An analysis of the microsnails from six habitats in the "Kochi Hill" area, Bernheim Arboretum and Research Forest, Bullitt County, Kentucky

by Harry G. Lee and Lori Schroeder

Abstract

Now in its third year, a land snail biodiversity study is being conducted in the Bernheim Arboretum and Research Forest (BARF), headquartered in Clermont, Bullitt County, Kentucky but covering some 14,000 acres in Bullitt and Nelson Counties (see Appendix: Map 1). This report focuses on a special collecting campaign within the study. It was designed to document abundance and diversity of microsnails (adult shells 5.5 mm or less) at a single location, "Kochi Hill," in the Bullitt Co. portion of BARF. We employed a strategy of studying duff samples taken from distinctly differing microhabitats within this small area, previously found to be unusually productive in numbers and diversity of mostly larger snail species. The results revealed the site to be a "biological hotspot" in terms of microsnail abundance (951 specimens identifiable to the species level) and diversity (31 species). Ecological implications of the qualitative and quantitative attributes of the data are discussed.

Key words: Bernheim; Bullitt County; biodiversity; ecology; Kentucky; land snails.

Introduction

Located in the Knobs region of Kentucky, "Kochi Hill" is a feature within the Bernheim Arboretum and Research Forest (BARF) on Harrison Fork Road in Bullitt County. The location was thus informally named after extraordinary numbers (44 total) of dead *Anguispira kochi* (L. Pfeiffer, 1846) Banded Tigersnail were found strewn about the hillside at the time of initial reconnoiter (7 June, 2009). Considering the abundance and biodiversity of land snails and their remains [18 species] found at that time, we determined a systematic re-collection of the site was advisable. This decision was based on three considerations: (a) since only visual reconnaissance was employed, microsnails were nearly excluded from the initial inventory (only two species found), (b) previous work had demonstrated a distinct synergy between duff sampling/microscopic examination and visual reconnaissance techniques in detecting biodiversity (Lee, 1990, 1993, 2008a, 2008b), and (c) differing microhabitats occur on and in the immediate vicinity of the hill. Consequently a strategy was employed to liberally sample and analyze duff from a variety of ecologically distinctive sites in the area in expectation of a much augmented biodiversity inventory and to allow analysis of possible microhabitat-microsnail species interplay.

Materials and Methods

Perched atop the southern end of a low ridge between Overalls and Wilson Creeks, "Kochi Hill" rises rather abruptly some 30 m and is capped by scarps of moss-laden limestone. Beginning at the base of the scarps a mature hardwood forest rapidly becomes dominant. The area included in the study was limited to somewhat less than an acre (see Appendix: Map 2). Due to heavy foliage during the summer months, fall was chosen as the optimal time for sampling.

All samples were collected by the junior author and Jeff Schroeder on 25 November, 2011. Six one gallon Ziploc™ bags were labeled and each filled with ample material from one of the following loci on and immediately adjacent to "Kochi Hill: (1) a limestone escarpment high on the slope, (2) a tree crotch downhill, (3) soil (paucity of leaves), (4) leaf litter roughly 2 m distant from the soil sample, (5) under decayed hardwood deadfall, and (6) a low grassy tract along Wilson Creek, a portion of which was particulate alluvial material (wrack). For further elaboration see Appendix: Figures 1-5.

Samples were processed by the junior author using a slight modification of the technique of Lee (1990, 1993): (1) drying of each sample in an oven set to 180° for 24 hours, (2) cooling for one or more hours at room temperature, (3) and sifting through a (2.2 mm square porosity) kitchen strainer to remove large objects such as rocks, stems, leaves, and nut hulls followed by a second sifting through a finer sieve (1.3 mm square porosity). It should be noted that, although an attempt was made to sample roughly equal volumes of material at the six sites, after the exclusion of material not clearing the 2.2 mm square sieve, apparently due in large part to the physical composition of the sample material, the remaining volumes differed somewhat: (sample 1: 700 mL; 2: 925 mL; 3: 550 mL; 4: 700 mL; 5: 500 mL; 6: 900 mL.

With the use of a stereomicroscope at 10-20X, shells and shell fragments of microsnails from each of the three subsamples (retained on sieve 1, retained on sieve 2, and that which passed through both) were segregated into no. 3 gelatin capsules. Two-dram clear glass vials were utilized for protection of the capsules thereafter. The relative homogeneity within each subsample improved the ease and efficiency of this culling process.

Subsequently the senior author reviewed the cullings by species using similar microscopy. Material too fragmented or otherwise degraded for species-level identification was discarded at this point. Identification was made by reference to a number of works (notably Pilsbry, 1940, 1946, 1948 and Dourson, 2011) as well to material in the Lee collection. All specimen lots are vouchered in the Lee collection.

Results

A total of 951 microsnails of thirty-one species in 111 lots were identified. The great majority were empty (dead) shells. Table 1 indicates the species identified; the number of specimens for each species appears in parentheses. Overall microsnail abundance varied widely, any species being represented by 1 to 199 specimens. Figure 1 demonstrates this species distribution graphically. Figure 2 shows the occurrence of species by sample site. Figure 3 demonstrates this distribution graphically.

Despite nearly equivolumetric sample sizes, disparate specimen richness (33 to 394) at each site can be seen in Table 2 and is graphically depicted in Figures 3 and 4. Much less variable was the species diversity by site (14-22), which is also indicated in Table 2 and graphically represented in Figures 3, 4, and perhaps best in Figure 5, where it is expressed as **percentage** of the sample.

Discussion

This dedicated search for microsnails produced prodigious numbers of specimens (951) and diversity (31 species); see Table 1. Corollary to this discovery is its complementarity with more traditional collecting methods, which target larger snail species. As anticipated, this combination of strategies

greatly enhanced the scope of overall land snail biodiversity at "Kochi Hill." Appendix Table 1 combines these 31 microsnail species with 22 others, only one of which is a microsnail, taken principally by visual surveillance. The product is a total of 53 species of land snails collected here from 7 June, 2009 to 25 November, 2011.

Another noteworthy attribute of the data is the relatively uniform level of species diversity across the six sampling sites (14-22 species per sample) despite the wide variation in specimen abundance (33-394); see Table 2. Corollary to this finding, and evidenced in Table 2 and Figures 3, 4, and 5, is the remarkable ubiquity of any single species across samples. Each species was found in an average of 3.3 of the six stations, and only seven species were unique to a single station. Interestingly, of the seven, all but two records reflect a single specimen, the exceptions being two shells of *Lucilla* cf. *nummus* and five of *Gastrocopta tappaniana* (both species in sample 6).

What difference does microhabitat make? While it certainly seems to influence the richness of microsnail abundance, its effect on species composition is far from obvious. The following analysis attempts to formulate an answer to the latter question, which is central to the design of this study, and for which Table 2 and Figures 1-4 are intended to help clarify.

Sample 1.
The expected salutary effect of surface calcium carbonate manifest at sample site 1, limestone escarpment, seems confirmed in this study, with nearly half the microsnail specimens found at this one site. Yet, if one is to remove the 147 specimens of *Carychium exile* from consideration, the differences are far less evident, and a statistical analysis would likely refute this correlation – at least with consideration of sites 2 and 3.

Of the 21 species found in sample 1, only one, *Gastrocopta corticaria*, represented by a single specimen, was unique to the sample. Ecologically, *G. corticaria* has been associated with the bark of hardwood trees since its original description (the species epithet means "of bark"), and, although it seldom occurs in great numbers, it has not been associated with limestone-rich habitats. The likelihood of its unique occurrence at site 1 may be considered as a stochastic (random) event. On the other hand, the finding of 77% of the specimens of *Hawaiia alachuana* in sample 1 not unlikely reflects the favorable influence of a calcium-rich microhabitat on this species, which was recognized as a calcphile by Hubricht (1985: 29).

The remainder of the species at site 1 (19) were shared with an average of 3.5 of the other five stations. Thus it is difficult to tease out any species that is strongly dependent on abundant calcium, an obligate calciphile

On the other hand, the absence of *Zonitoides arboreus*, which occurred, albeit in relatively small numbers, at all of the other five sample sites, two of which had relatively few microsnails, may well indicate this species' affinity for trees or wood (*arboreus* means "of trees") and/or disaffection for abundant calcium, a recognized attribute of calcifuge snails.

Sample 2.
The 18 species found at site 2, the tree crotch, were shared with an average of nearly four of the other five stations, and none of the sample 2 species was unique to the site. A close look at Table 2 fails to reveal evidence of any clustering by specimen count of species in this sample.

Sample 3.

Of the 20 species found in the sample taken at site 3 (soil sample with a paucity of leaf litter), none was unique, and each was shared with an average of 3.75 other site samples. A close look at Table 2 fails to reveal evidence of any clustering of species by specimen count in this sample.

Sample 4.
This sample (leaf litter) contained 22 species, the highest diversity of all six sites. Two snails, *Punctum blandianum* and *Glyphyalinia lewisiana*, were unique to this sample, but each was represented by only a single specimen. Of the remaining 20 species, each was found in an average of 3.5 other samples. Further, a comparison with sample 3, taken 2 m away in a leaf-poor microhabitat, shows a high concordance in species composition (18 in common). Two species were present in sample 3 not 4 and four in sample 4 not 3, but, of these six species, all but one, *Carychium exiguum* (two individuals in sample 4), was represented by only a solitary specimen . A close look at Table 2 fails to reveal evidence of any clustering of species by specimen count in this sample.

Sample 5.
The number of specimens found at this site (under hardwood deadfall) was relatively quite low but the species composition was high (33 shells of 14 species). No species was unique to this sample, and each was found in an average of 4.2 other samples. A single quantitative anomaly, a disproportionate frequency of the uncommon microsnail, *Zonitoides limatulus*, is noteworthy.

Sample 6.
The sample of grass and wrack near Wilson Creek had the most atypical composition of all six sites. Comprised of only 50 specimens, it had a relatively high diversity (16 species), and, most notably, contained four species not found at any other sampling site. Only three species in all the other 901 specimens distributed over five samples were thus unique. The Sample 6-only species (no. specimens): *Pupoides albilabris* (1), *Vallonia costata* (1), *Lucilla* cf. *nummus* (2), and *Catinella* species (1), although rare, are undeniably wed to this site only. Another species, *Gastrocopta tappaniana* (5), was represented by only one specimen in the remaining 901 shells. Each of these six species is recognized as preferring at least two of the attributes of this site: low, moist, relatively open, grassy, and disturbed (Hubricht, 1985).

In order to determine if there are actual ecological forces driving the distribution of the species whose shells were found during this survey, one must address two overarching considerations: (1) Is it correct to presume the shells found accurately represent the species that actually lived at the respective sites? Two principal factors bear on the legitimacy of this assumption: (a) Taphonomy: movement of the shells over space and time. Transport of shells by water drainage, wind, foraging animals, etc. can certainly rearrange a natural thanatacenosis (snail mortuary) in a confusing manner. (b) Persistence of the shells under natural conditions: how long has the average specimen been around? (2) To what extent do random forces (stochastic) forces shape the composition of our samples?

Admittedly a bit hazardous, in the interest of expedience, we have accepted assumption (1) above for Samples 1-5. Although the possible taphonomic forces of downhill displacement of shells may well have contributed to this homogeneity, on consideration of the **remarkable similarities in species composition** of these five samples, along with the **rarity of exceptional species occurrences**, the findings appear best explained by stochastic factors. The relatively few exceptions specifically cited above might be put to the test at a later date using different protocols, but it appears that ecological partition among these five samples (sites) played only a minor role in their species composition.

In interpreting the Station 6 fauna we must, however, confront the taphonomic issue of the constantly

running water of nearby Wilson Creek and the consequent delivery of shells from upstream origins to the sample site, especially the (unsegregated) wrack moiety, producing a biased sample. While there is no certainty that the shells of some of the four unique Station 6 species and *Gastrocopta tappaniana* naturally occurred there, it seem reasonable to consider that the case for at least the latter based on the species' well-documented preference for wet places including stream margins (*e.g.*, Hubricht, 1985: 9). As noted above, the five species are adapted to ecological conditions prevailing at the sample site and not characteristic of the other five sites.

It must be remembered that the study was driven by a quest for a more thorough biodiversity inventory. Limited ecological implications notwithstanding, the gathering of multiple samples and specifically the inclusion of grass and wrack along Wilson Creek (Station 6) certainly accomplished that aim. The contribution of the latter sample to overall diversity distinctly exceeded that expected from the habitat distinctions upon which the Stations 1 through 5 were based.

It is anticipated that a more focused sampling of the Wilson Creek bank, floodplain, and immediately adjacent uplands with limited tree cover but less moisture may provide further insight into land snail ecology in this relatively scarce habitat in BARF.

In retrospect the peninsular shape of "Kochi Hill," with two very long sides exposed to the elements, might not have been a landscape particularly hospitable to land snails and their collecting. The southern terminus, the area of the most focus of this report, is very near a road, albeit lightly traveled, which exhibits ample evidence of human impact some distance from its swath. The steepness of the terrain poses a challenge to collecting since gaining solid footing is not easy. These apparent detractions notwithstanding, the thriving land snail populations discovered in this somewhat disturbed yet reasonably accessible location has proven of significant interest and lends itself well to continued study.

Conclusions

A systematic sampling of the microsnails of a small area on and immediately adjacent to "Kochi Hill," BARF, Bullitt Co., KY succeeded in greatly augmenting the assessment of land snail biodiversity at the location. Despite strategic sampling of discrete microhabitats to test ecological interactions with the faunal composition, the microsnail species distribution generally conformed to a stochastic model. A noteworthy exception was one low streamside sample in which ecological factors were likely operative, but taphonomic forces may have introduced a certain bias.

Acknowledgments

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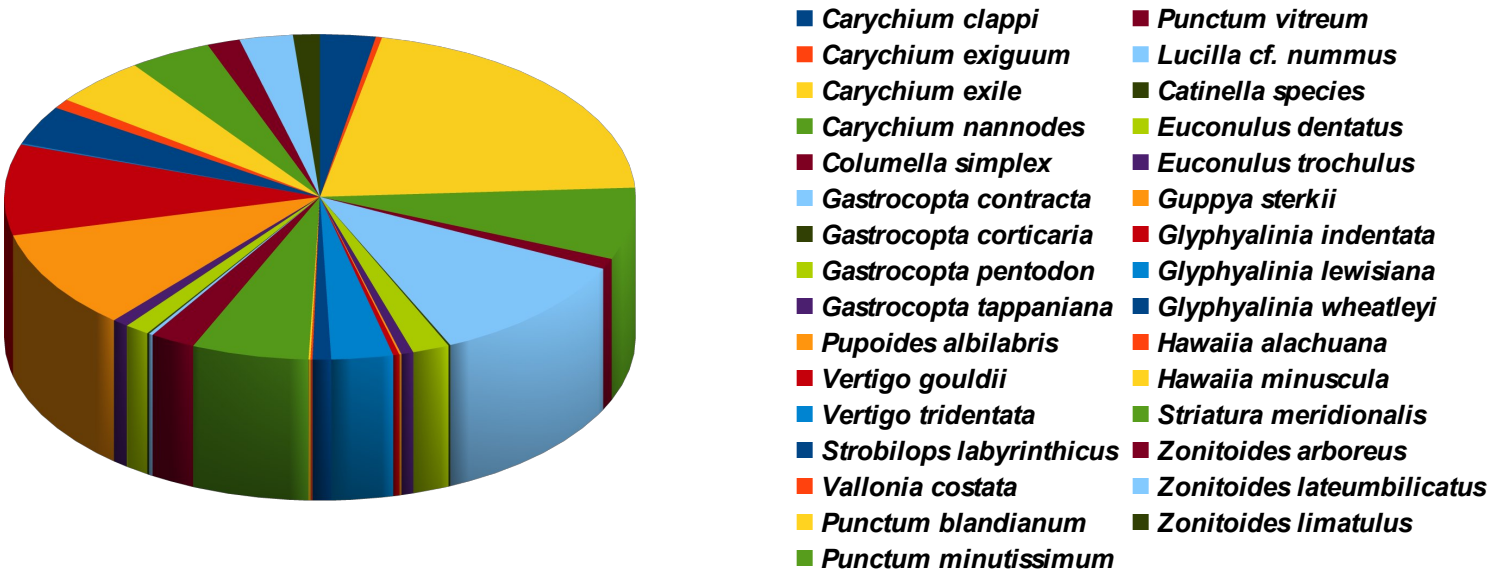
Table 1. The 31 microsnail taxa and individuals (951) collected.

Carychium clappi Hubricht, 1959 Appalachian Thorn (27)
Carychium exiguum (Say, 1822) Obese Thorn (3)
Carychium exile H.C. Lea, 1842 Ice Thorn (199)
Carychium nannodes G. Clapp, 1905 File Thorn (68)
Columella simplex (Gould, 1841) Toothless Column (10)
Gastrocopta contracta (Say, 1822) Bottleneck Snaggletooth (104)
Gastrocopta corticaria (Say, 1817) Bark Snaggletooth (1)
Gastrocopta pentodon (Say, 1821) Comb Snaggletooth (18)
Gastrocopta tappaniana (C.B. Adams, 1841) White Snaggletooth (6)
Pupoides albilabris (Say, 1821) White-lip Dagger (1)
Vertigo gouldii (A. Binney, 1843) Variable Vertigo (3)
Vertigo tridentata Wolf, 1870 Honey Vertigo (30)
Strobilops labyrinthicus (Say, 1817) Maze Pinecone (9)
Vallonia costata (Müller, 1774) Costate Vallonia (1)
Punctum blandianum Pilsbry, 1900 Brown Spot (1)
Punctum minutissimum (Lea, 1841) Small Spot (57)
Punctum vitreum (H.B. Baker, 1930 Glass Spot (22)
Lucilla cf. *nummus* (Vanatta, 1899) cf. Wax Coil (2)
Catinella species unknown Ambersnail (1)
Euconulus dentatus (Sterki, 1893) Toothed Hive (12)
Euconulus trochulus (Reinhardt, 1883) Silk Hive (8)
Guppya sterkii (Dall, 1888) Tiny Granule (94)
Glyphyalinia indentata (Say, 1823) Carved Glyph (86)
Glyphyalinia lewisiana (G. Clapp, 1908) Pale Glyph (1)
Glyphyalinia wheatleyi (Bland, 1883) Bright Glyph (37)
Hawaiia alachuana (Dall, 1885) Southeast Gem (9)
Hawaiia minuscula (A. Binney, 1840) Minute Gem (46)
Striatura meridionalis (Pilsbry and Ferriss, 1906) Southern Striate (40)
Zonitoides arboreus (Say, 1817) Quick Gloss (16)
Zonitoides lateumbilicatus (Pilsbry, 1895) Striate Gloss (26)
Zonitoides limatulus (A. Binney. 1840) Dull Gloss (13)

Table 2. Microsnail taxa and specimens collected by sample site.

	1. Limestone escarpment	2. Tree crotch	3. Soil sample	4. Leaf litter	5. Under deadfall	6. Creek & wrack
Carychium clappi	2	25				
Carychium exiguum				2		1
Carychium exile	157	1	16	12	2	11
Carychium nannodes	6	4	39	16	3	
Columella simplex	1		1	2	4	2
Gastrocopta contracta	37	13	15	31	2	6
Gastrocopta corticaria	1					
Gastrocopta pentodon	6	2	4	3	1	2
Gastrocopta tappaniana	1					5
Pupoides albilabris						1
Vertigo gouldii		2		1		
Vertigo tridentata	3		5	20		2
Strobilops labyrinthicus	3	1	1	4		
Vallonia costata						1
Punctum blandianum				1		
Punctum minutissimum	22	6	12	14	2	1
Punctum vitreum	1	1	9	10	1	
Lucilla cf. *nummus*						2
Catinella species						1
Euconulus dentatus	2		1	7		2
Euconulus trochulus		1	2	4	1	
Guppya sterkii	45	20	21	4	4	
Glyphyalinia indentata	35	13	19	8	4	7
Glyphyalinia lewisiana				1		
Glyphyalinia wheatleyi	7	7	8	13	2	
Hawaiia alachuana	7	1	1			
Hawaiia minuscula	31	8	5	2		
Striatura meridionalis	15	10	8	1	2	4
Zonitoides arboreus		2	3	8	1	2
Zonitoides lateumbilicatus	4	9	9	4		
Zonitoides limatulus	8		1		4	
Total specimens collected	**394**	**126**	**180**	**168**	**33**	**50**
Total species found	**21**	**18**	**20**	**22**	**14**	**16**
Species unique to substation	**1**	**0**	**0**	**2**	**0**	**4**

Figure 1. Overall microsnail abundance (all six samples); n = 951



Slices begin at noon and progress clockwise in customary phylogenetic order as per legend.

Figure 2. Microsnail abundance by sample; n = 951.

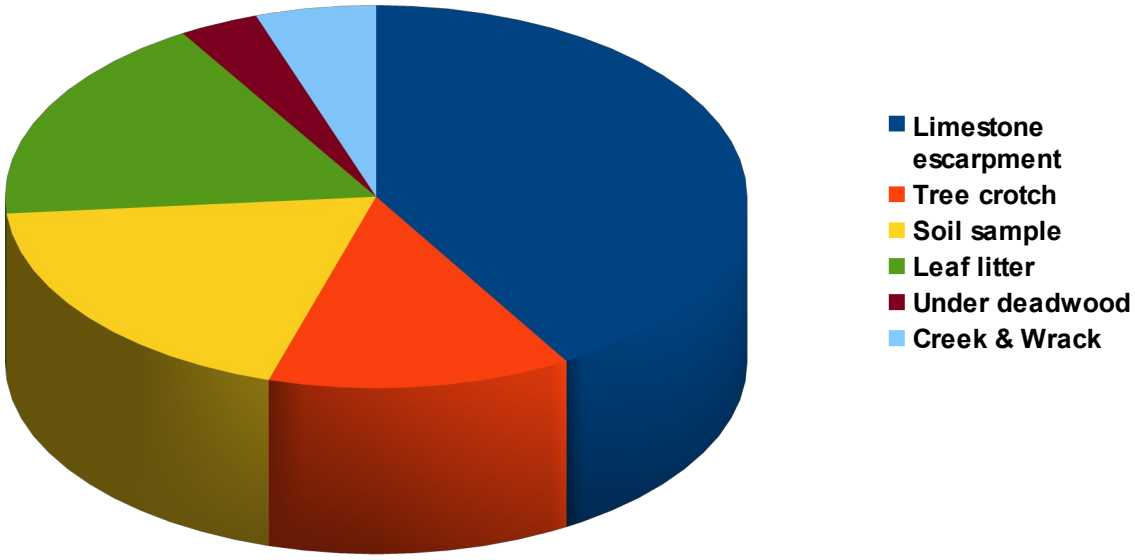


Figure 3. Microsnail species abundance showing contribution by sample.

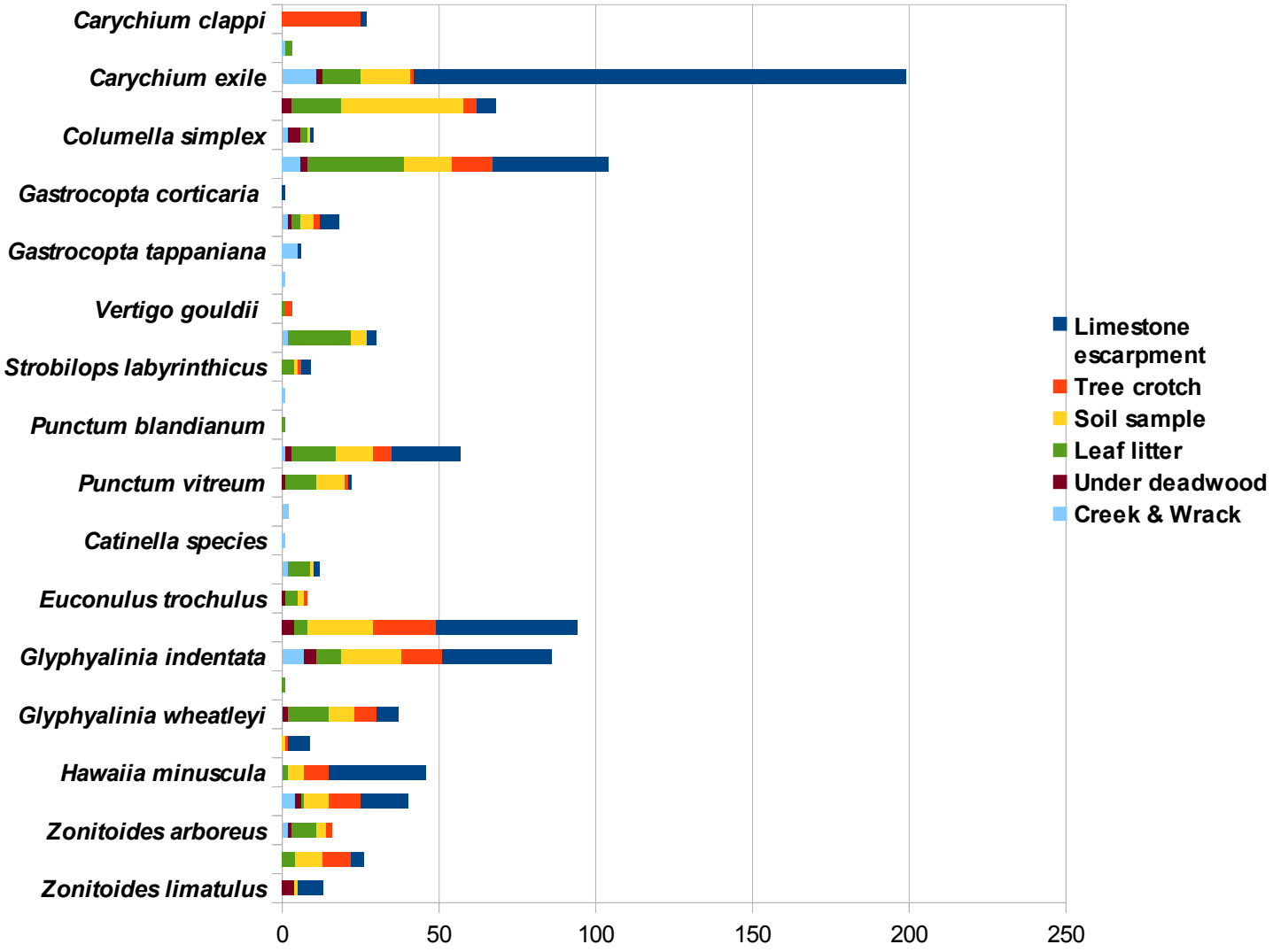


Figure 4. Absolute microsnail abundance by species for each sample.

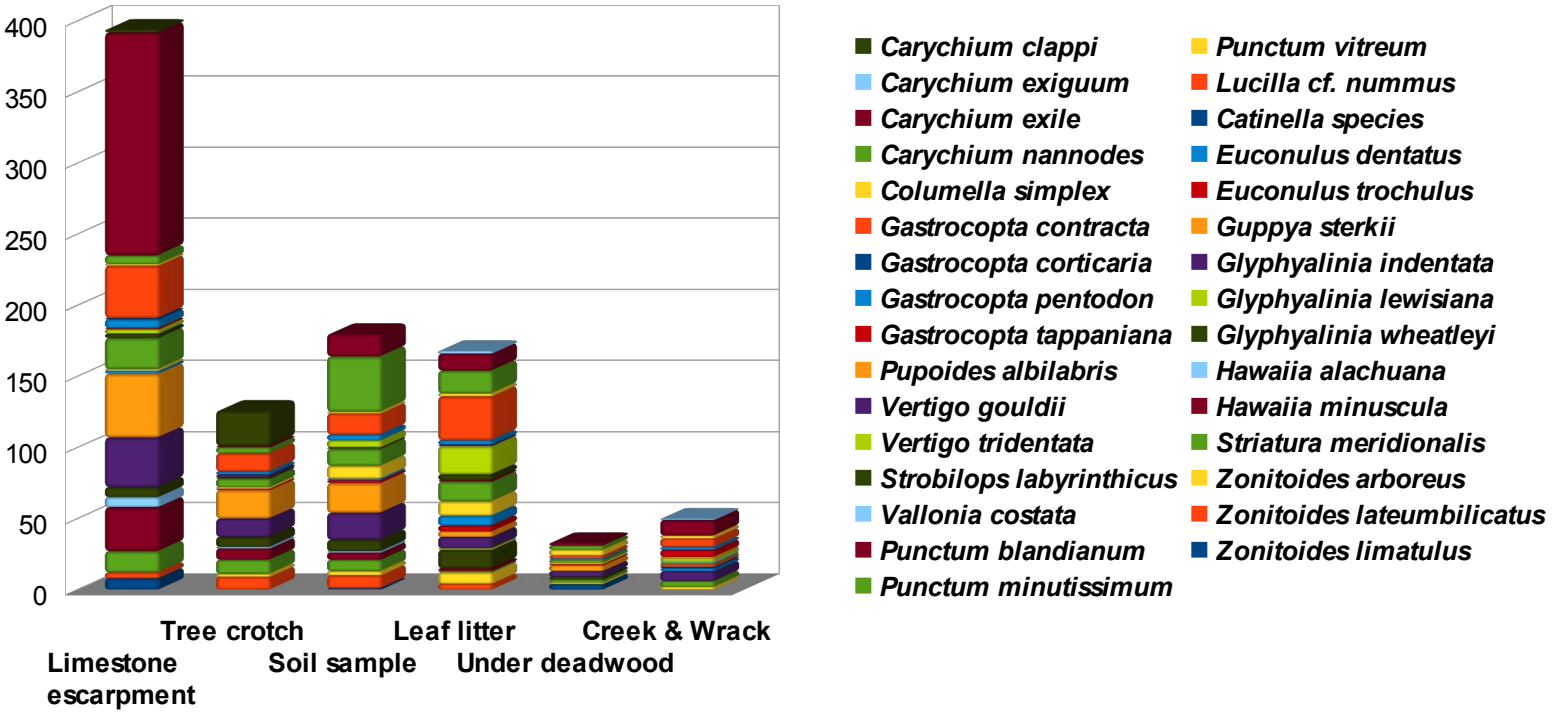
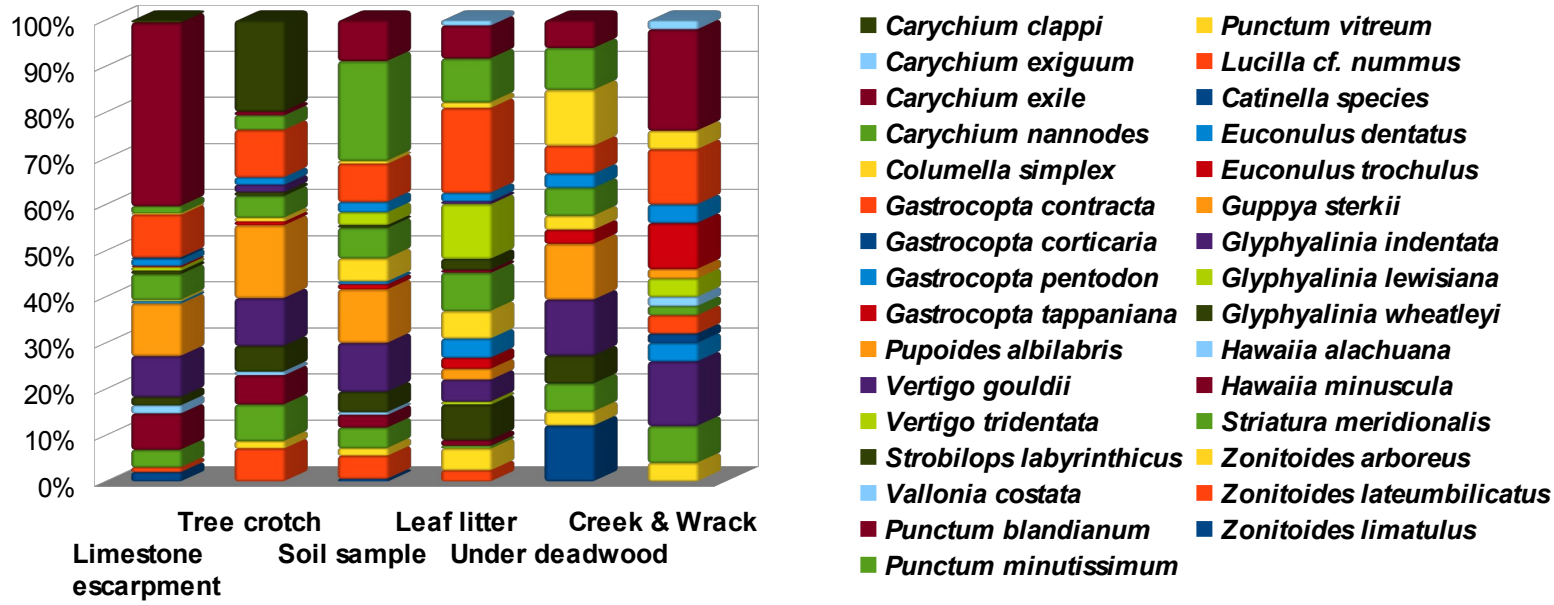
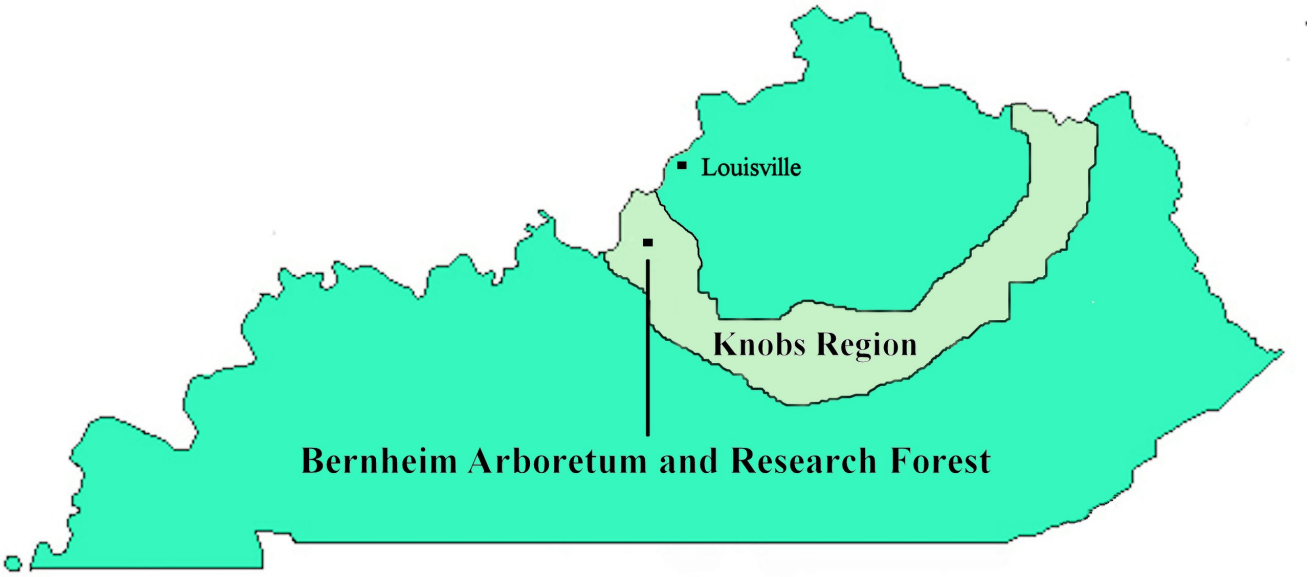


Figure 5. Relative microsnail abundance by species for each sample (as percent).

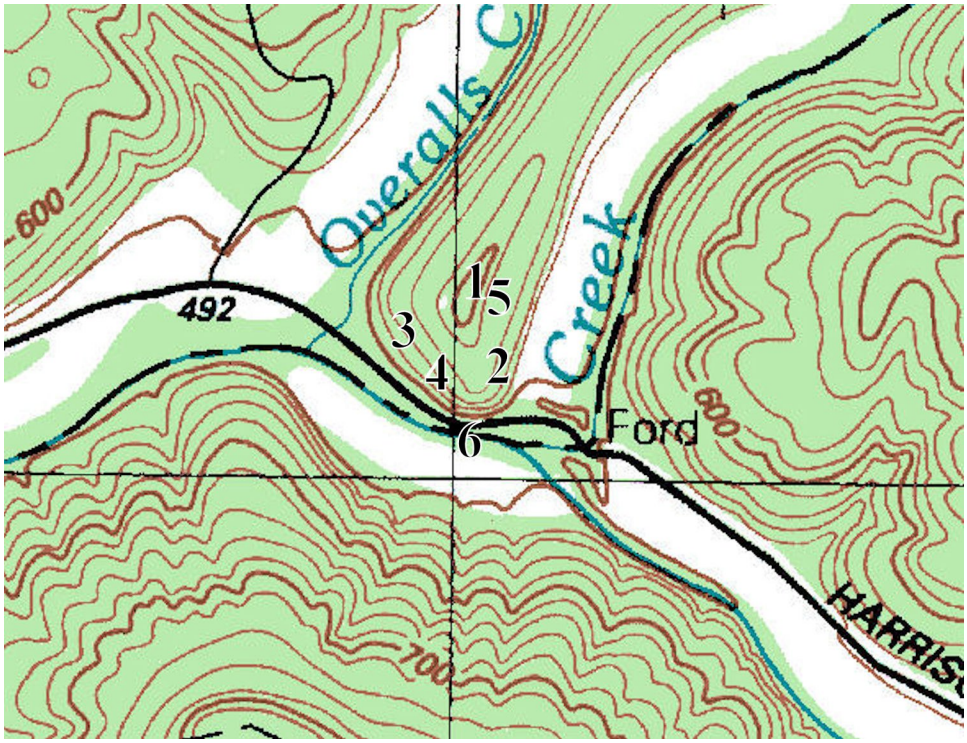


Appendix

Map 1. Location of Bernheim Arboretum and Research Forest in the Commonwealth of Kentucky.



Map 2. Location of sampling sites at “Kochi Hill.” Credit: Maps.google.com Topography View



Figures 1, 1a. Limestone escarpment at summit of “Kochi Hill.” Elevation about 30 m above road grade (sample site no. 1).

Figures 2, 2a. Tree crotch site, situated within a larger fallen tree (site no. 2).

Figures 3, 3a. Foot of “Kochi Hill.” Here both soil and leaf litter samples (sites nos. 3 and 4) taken in close proximity.

Figures 4, 4a. Deadwood just below limestone escarpment near summit of "Kochi Hill." A fresh *Mesomphix* species shell was uncovered when bark was lifted to obtain the sample (site no. 5).

Figures 5, 5a. View of Wilson Creek at site no. 6. The photo on left shows the close proximity of "Kochi Hill" (background, right). Another view looking in the opposite direction.

Table 1. Cumulative list (53 species) collected at "Kochi Hill," BARF from 7 June, 2009 to 25 November, 2011.

Pomatiopsis cincinnatiensis (I. Lea, 1840) Brown Walker
Pomatiopsis lapidaria (Say, 1817) Slender Walker
***Carychium clappi* Hubricht, 1959 Appalachian Thorn**
***Carychium exiguum* (Say, 1822) Obese Thorn**
***Carychium exile* H.C. Lea, 1842 Ice Thorn**
***Carychium nannodes* G. Clapp, 1905 File Thorn**
***Columella simplex* (Gould, 1841) Toothless Column**
***Gastrocopta contracta* (Say, 1822) Bottleneck Snaggletooth**
***Gastrocopta corticaria* (Say, 1817) Bark Snaggletooth**
***Gastrocopta pentodon* (Say, 1821) Comb Snaggletooth**
***Gastrocopta tappaniana* (C.B. Adams, 1841) White Snaggletooth**
***Pupoides albilabris* (Say, 1821) White-lip Dagger**
***Vertigo gouldii* (A. Binney, 1843) Variable Vertigo**
***Vertigo tridentata* Wolf, 1870 Honey Vertigo**
***Strobilops labyrinthicus* (Say, 1817) Maze Pinecone**
***Vallonia costata* (Müller, 1774) Costate Vallonia**
Haplotrema concavum (Say, 1821) Gray Lancetooth
***Punctum blandianum* Pilsbry, 1900 Brown Spot**
***Punctum minutissimum* (Lea, 1841) Small Spot**
***Punctum vitreum* (H.B. Baker, 1930 Glass Spot**
***Catinella* species unknown Ambersnail**
***Lucilla* cf. *nummus* (Vanatta, 1899) cf. Wax Coil**
Anguispira alternata (Say, 1817) Flamed Tigersnail
Anguispira kochi (Pfeiffer, 1845) Banded Tigersnail
***Euconulus dentatus* (Sterki, 1893) Toothed Hive**
***Euconulus trochulus* (Reinhardt, 1883) Silk Hive**
***Guppya sterkii* (Dall, 1888) Tiny Granule**
***Glyphyalinia indentata* (Say, 1823) Carved Glyph**
***Glyphyalinia lewisiana* (G. Clapp, 1908) Pale Glyph**
***Glyphyalinia wheatleyi* (Bland, 1883) Bright Glyph**
***Hawaiia alachuana* (Dall, 1885) Southeast Gem**
***Hawaiia minuscula* (A. Binney, 1840) Minute Gem**
Mesomphix cupreus (Rafinesque, 1831) Copper Button
Mesomphix globosus (MacMillan, 1940) Globose Button
Mesomphix vulgatus H.B. Baker, 1933 Common Button
Paravitrea cf. *capsella* (Gould, 1851) Dimple Supercoil
***Striatura meridionalis* (Pilsbry and Ferriss, 1906) Southern Striate**
Ventridens ligera (Say, 1821) Globose Dome
***Zonitoides arboreus* (Say, 1817) Quick Gloss**
***Zonitoides lateumbilicatus* (Pilsbry, 1895) Striate Gloss**
***Zonitoides limatulus* (A. Binney. 1840) Dull Gloss**
Allogona profunda (Say, 1821) Broad-banded Forestsnail
Euchemotrema fraternum (Say, 1824) Upland Pillsnail
Inflectarius inflectus (Say, 1821) Shagreen
Mesodon thyroidus (Say, 1817) White-lip Globe
Mesodon zaletus (A. Binney, 1837) Toothed Globe
Neohelix albolabris (Say, 1817) Whitelip
Stenotrema angellum Hubricht, 1958 Kentucky Slitmouth
Stenotrema barbatum (G. Clapp, 1904)/*S. hirsutum* (Say, 1817) Bristled/ Hairy Slitmouth
[single immature shell denuded of periostracum; ID limited to two taxa]
Stenotrema stenotrema (L. Pfeiffer, 1842) Inland Slitmouth
Triodopsis vulgata Pilsbry, 1940 Dished Threetooth
Xolotrema denotatum (Férussac 1821) Velvet Wedge
Xolotrema obstrictum (Say, 1821) Sharp Wedge
Microsnails in black (32), **boldface this study (31)**; non-microsnails in red (21).