075	13	1	216	46656	216	13		28	784	0	13	1	244	59536	244
15 0 218 47524 0 15 0 28 784 0 15 0 246 60516 0 TOTAL 218 2613 513455 19030 TOTAL 28 309 7389 328 TOTAL 246 2022 643742 24486 MEAN 14.5333333 174.2 MEAN 1.86666667 20.6 MEAN 16.4 194.8 SLOPE -0.3251325 SLOPE -0.2430637 SLOPE -0.3144075	14	1	217	47089	217	14		28	784	0	14	1	245	60025	245
TOTAL 218 2613 513455 19030 TOTAL 28 309 7389 328 TOTAL 246 2922 643742 24486 MEAN 14.5333333 174.2 MEAN 1.86666667 20.6 MEAN 16.4 194.8 SLOPE -0.3251325 SLOPE -0.2430637 SLOPE -0.3144075 Y-INTERCEPT 71.1714124 Y-INTERCEPT 6.87377882 Y-INTERCEPT 77.6465727 POP EST 218.899727 POP EST 28.2797428 POP EST 24.24187 MEAN POP EST 21.246187 MEAN POP EST 21.246187 MEAN POP EST 201.3787	15	0	218	47524	0	15	0	28	784	0	15	0	246	60516	
MEAN 14.5333333 174.2 MEAN 1.86666667 20.6 MEAN 16.4 194.8 SLOPE -0.3251325 SLOPE -0.2430637 SLOPE -0.3144075	TOTAL	218	2613	513455	19030	TOTAL	28	309	7389	328	TOTAL	246	2922	643742	24486
SLOPE -0.3251325 SLOPE -0.2430637 SLOPE -0.3144075 Y-INTERCEPT 71.1714124 Y-INTERCEPT 6.87377882 Y-INTERCEPT 77.6465727 POPEST 218.899727 POP EST 28.2797428 POP EST 28.2797428 MEAN POP. EST. FON TWO ANNEOLA SAMPLES 1800 11800 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES 21 246187	MEAN	14.5333333	174.2			MEAN	1.86666667	20.6	1		MEAN	16.4	194 8		
Y-INTERCEPT 71.1714124 Y-INTERCEPT 6.87377882 Y-INTERCEPT 77.6465727 POPEST 218.899727 POPEST 28.2797428 POPEST 246.981613 POPEST 21.246187 MEAN POP. EST. FOR TWO VALVATA SAMPLES	SLOPE	-0.3251325		_		SLOPE	-0.2430637	1			SLOPE	-0.3144075			
POPEST 218.899727 POPEST 28.2797428 POPEST 28.2797428 POPESTIMATE 246.961613	Y-INTERCEPT	71.1714124				Y-INTERCEPT	6.87377882				Y-INTERCEPT	77.6465727		-	
MEAN POP. EST. FROM TWO AMMICOLA SAMPLES 180 11808 MEAN POP. FRT. FOR TWO VALVATA SAMPLES 21 246187 MEAN POP. FRT. OF SMALL ARINDANCE IN CARP 201 37875	POPEST	218.899727				POP EST	28.2797428				POP ESTIMATE	246.961613			
	MEAN POP. E	ST. FROM TW	O AMNICOLA	SAMPLES	180.11808	MEAN POP.	EST. FOR TW	VALVATA S	AMPLES	21.246187	MEAN POP E	ST OF SNAIL	ABUNDANCE	N CARP	201.37675

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IST DAY SAMPLES OF PHYSA AND LIMPET					2ND DAY SA									
PHYSA ESTI	MATION #1				PHYSA ESTIMATION #2									
SAMPLE #	#/SAMPLE	TOTAL TAKEN	X*2	X•Y	SAMPLE #	#/SAMPLE	TOTAL TAKEN	X*2	X°Y	SAMPLE #	SNAIL/SM#1	TOTAL TAKEN	X*2	X*Y
1	37	0	0	0	1	41	0	0	0	1	58	0	0	0
2	32	37	1369	1184	2	34	41	1681	1394	2	47	58	3364	2726
3	31	69	4761	2139	3	32	75	5625	2400	3	42	105	11025	4410
4	30	100	10000	3000	4	32	107	11449	3424	4	39	147	21609	5733
5	29	130	16900	3770	5	35	139	19321	4865	5	36	186	34596	6696
6	28	159	25281	4452	6	26	170	28900	4420	6	29	222	49284	6438
7	19	187	34969	3553	/	25	196	38416	4900	<u> </u>	20	251	83001	5020
8	15	206	42436	3090	8	23	221	48841	5083	8	16	2/1	/3441	4336
9	16	221	48841	3536	9	1/	244	59536	4148	9	10	207	02309	4382
10	12	237	56169	2844	10	9	261	68121	2349	10	12	303	91809	3636
11	9	249	62001	2241		8	270	72900	2160	10		315	108078	1056
12	5	258	00504	1290	12	3	2/0	//284	1390	12	0	320	110270	884
13	2	203	70005	520	13	3	283	00008	049	13		332	111558	334
19		205	70225	205	14		200	01/30	200	14		334	112225	335
	0.07	200	570441	200	ТОТА	202	20/	676338	207	TOTAL	338	3472	970004	50341
MEAN	17.0	178 488887	5/8441	32130	MEAN	10.47	100 53	0/0320	07833	MEAN	37.27	369.67	0,0004	
SIODE	-0 1391700	170.400007			SIOPE	-0 1341649	180.33		· · · ·	SLOPE	-0 1649024	000.07		
VINTERCEDT	41 2018203				VINTERCEPT	45 0324123	1			V-INTERCEPT	98 2294701			
POPESTIMAT	310 120427				POPESTIMAT	335 650072	1	1		POP ESTIMATI	595 682478			
MEAN DOD F	STIMATE FOR	PHYRA	322 AA525			000.000072	•		<u> </u>					
Merat Por C			ULL.UUULU											
LIMPET EST	MATION #1				LIMPET EST	MATION #2		1						
SAMPLE	#/SAMPLE	TOTAL TAKEN	X*2	X•Y	SAMPLE #	#/SAMPLE	TOTAL TAKEN	X*2	X"Y	SAMPLE #	SNAIL/SM#	TOTAL TAKEN	X*2	X"Y
1	21	0	0	0	1	21	0	0	0	1	62	0	0	0
2	15	21	441	315	2	12	19	361	228	2	46	62	3844	2852
3	11	36	1296	396	3	15	31	961	465	3	47	108	11664	5076
4	9	47	2209	423	4	3	42	1764	126	4	35	155	24025	5425
5	7	56	3136	392	5	6	51	2601	306	5	41	190	36100	7790
6	1	63	3969	63	6	2	57	3249	114	6	28	231	53361	6468
7	1	64	4096	64	7	1	61	3721	61	7	26	259	67081	6734
8	1	65	4225	65	8	0	62	3844	0	8	23	285	81225	6555
9	0	66	4356	0	9	0	64	4096	0	9	17	308	94864	5236
10	0	66	4356	0	10	0	64	4096	0	10	9	325	105625	2925
11	2	66	4356	132	11	0	64	4096	0	11	8	334	111556	2672
12	1	68	4624	68	12	1	64	4096	64	12	6	342	116964	2052
13	0	69	4761	0	13	0	65	4225	0	13	3	348	121104	1044
14	0	69	4761	0	14	0	66	4356	0	14	1	351	123201	351
15	0	69	4761	0	15	0	66	4356	0	15	1	352	123904	352
TOTAL	69	825	51347	1918	TOTAL	61	776	45822	1364	IUTAL	353	3650	10/4518	55532
MEAN	4.6	55			MEAN	4.07	51.73			MEAN	23.53	243.33		
SLOPE	-0.3143001				SLOPE	-0.3156164	·			SLUPE	-0.1629431			
T-INTEHCEPT	21.8865037					20.396837	·			DOD CETIMAT	03.1/89481	· · · · · · · · · · · · · · · · · · ·		
PUPESI	09.0350953	1 11 10 5 7 0	07 4005		POPESTIMATI	04.6254004	Y			PUP. ESTIMAT	38/./30225		NOE OF PLAT	401 70005
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