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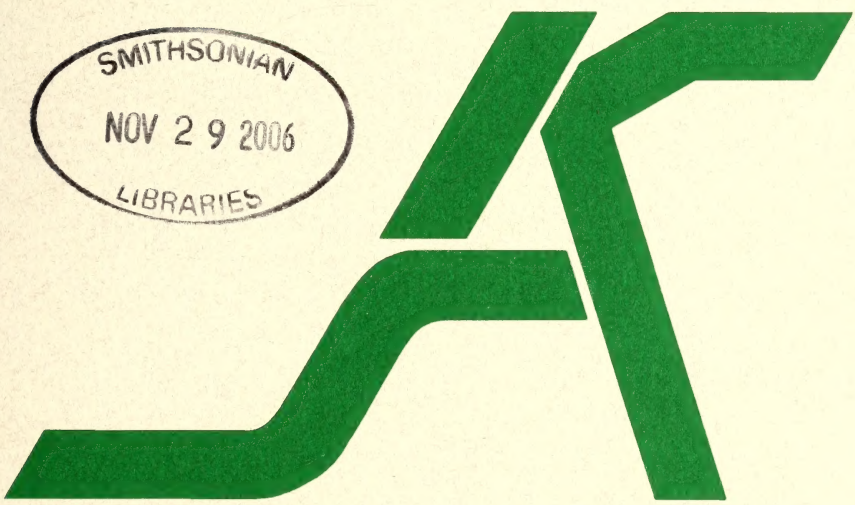

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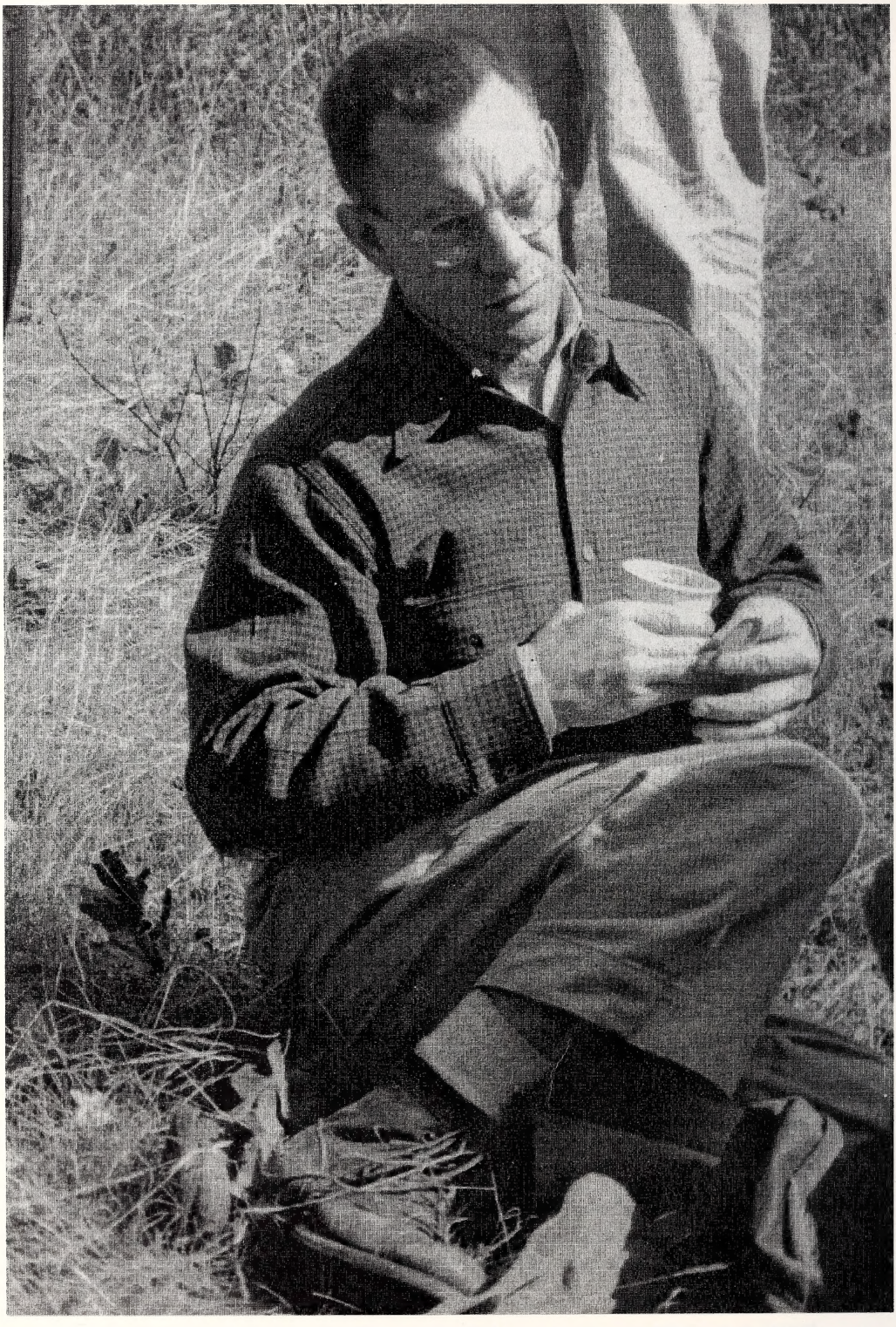

Figure 1. Dr. John C. Goodlett in the field at the Harvard Forest ca. 1957.

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John C. Goodlett (1922–1967), Botanist, Plant Geographer, and Teacher

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Some native Kentucky scientists, e.g., Thomas Hunt Morgan and Nathaniel Shaler, are better known for their research and other accomplishments outside rather than inside the state. Botanist and plant geographer John Campbell Goodlett (Fig. 1) was another of those individuals. Goodlett was born 1 May 1922 in Lawrenceburg, Anderson County, in the Bluegrass Region of Kentucky. Lawrenceburg, then, as now, was a small rural community ca. 12 miles south of Frankfort, the state capitol. John was the youngest child, by seven years, to two brothers and one sister. His father, Robert, was the county clerk and his mother, Martha, was a homemaker.

At an early age, John acquired the nickname "Pud," that he affectionately would be called for the rest of his life. His early education was in the Lawrenceburg public schools. He was recognized as an outdoorsman even as a young boy because of the time he spent roaming the forests and fields throughout the county, especially those in the vicinity of Salt and Kentucky rivers. While still a teenager, he and a schoolmate built a rustic cabin near Salt River; the chimney and scattered remains of that building were still evident in 2005. Pud kept a detailed journal of the flora and fauna of Anderson County, especially those that he observed at the Salt River camp.

Pud graduated from Lawrenceburg High School in 1940 near the top of an exceptionally talented class. He enrolled at the University of Kentucky in fall and began life as a college student. By the middle of his sophomore year, the United States entered World War II. Goodlett was enrolled in the ROTC program and at the end of his junior year was drafted into the U.S. Army. Following 6 weeks of basic training, he was commissioned a second lieutenant. He was an infantryman, and along with his unit, he moved across Europe with Patton's army. His unit was one of the first to see the opening and horrors of the concentration camps. Following the German surrender in 1945, Goodlett, now a first lieutenant, was in command of a bakery company in Pilsen, Czechoslovakia that provided 700,000 pounds of bread weekly to occupation troops. Although he regarded war as a "gruesome experience," he had some fond memories of his time with this Company, especially his early morning visits to the bakery where he would eat the fresh baked bread with butter. Although he did not talk much about his wartime experiences, these apparently left an indelible mark on him; later he became a student of war and wars. He had always been an avid reader, but now especially of books by Hemingway, and about the Civil War and wars in general.

After his discharge from the army, Goodlett returned home to Lawrenceburg and in fall 1946 began his senior year of college at the University of Kentucky. Dr. Thomas D. Clark (1982); a history professor at the University of

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Kentucky at that time, noted the great avalanche of returning veterans after the end of WWII. "Never before were universities so overrun by so many mature students demanding better instruction. State universities, and many of the better private schools as well, began offering work leading to the doctorate. There was begun a search far afield for promising candidates to fill the newly organized graduate lecture courses and seminars."

Brokaw (1998); referring to these returning GIs as members of America's Greatest Generation, wrote "men and women who immediately began the task of rebuilding their lives, and the world they wanted. They were mature beyond their years, tempered by what they had been through, disciplined by their military training and sacrifices. They married in record numbers and gave birth to another distinctive generation, the Baby Boomers. They stayed true to their values of personal responsibility, duty, honor, and faith.

They became part of the greatest investment in higher education that any society ever made, a generous tribute from a grateful nation. The GI Bill, providing veteran tuition and spending money for education, was a brilliant and enduring commitment to their nation's future. Campus classrooms and housing were overflowing with young men in their mid-twenties. They left those campuses with degrees and a determination to make up for lost time. They were a new kind of army now, moving onto landscapes of industry, science, art, public policy, and all fields of American life, bringing to them the same passions and discipline that had served them so well during the war.

John C. Goodlett exemplified the men of that Greatest Generation. Not only did he use the GI Bill to complete the B.S. in Biology that he had started in 1940, he graduated Phi Beta Kappa in spring of 1947. He received a teaching fellowship at Harvard University for fall 1947 and later that year married his hometown sweetheart, Mary Marrs Board. While at Harvard, he came under the influence of Dr. Hugh M. Raup, Director of the Harvard Forest. Also, the student John Goodlett was exposed to challenging teachers and coursework. One course, in particular, an interdisciplinary seminar team taught by Professors Raup (botanist), Bryan (geologist), Movius (anthropologist), and Brooks (climatologist) had a profound impact on his career and future research endeavors. This seminar attracted graduate students from a number of disciplines and viewpoints. Goodlett began to realize that there were different ways of looking at a situation and that there may be more than one answer to a question. Thereafter, he would often collaborate with scientists from other fields, especially geologists and soil scientists, in an effort to gain a more thorough understanding of a research problem.

Goodlett received his A.M. in 1949 and immediately, starting in summer 1949, began the pursuit of his doctorate with Dr. Hugh M. Raup through the Harvard Forest. He began a research study of vegetation adjacent to the glacial border in Potter County, Pennsylvania. He worked closely with Dr. Charles Denny, a geomorphologist with the U.S. Geological Survey (U.S.G.S.), and K.V. Goodman, a soil scientist with the Soil Conservation Service (S.C.S.).

After receiving his Ph.D. in 1951, Dr. Goodlett joined the staff of the Harvard Forest as a research associate. This was a fortunate career move because it gave him time to carry out a number of research projects, expand his reading, work with graduate students on their projects, and hone his writing skills. His dissertation, Vegetation Adjacent to the Border of the Wisconsin Drift of Potter County, Pennsylvania, was published as Harvard Forest Bulletin 25 (Goodlett 1954). In 1955 Dr. Goodlett was given the title of forest geographer and lecturer in forest biology in recognition of the high quality of his work thus far. During that summer and again in 1956 he worked in the Central Appalachians of Virginia with the geologist John T. Hack for the U.S.G.S. Their time in the field involved encounters with rattlesnakes and unfriendly black bears. Goodlett pioneered a field technique for recognizing vegetation based on the presence or absence of key indicator species (Hack and Goodlett 1960). While in the Virginia area, much of his nonresearch time was spent visiting and walking Civil War battlefields.

In the summers of 1958 and 1959, Dr. Goodlett worked at Death Valley, California for the U.S. G.S. For 12 years, Goodlett had been guided and mentored by Dr. Raup at the

Harvard Forest; however, in 1959, he was recruited by Dr. M.G. Wolman for a plant geography position at Johns Hopkins University (JHU). Wolman had known Goodlett since their graduate school days. Raup hated to lose Pud, but he recognized that Dr. Goodlett was probably just entering his most productive years and that publications, some based on research already completed, were forthcoming. Raup considered Dr. Goodlett's most outstanding qualities were, first, the clarity and sharpness of his intellectual processes, and, second, his ability to express the results in writing. Regarding the latter, Raup wrote that, "There is often a paradoxical contrast between his spoken and his written English, for he commonly speaks the curious dialect of central Kentucky."

Raup regarded John Goodlett as both a "florisitic" plant geographer and an "ecological" one. Raup noted that there was a rather sharp division among American plant geographers between those who hold to the "species" of plants as the basic units of study and those who renounced the species in favor of units variously called "plant communities," "plant associations," and the like. Most plant geographers who have been trained in American schools have been brought up under the second of these systems, which has dominated. Through the years, however, serious failings have emerged in it. Raup was describing the Individualistic Concept (Gleason 1926, 1927, 1939) and the Organismic Concept (Clements 1916, 1936). Dr. Raup considered Goodlett to be one of the few, and perhaps the best, of the young plant geographers with the perquisite training, or patience and interest, to go back and pick up the essential threads of knowledge and skill in floristic geography to make themselves proficient in it. Dr. Goodlett is skilled in floristic and ecological geography, but sees and evaluates them in historical perspective as well as terms of his immediate research interests.

Raup also observed that Dr. Goodlett "seems to have a well-nigh instinctive knowledge of the way students think, and of what they must go through in order to reach understanding of their problems. He does not drive them, rather, he leads them, gently, but rigorously."

In fall 1959, the 37-year-old Goodlett was brought to JHU as visiting lecturer in the Department of Geography. True to Raup's prediction a number of publications began to appear. Also, perhaps because of his excellent writing skills, Dr. Goodlett was appointed associate editor of *Ecological Monographs,* a position he would hold from 1959 to 1962.

In 1960, Dr. Goodlett was appointed associate professor in the Department of Geography and he settled into the life of a college professor, husband, and father. His two daughters, Virginia and Sallie, had been born in 1957 and 1959. In addition to plant geography, Goodlett taught economic botany. His teaching style was informal and he often used the seminar approach. Although he appeared to have a low-key attitude, he was observant, analytical, and a good judge of people. His insight may have helped the department maintain its interdisciplinary approach and high level of productivity. The Department of Geography was small and the students and faculty worked closely together. There was an open atmosphere for new ideas. Faculty get-togethers often involved open discussions of current events, e.g., the Cuban missile crisis. True to his Kentucky heritage, Pud enjoyed these get-togethers, especially with a glass of bourbon.

Like so many other professors, Goodlett always hoped to get more writing and research completed than he did, but he noted that "my open door policy with students is ruining me. I get almost no work done." However, he stated that, "unfinished reports, though they haunt me, do not stop me from rash new beginnings."

Goodlett, the teacher and mentor, always seemed to keep the interests of his students first and that is why he often sent his students to the Harvard Forest to take basic science courses or seminars. This was something that he resented having to do, especially when he felt that these could have been offered at JHU. On several occasions, he and a few other faculty members had hopes of improving the department by adding a zoogeographer, a pedologist, a geologist, or a non-urban economist, however, he recognized that the department probably would end up with another city planner instead. He preferred that his students gain a strong interdisciplinary view of geography, grounded in geology and biology,

but feared that "geochemistry and geophysics were doing to geology what DNA has done to biology."

He was concerned that too often the students in his classes had not been exposed to enough field trips, or experiences, and he tried to arrange as many trips as possible, especially in an effort to improve student observational skills. In fact, Dr. Goodlett, his colleagues, and students developed what they termed, "Four Rules of Field Work":

1. Water, generally, runs downhill. There might be some rare exceptions, but this was an essential landscape process.

2. Plants occur where you find them. This requires that a person must get into the field to see the plants. The questions of why they occur where they do can then be asked and investigated.

3. Never get separated from your lunch. Time in the field is too valuable for a person to waste for any reason.

4. Never go back the same way you came. It helps to get another view or perspective.

Common sense, and a sense of humor, were essentials for John Goodlett. He found it a good practice always to visit the local general store, or other gathering place, in the area where he planned to conduct field work. That allowed him to become familiar with the local people and for them to get to know him and what he was doing. He always learned a great deal from those encounters.

Goodlett was appointed full professor at JHU in January 1967. He had applied for and had been granted a sabbatical to return to the Harvard Forest for fall 1967. However, on 1 April 1967, one month shy of his 45th birthday, Dr. Goodlett died of a massive heart attack. His body was returned to Kentucky for burial in the Lawrenceburg Cemetery. His pall bearers were all friends, mostly from his childhood, and his home town.

At the time of his death, Goodlett's research mostly had been in New England but had been expanding as far south as Georgia and as far west as Death Valley, California and Mt. Rainier, Washington. Early in his career, he may have entertained notions of research in western Kentucky, but, those never materialized. After Christmas 1951, Pud wrote his mother, "Don't write us off as permanent residents of the north. We belong in the South, and that's where I need to do a lot of work. We need a lot of botanizing in Kentucky. Maybe someday the South will be willing to pay for pure research like the northeast." That someday never came for Dr. Goodlett, and his yearly visits to Kentucky were essentially family visits. He had supervised two dissertations, one on vegetation in Michigan and the other on vegetation in Arizona and was currently mentoring a third. He had several manuscripts in various stages of completion.

What was the impact of Dr. John C. Goodlett's life and career? In my opinion there are several areas that stand out. First, was the collaborative research for which he was extraordinarily successful. This began as a graduate student (Goodlett 1954, 1956; Denny and Goodlett 1956) and was an approach that he encouraged for his own students. Goodlett collaborated with the palynologist Margaret Davis on the comparison of pollen spectra with existing vegetation in northern Vermont (Davis and Goodlett 1960); with the geomorphologist John Hack in western Virginia (Hack and Goodlett 1960); with Charles Denny and W. H. Lyford of the S. C. S. in the upper Susquehanna region of Pennsylvania (Goodlett and Lyford 1963); with Lyford and W. Coates in the mapping of forest soils in the Harvard Forest (Lyford, Goodlett, and Coates 1963). Raup observed that the high levels of productivity in each of these cases rested not merely upon the fusion of technical proficiencies, but rather upon the ability and willingness of the people concerned to find conceptual levels in their respective fields at which there was a common ground. They could then state problems in mutually significant terms, and genuine collaboration could be achieved.

Second, was the development of site concepts at the Harvard Forest and their impact on management policy (Goodlett 1960). This publication gives a critical review of a great mass of research that had been done there on forest site evaluation and then places it in perspective with relations to the whole field of site studies in northeastern United States in the same period. Nothing so searching as this paper had ever been written about American forest site problems.

Third, 20 and 25 years after the publication of Goodlett's (1954) paper, Wright (1974) and Bormann and Likens (1979a, 1979b) respec-

tively, cited that paper as one that clearly documented the effects of wind and microrelief on forest development. Wright (1974) recognized windstorms as a major disruption renewing succession. He pointed out that Goodlett's study of mound microrelief in a forest in Pennsylvania showed that the presence of white pine is related to the incidence of wind throw of old hemlock trees. Bormann and Likens (1979a, b) used that study to show the importance of windstorms in maintaining shade intolerant species in the pre-settlement northern hardwood forest.

Fourth, Wright (1974) specifically singled out the Hack and Goodlett (1960) paper as an outstanding example of the dynamic equilibrium. Wright wrote that the pattern of the vegetation that Hack and Goodlett studied in the Shenandoah Valley of Virginia was a definite polyclimax. This interpretation is supported by detailed geomorphic work, which shows the sensitive response of certain tree species to moisture, slope, and soil conditions. Ridge crests and noses are characterized by pitch and table mountain pine, ravines by yellow birch, basswood, and sugar maple, and intermediate slopes by the absence of these species and the presence of certain oaks. Their study shows the dynamic equilibrium between geomorphic processes and vegetation (Wright 1974).

Hack and Goodlett (1960) wrote, "The writers believe that the present distribution of vegetation can be accounted for largely in terms of present relations of component species to environments, and that environments can be accounted for largely in terms of geomorphic processes acting at the present time. The physiological basis for coincidences observed between species and environments are unknown. The origin of the present relations of species to environments constitutes a knotty problem in the evolution of physiological responses, which can hardly be solved by the methods of physiological ecology."

This led Goodlett and some of his contemporaries to organize an informal group that they called the "Here and Now Society." His background in glacial processes and their recent impact on landscapes and vegetation forced him to disagree with the interpretations of Braun (1950) regarding forest development in the Eastern United States. However, rather than be critical of Dr. Braun's interpretations, Dr. Goodlett praised her field work, her mapping of forest communities, and her attention to detail.

Fifth, Goodlett's role as a mentor and teacher had long-term effects on many of his students. As an example, Olson (1971) in the acknowledgments for her book wrote, "The greatest credit is due John C. Goodlett, much of whose research and writing lie unfinished because of the time he shared with his students and colleagues, the standard of craftsmanship he demanded of them and of himself, and a life so generous, so intense and brimming over, that it called for more years than were given."

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A Survey of Terrestrial Mollusca in Selected Areas of the Land Between the Lakes National Recreation Area

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ABSTRACT

The terrestrial Gastropods in selected areas of the Land Between the Lakes National Recreation Area (LBL) in Kentucky and Tennessee were studied in 2002. Thirty-three native land snails were documented. *Discus patulus, Inflectarius inflectus,* and *Stenotrema stenotrema* were the most frequently encountered and among the most widely distributed species within the area. Species richness and abundance increased around calcareous soils and outcrops of limestone but declined on the upland sites where soils are more acid and well drained. Terrestrial snail fauna at Land Between the Lakes is more diverse than once believed and represents an important Mollusca region.

KEY WORDS: Mollusca; land snail; terrestrial Mollusca; Land Between the Lakes; *Xolotrema*; *Gastrocopta*; *Glyphyalinia*

INTRODUCTION

The land snail fauna of Kentucky and Tennessee has long been recognized for its diversity. Throughout the 19th and 20th centuries, malacologists made frequent field trips to this region to collect and catalogue land snail fauna and determine their distributions. The mountain regions of these two states were renowned for their rich and unique assemblages of species. Most investigations in Kentucky and Tennessee were concentrated in the eastern mountains with little attention given to the western regions of these states. Hubricht (1985) displays many county gaps for common species in western Kentucky and Tennessee.

We investigated terrestrial Mollusca within LBL, located in western Kentucky and Tennessee, with all survey sites occurring in Trigg County and Lyon County, Kentucky and Stewart County, Tennessee. The preliminary investigation was conducted to provide the United States Forest Service, the agency currently responsible for management of LBL, with information on this under-surveyed group of organisms. The information gathered from the survey should provide assistance in their efforts to maintain and protect current populations of indigenous species of terrestrial snails. Results also will add to the overall knowledge of the occurrence and distribution patterns of land snail fauna.

STUDY AREA

The Land Between the Lakes, located in western Kentucky and Tennessee, is a large landmass of around 170 thousand acres, bounded on the east side by Lake Barkley (Cumberland River), on the west by Kentucky Lake (Tennessee River) and on the north by a canal at Grand Rivers connecting the two lakes. The area marks a transition between the Mississippian Plateau to the east and the Mississippian Embayment to the west. Consolidated and unconsolidated sediments of the Cretaceous overlie residual Mississippian limestone (McFarlan 1943). Topography of the area is moderate, ranging from 360 feet to 460 feet above sea level. Limestone outcrops occur along the edges of the lakes at the lowest elevations. Mixed hardwood forests interspersed with pine plantation and grassy openings dominate the landscape.

METHODS

Empty snail shells were collected from under leaf litter, rocks, logs, exfoliating bark of

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dead standing and fallen trees, and from the surface of exposed rocks and small outcrops of limestone. Leaf and soil collections also were made to retrieve snail species that were difficult to detect with the unaided eye (snails under 3mm in size). We sorted and identified to genus and species using Burch (1962), Pilsbry (1940, 1946, 1948), Dan Dourson's reference collection, and various recent publications. Taxonomy was based on Turgeon, et al. (1998).

Hubricht (1985) and Branson (1973) were used to determine general land mollusca distributions and new county records for western Kentucky and Tennessee. The Kentucky State Nature Preserve Commission (2000) and the Tennessee Natural Heritage Program (TNHP) records were reviewed to determine if rare species were found at LBL.

COLLECTION SITES

Eleven sites within LBL were selected based on their suitability for land snails. Sites 1 and 7 were located in Lyon County, Kentucky; Sites 2 through 6 and 8 through 10 in Trigg County, Kentucky; Site 11 in Stewart County, Tennessee. The following list of sites includes a brief description of each location and habitat.

1. Forested habitats of mixed hardwood along the North/South trail between Birmingham Ferry Road and Road 139. Most snails were collected in and around ravines. 36°52′ 5.30″ N 88°06′ 34.21″ W

2. East side of road at Hematite Lake next to Old Furnace around old slag piles. Habitat was a hardwood bottomland forest including pawpaw *(Asimina triloba),* black walnut (*Juglans nigra),* sugar maple *(Acer saccharum),* box elder *(Acer negundo),* and river cane (*Arundinaria gigantea*). 36°53′ 58.41″ N 88°02′ 16.81″ W

3. Around old road/trail between the LBL Ranger Station and Devil's Elbow Creek. Area was surrounded by mixed hardwood of oak (*Quercus sp.)* and hickory (*Carya species)* with some planted loblolly pine *(Taeda pinus).* 36°46′ 47.50″ N 88°02′ 34.39″ W

4. Limestone outcrops in mixed hardwood forest including sugar maple, white oak (*Quercus alba*), and hickory at Ferguson Springs. 36°51′ 2.22″ N 88°02′ 24.28″ W

5. Opening #369 located in North Fork of Sugar Branch. The forest was a mixture of hardwoods including sugar maple, poplar (*Liriodendron tulipifera),* black cherry (*Prunus serotina),* sweet gum *(Liquidambar styraciflua)* and some redcedar (*Juniperus virginiana*). 36°52′ 4.79″ N 88°06′ 41.14″ W

6. Opening #392 in South Fork of Sugar Branch. Habitat was a mixed hardwood forest. 36°51′ 20.42″ N 88°07′ 5.35″ W

7. A small area of exposed limestone. Habitat, glade-like and dry, included red cedar, Virginia pine (*Pinus virginiana),* and several uncommon prairie plants. 36°53′ 53.75″ N 88°03′ 22.22″ W

8. A limestone outcrop next to Energy Lake. Habitat was mixed oak and hickory, with scattered redcedar. 36°51′ 52.41″ N 88°00′ 48.05″ W

9. A limestone outcrop at the junctions of Roads 174 and 165. Habitat was mixed hardwoods including oak and hickory, with scattered river cane. 36°42′ 31.48″ N 87°59′ 58.94″ W

10. Limestone outcrops just above Hematite Lake. Habitat was mixed hardwoods including oak and hickory, with some redcedar. 36°53′ 50.02″ N 88°02′ 44.88″ W

11. Small chunks of limestone close to Prior Spring. Habitat was a mixture of redcedar and oak hardwoods. 36°392′ 35.75″ N 87°58′ 4.73″ W

RESULTS

Specimens collected at LBL represented 33 species. This study documented 36 new county records and several range extensions for terrestrial snails in Kentucky and Tennessee. No species were collected that had been listed as endangered, threatened, or special concern by either Kentucky State Nature Preserves Commission (2000), or Tennessee Natural Heritage Program. Although most species found during the survey are considered relatively widespread and common in Kentucky and Tennessee, there were several species of interest. *Xolotrema obstricta,* a species normally associated with rocky river bluffs (Hubricht 1985), was discovered among old slag piles from a nearby historic furnace. *Glyphyalinia lewisiana,* documented exclusively in Edmundson County, Kentucky by Branson (1973), was found in the LBL survey in Trigg County, Kentucky, representing a five county range extension to the west. The survey also documented the first

western Kentucky locations for *Gastrocopta corticaria* and the first western Tennessee records for *Vertigo tridentata.* The following species accounts provide range-wide distribution information, habitat and LBL collection information.

SPECIES ACCOUNTS

Species documented at LBL are correlated with collection site number in the list below. The numbers in parentheses represent the number of individuals collected at each site.

Family Pupillidae

Gastrocopta contracta (Say)

Collections: 2(2)

A wide-ranging species found from Maine to Florida, west to Mexico (Burch 1962). Sparsely known across Kentucky, *G. contracta* is a species of varied habitats including low wet locales, sunny roadsides and limestone outcrops that are often quite dry. At LBL, it was found at one site around old slag piles.

Gastrocopta corticaria (Say)

Collections: 2(12), 11(1)

A wide-ranging species found from Maine west to Minnesota, south to Florida and Louisiana (Burch 1962). In Kentucky, Hubricht (1985) shows it from Jefferson, Trimble, Edmonson, and Harlan counties. Branson (1973) shows it occurring in Clark County, Kentucky, but later Branson and Batch (1988) reported it from Franklin and Madison counties. Most states have very sparse records for this species. *Gastrocopta corticaria,* rarely found in large numbers, is often documented crawling on logs and tree trunks in wet weather. It is a small (2.5 mm) calciphile species (Hubricht 1985). At LBL, it was found near limestone outcrops at two sites from soil/leaf litter collections.

Gastrocopta pentadon (Say)

Collections: 10(1)

A wide-ranging species found from Maine to Florida, west to Arizona. Sparsely known across Kentucky, this tiny calciphile (1.5 mm) is often found in upland woods in rather dry situations but has also been recorded in low, wet places (Hubricht 1985). At LBL, it was found at one site in the thin soil on a limestone outcrop.

Gastrocopta procera (Gould) (Figure 5)

Collections: 8(5)

A wide-ranging species found from Maryland and South Carolina, west to South Dakota and Arizona. In Kentucky, it is known from a few central and southeastern counties. At LBL, it was found at only one site, a limestone outcrop, next to Energy Lake.

Vertigo tridentata (Wolf)

Collections: 11(1)

The distribution of this tiny species (2.3 mm) is sparse from Maine to West Virginia, west to Minnesota, Kansas, and Texas. In Tennessee, it is known only from the extreme eastern mountain region, with scattered fossil records along the Ohio and Mississippi Rivers (Hubricht 1985). It can be found crawling on logs in low, sunny places (Hubricht 1985). At LBL, it was found in soil and leaf litter samples taken from the base of small chunky outcrops of limestone.

Family Zonitidae

Glyphyalinia indentata (Authors)

Collections: 1(6), 2(6), 3(2), 4(1), 7(1), 8(2), 11(1)

A wide-ranging species found from Maine to Alabama, west to Utah and Arizona (Burch 1962). Scattered across Kentucky, it is found in a variety of habitats, most commonly in leaf litter in woods but also along roadsides and railroads and in meadows and urban areas (Hubricht 1985). It was found at most sites sampled at LBL.

Glyphyalinia lewisiana (Clapp)

Collections: 9(1)

This land snail has been documented in Edmonson County, Kentucky and two counties in Tennessee, according to Hubricht (1985) and Branson (1973). Considered a burrowing calciphile, *G. lewisiana* was found at the base of a small outcrop of limestone among Price's potato bean (*Apios priceana).*

Glyphyalinia wheatleyi (Bland)

Collections: 2(2), 7(2), 8(2)

Found from New York and Connecticut, south to Florida, and west to Oklahoma (Hubricht 1985). Known from Warren County, Kentucky eastward to the mountains, our new

Figures 1–6. The photographs show the diversity of land snail shells found at LBL. Figure 1, *Anguispira alternata,* is one of the few eastern land snails that possess color features. Figure 2, *Carychium exile,* is among the smallest land snails (less than 2 mm in height) in Kentucky. Figure 3, *Mesodon clausus,* a common species of disturbed habitat. Figure 4, *Xolotrema obstricta,* one of the most distinctive land snails in Kentucky, possesses a carinate periphery and prominent white teeth. Figure 5, *Gastrocopta procera,* another minute species less than 2 mm in height with distinct internal teeth. Figure 6, *Neohelix albolabris,* among the largest of the land snails up to 40 mm in diameter.

sites in Trigg County extend the species range three counties westward. At LBL, we found the species under rotting logs at three sites.

Hawaiia miniscula (Binney)

Collections: 8(12), 10(1)

Hawaiia miniscula is a small species (2.5 mm) found on bare soil of floodplains, meadows, and roadsides, along railroads, and on waste ground in urban areas but can also be found in mountainous regions; the species distribution includes all the states east of the Mississippi River (Hubricht 1985). Known from scattered locations across Kentucky, but likely occurs in every county. At LBL, it was collected at two sites from thin soil and leaf litter around limestone outcrops.

Mesomphix vulgatus (H. B. Baker)

Collections: 1(3), 2(12), 4(11), 6(1), 7(8), 8(4),

Hubricht (1985) shows this species occurring in southern Indiana, central Kentucky, and north central Tennessee. The species documentation in LBL is another several county range extension for Kentucky. *M. vulgatus* generally occurs under leaf litter on wooded hillsides, ravines, and sinks (Hubricht 1985). Found at seven sites, it is one of the more common snails in the rich woods at LBL.

Paravitrea capsella (Authors)

Collections: 2(10), 3(1), 4(1), 9(2), 11(8)

This species ranges from Virginia and North Carolina, west to Illinois and Alabama (Burch 1962). Scattered across Kentucky, although there remain many county gaps, it was found under leaf litter at five sites at LBL.

Striatura meridionalis (Pilsbry & Ferriss)

Collections: 2(2), 11(1)

Striatura meridionalis is a wide-ranging species found from New Jersey to Florida, west to Missouri and Arizona (Burch 1962). This minute species (1.7 mm) is known from scattered locations across Kentucky. As with many of Kentucky's small snail species, there remain large gaps in the range. It usually occurs in moist leaf litter on wooded hillsides and in ravines or occasionally in flood plains (Hubricht 1985). At LBL, the species was found in soil and leaf litter samples from two sites.

Ventridens ligera (Say)

Collections: 1(2), 2(8), 7(2), 8(6), 9(3), 10(2), 11(4)

A wide-ranging species found from New York to Florida, west to Michigan and Oklahoma. Scattered across Kentucky, this species is typically found among wet, weedy open ground, meadows, roadsides, and beneath forested limestone cliffs. *V. ligera* is common species at LBL.

Zonitoides arboreus (Say)

Collections: 1(4)

This species is reported from all the contiguous states with the exception of Nevada (Burch 1962). In Kentucky, records are well scattered across the state but it likely occurs in every county. It is usually found on rotting hardwood logs in advance stages of decay and standing dead trees under exfoliating bark. Although it was found at only one site, it likely occurs throughout LBL.

Family Polygyridae

Inflectarius inflectus (Say)

Collections: 2(7), 3(3), 4(6), 5(7), 6(3), 7(5), 8(4), 9(3)

This species is distributed from North Carolina to Florida, west to Michigan, Oklahoma, and Louisiana (Burch 1962). A common species found throughout Kentucky, it appears to prefer roadsides and waste places under logs, rocks, and leaf litter. At LBL, it was found at nine sites.

Inflectarius kalmianus (Hubricht)

Collections: 7(5)

The range of this species is restricted to three states: south central Kentucky, north central Tennessee and western Virginia (Hubricht 1985). In Kentucky, Branson (1973) shows it ranging from Warren County and eastward into Whitley County, north to Madison County. It is usually found in open grassy places, meadows, and roadsides but also in kudzu banks (Hubricht 1985). At LBL, we found five weathered specimens in a dry, open glade habitat at Site 7.

Mesodon clausus (Say)

Collections: 2(4)

The species occurs from Ohio to Georgia,

west to Minnesota and Oklahoma (Burch 1962). Scattered across Kentucky, it is considered a calciphile and usually is found in low open weedy places, meadows, roadsides, and along railroads (Hubricht 1985). *M. clausus* was found under leaf litter around old slag piles from a nearby historic furnace (Figure 3).

Mesodon thyroidus (Say)

Collections: 2(4), 3(1), 4(11), 5(1), 6(1), 8(2)

M. thyroidus is one of the most widely distributed *Mesodon* species in the eastern United States. Found throughout Kentucky, it occurs in a variety of habitats including floodplains, woods, leaf litter, hillsides and ravines, roadsides, along railroads, marshes, and waste places (Hubricht 1985). It is largely absent in continuous forest areas.

Millerelix plicata (Say)

Collections: 9(4), 11(3)

The species ranges from Indiana south into Alabama and Georgia (Burch 1962). In Kentucky, it is known from the central counties. This calciphile snail is found in leaf litter on dry wooded hillsides and in redcedar glades (Hubricht 1985). At LBL, it was found at the base of chunky outcrops of limestone at two sites.

Stenotrema stenotrema (Pfeiffer)

Collections: 1(2), 2(7), 3(2), 4(1), 6(2), 7(11), 8(2), 9(3), 10(1)

This common species is found from Virginia to Georgia, west to Ohio, Missouri, Oklahoma, and Louisiana (Burch 1962). In Kentucky, it is most common in the southeastern part of the state (Hubricht 1985) where it occurs beneath leaf litter, rocks, and logs in mesic, forested ravines and submesic, xeric situations such as forest openings. Based on collections, *S. stenotrema* is a common species at LBL, found at all but two sites.

Neohelix albolabris (Say) (Figure 6)

Collections: 1(1), 3(1), 5(1)

A large (up to 40 mm) wide-ranging species found from Maine to Georgia, west to the Mississippi River and Oklahoma (Burch 1962). Known from scattered sites across Kentucky, it can be found under logs and rocks, and in leaf litter on wooded hillsides, in ravines, along roadsides, railroad tracks, and on waste ground in urban areas (Hubricht 1985). In the Cumberland Plateau of eastern Kentucky, it is a common species of dry acid ridge tops as well as rich limestone coves. It was found in a variety of habitats at LBL including around limestone outcrops and on acid ridge tops dominated by oak and pine.

Triodopsis vulgata (Pilsbry)

Collections: 1(4), 2(11), 5(3), 6(5), 9(27), 11(31)

A species found from Michigan to Alabama, west to Illinois, and east to Virginia. It occurs across Kentucky. Habitats include leaf litter and rotten logs in ravines and on forested hillsides (Hubricht 1985).

Xolotrema obstrictum (Say) (Figure 4)

Collections: 2(12)

The species ranges from South Carolina northwestward to Illinois and south to Arkansas (Burch 1962). In Kentucky, Hubricht (1985) shows it occurring in Warren, Barren, Edmonson, and Hart counties. The species is a calciphile usually found on rocky, river bluffs near logs (Hubricht 1985). At LBL, it was found in large numbers around old slag piles associated with a nearby historic iron furnace. Both live specimens and empty shells were found under leaf litter next to large logs in mature bottomland forest habitats.

Family Punctidae

Punctum minutissimum (I. Lea)

Collections: 2(1)

A wide-ranging species, it is found from Maine to Florida and west to Oregon and New Mexico (Burch 1962). We found it scattered across Kentucky in deep pockets of wet leaf litter around logs or depressions in the ground and around seeps and small streams. This species was found in soil/leaf litter samples.

Family Discidae

Anguispira alternata (Say) (Figure 1)

Collections: 11(6)

This wide-ranging species is found from Pennsylvania south to Alabama, west to South Dakota and Texas (Burch 1962). It is scattered across Kentucky and Tennessee in forested habitats about logs, hollow trees, and rocks, as

well as in weedy roadsides and along railroads, and in vacant lots and gardens in urban areas (Hubricht 1985). It was found around small limestone outcrops.

Discus patulus (DeShayes)

Collections: 1(4), 2(23), 3(12), 4(13), 5(8), 6(6), 7(18), 9(4)

This species ranges from New York to Florida and west to Iowa and Arkansas (Burch 1962). Distribution is cattered across Kentucky and usually associated with logs in advanced stages of decay in upland woods. Although *D. patulus* is largely associated with log structure, we found it quite commonly under leaf litter.

Family Carychiidae

Carychium exile (H. C. Lea) (Figure 2)

Collections: 2(24), 11(2)

C. exile is wide-ranging species found from Canada and Maine, south to Alabama, and west to Oklahoma. Branson (1973) gives records from scattered locations across Kentucky. This tiny species (1.8 mm) was found in deep pockets of wet leaves at two sites.

Family Helicarionidae

Euconulus trochulus (Reinhardt)

Collections: 2(1), 11(1)

A species found from southern Indiana south to Florida, and from North Carolina west to Texas. In Kentucky, it is known from fewer than a dozen counties, usually associated with moist leaf litter on wooded hillsides and in ravines (Hubricht 1985). At LBL, it was found at two sites in leaf litter at the base of limestone outcrops.

Guppya sterkii (Dall)

Collections: 2(4), 8(4), 11(2)

This is a minute species (1.5 mm) found from New York south to Florida and west to Ohio and Louisiana (Hubricht 1985). In Kentucky, it is known from Breckinridge County eastward to Virginia with numerous county gaps. It is found in moist leaf litter on wooded hillsides and in ravines (Hubricht 1985). At LBL, it was found in soil and leaf samples collected from limestone outcrops at three sites. In Kentucky, these new sites at LBL represent a four-county range extension to the west.

Helicodiscus notius notius (Hubricht)

Collections: 1(1), 2(3), 7(1), 10 (1)

This is a species found from Maine southward to Alabama and westward to South Dakota and Oklahoma. Hubricht (1985) shows it ranging across Kentucky. At LBL, it was found at four sites in a variety of conditions from deep moist woods to dry outcrops of limestone.

Family Haplotrematidae

Haplotrema concavum (Say)

Collections: 4(7), 5(3), 8(1)

A wide-ranging and common species it is found from Maine to Florida, west to Iowa and Arkansas (Burch 1962). In Kentucky, there are scattered records across the state. At LBL, it was found under leaf litter in four sites. It has been reported to be a carnivorous species, preying on other land snails.

Family Philomycidae

Philomycus carolinianus (Bosc)

Collections: 2(3)

A species of slug it ranges from Maine to Florida and west to Iowa and Texas with scattered records across Kentucky (Branson 1973). *Philomycus carolinianus* is likely more common then present records indicate. Because slugs prefer moist environments, most live under large sheets of exfoliating bark on fallen trees usually in and around small creeks and in trees with large moist cavities. Although *P. carolinianus* was found at only one site (probably due to exceptionally dry conditions at the time of the survey), it is likely more widespread at LBL.

DISCUSSION

When compared with other eastern states, Kentucky has a relatively rich assemblage of land snails. Branson (1973) recorded 179 species of terrestrial snails and slugs in Kentucky; Hubricht (1985) around 165 species. Estimates of terrestrial snail species documented from surrounding states include Tennessee (250), Alabama (185), Arkansas (98), Missouri (102), Illinois (122), Indiana (100), Ohio (105), West Virginia (132), Pennsylvania (102), and North Carolina (163) (Hubricht 1985). Snail diversity in Kentucky can be attributed to several factors, with geography being perhaps the

most important. Land snails that are considered to be more Midwestern are found in the western tip of the state that extends into the Mississippi Embayment. The Cumberland Plateau and Pine Mountain land masses shelter many southern Appalachian snails as well as several state endemics. Karst regions also conceal unique and rare subterranean land mollusca.

Where large physiographic regions coincide, land snail diversity can be exceptional. One such example occurs on Furnace Mountain in Powell County, Kentucky, where 60 species of native land snails have been documented in an area of less than 5 acres (Dourson 2005 unpublished). Furnace Mountain could be best described as a large landscape edge where the outer Bluegrass, the Knobs, and the Cumberland Plateau all blend together. Snails from these three regions of Kentucky are found coexisting.

Although, we sampled only eleven sites making up less than one percent of LBL lands, there were 35 new county records for Kentucky and several noteworthy range extensions for both states. With such large information gaps, it would appear that western Kentucky has been less frequently sampled for this group of animals, and it is likely that new county and state records await discovery.

While much of the overall habitat within the LBL harbors relatively few species of land snails, rich pockets were discovered that were associated largely with calcareous soils or outcrops of limestone. The more exposed and drier limestone outcrops yielded most of the *Gastrocopta* species; limestone outcrops that were facing north or northeast remain shaded and moist harboring greater snail diversity. Site 2 contained 21 species, a respectable number of land snails for any single site. The 33 species accounted for at LBL, likely represent a fair estimate of the total snail fauna there. Further sampling however should yield additional species of common varieties and perhaps others of rare status.

Land snails are an important component of the forest community. Many small mammals, such as shrews and mice, are known to include land snails in their diet. Several species of salamanders including the terrestrial form of *Notopthalmus viridescens,* the red eft, are known to consume small snail species. Two North Carolina state records for land snails, *Vallonia excentrica* and *Cochlicopa lubrica,* were recovered from examining fecal matter of the red eft (Van Devender and Van Devender 2003 unpublished). There is a growing body of evidence that calcium depletion in the soil due to acid rain can affect breeding bird populations. Decreases in available soil calcium may greatly alter the number of available prey such as snails and snail shells that are consumed by breeding birds. Snails provide supplemental calcium to growing young (Hames et al. 2002).

There is a timely need to continue to document the distribution patterns and ecology of Kentucky land snails. Unlike mussels, of which many species are now extirpated from the state, the land snails of Kentucky have likely suffered few losses, if any. There are, however, twenty-five species of native snails that are state listed as either sensitive, threatened, or endangered (Kentucky State Nature Preserves Commission 2000). Limited ranges in Kentucky account for some of these listings, but declines have been observed in a few species. For example, relic shells of *Anguispira kochi* can be found in most of the Bluegrass region, but live populations of this species are rarely encountered (J. MacGregor pers. comm.).

Clearly the loss of indigenous habitats to development has pushed many native species to their limits and beyond. The population expansion of exotic gastropods such as Limacidae, Arionidae, and Helicidae poses additional concerns like the spread of non-native mollusca disease. New threats on the horizon may include the over-harvesting of wood products used in chip mills. Over-harvesting of trees of all sizes in a forest will result in the eventual elimination of rotting wood structure which provides gastropods a wide range of functions including protective cover from predation, moist habitats during droughts, food sources, and for many species, an area to lay eggs. Forest fires kill large numbers of land snails that reside under the leaf litter. Live snails, however, often survive under rocks, in moist depressions created from uprooted trees, and under logs that provide a moist refuge from the intense heat and fire (Dourson pers. obs.). These protected islands of unburned habitat are likely important for the maintenance of

snail populations and recolonization of burned-over forest environments.

In Cades Cove, Great Smoky Mountain National Park, a surplus of deer has severely damaged the herbaceous ground cover up to around 6 feet in surrounding forests. Leaf and duff layers are present, but common wildflower species are scarce. In this area, live snails and shells are largely absent; even around caves and outcrops of limestone that typically have many species (Dourson pers. obs.).

Mt. Airy Forest in Cincinnati, Ohio, may be suffering a similar loss of snail fauna, though not as a result of an overpopulation of deer. Signs of exotic earthworm infestations are evident throughout the forest. In some areas, the entire leaf and duff layers are absent and only bare, dry mineral soil remains. Without the duff layers, the microbe and fungi cycles responsible for the break down of organic matter into essential elements such as nitrogen, phosphorous, and calcium are severely altered. Once these exotic earthworms are introduced, it takes a relatively short amount of time for them to unnaturally deteriorate and even remove the detritus layer. Within a matter of 3 to 5 years, beginning with the O horizon, they can consume a whole layer of organic matter and affect the organisms that reside there. Habitat supporting native macro invertebrates, salamanders, frogs, small mammals, and herbaceous plants is compromised (Lee 1985). Since land snails are dependent on calcium for shell production, this calcium depletion may adversely affect land snail populations within the affected forest community. Dourson has searched these duffless landscapes at Mt. Airy Forest for native land snails with very little success in locating either live individuals or their empty shells. Generally, the only snail found is *Cepaea nemoralis,* itself an exotic invader from central and western Europe.

Declines of terrestrial snails have been observed in the Mixedwood Plains Ecozone (MPE) of Ontario and Quebec. The elimination of natural forest cover from nearly all of the Carolinian life zone in the southern MPE has confined the few remaining native snails in that area to isolated scattered remnant habitats. The remaining native molluscan communities in MPE are being eliminated quickly (Grimm 1995). Half of the 172 terrestrial mollusks known from this region are being recommended as rare, threatened or seriously endangered.

The long-term effects of these forest changes on land snail viability is unknown and in most areas unstudied. There are likely species of snails that can be used to determine the quality of forest habitat, much in the same way that freshwater mussels are used to determine the quality of a stream. For example, *Guppya sterkii, Philomycus carolinianus,* and *Xolotrema obstrictum* (all found at LBL) are species largely found in quality habitat.

The LBL study reasonably demonstrates that large information gaps in knowledge of land snail distribution still remain in Kentucky. While it may not be practical to survey every square acre across the state in order to fill in these distribution gaps, it is possible to target areas that concentrate species diversity. Areas that contain large landscape edges, calcium rich soils, outcrops of limestone, and rich mesic slopes will yield more species. Within a forest landscape, natural or constructed barriers like clifflines, retaining walls of highways, and bridge abutments will concentrate large numbers of snails into relatively small, linear regions. Moving forward, as we continue to study, collect, and document the distribution of land snails in Kentucky, we will undoubtedly find new county and state records, and perhaps even a few undescribed species.

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New Records of Butterflies and Moths (Lepidoptera) from Kentucky

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ABSTRACT

The authors add 29 species to the list of known butterflies and moths (Lepidoptera) recorded from Kentucky, bringing the total number to 2,452. Previous lists included Covell (1999) with 2,423 species, and Covell, Gibson and Wright (2000) that added 35 more.

KEY WORDS: butterflies, moths, Lepidoptera, Kentucky

INTRODUCTION

After 35 years of survey efforts by a number of people, the basic annotated checklist of 2,388 species of butterflies and moths of Kentucky was published by the Kentucky State Nature Preserves Commission (Covell 1999). A first supplement was published by Covell et al. (2000), adding 35 species to bring the total to 2,423. Here we add 31 more to bring the total to 2,454. There are numerous other specimens still to be identified and added to the list at a later date, and members of the Society of Kentucky Lepidopterists continue fieldwork to sample new habitats and localities to assist in learning more fully the extent of the lepidopterous fauna of the Commonwealth of Kentucky.

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SPECIES LIST ADDITIONS

Numbers in the species list follow Hodges et al. (1983). Numbers followed by a decimal point represent additions to the original Hodges et al. list.

Family DOUGLASIIDAE

2487.1 *Tinagma gaedikei* Harrison.

Boone County, Middle Creek Park, 29 April 2006, three adults found on blossoms of Miami-mist, *Phacelia purshii* (Buckley) (Hydrophyllaceae), Loran D. Gibson.

Family SESIIDAE

2571 *Synanthedon decipiens* (Henry Edwards).

McCracken County, Littleville site, Paducah, 6 September 2003, Ian Segebarth, in pheromone trap.

Family TORTRICIDAE

3347 *Epinotia septemberana* Kearfott.

One male in fresh condition of this rather rare species was collected in a blacklight trap, Owsley Co., Rt. 1411, near Booneville, 30 September 2005, Loran D. Gibson.

3407 *Dichrorampha incanana* (Clemens).

Rowan Co., East side of Rt. 1274, 2 miles west of Rt. 519, one specimen in blacklight trap, 30 August 1998, Loran D. Gibson.

3630 *Diedra cockerellana* (Kearfott).

Several individuals were collected in blacklight traps on a nice glade habitat, Larue Co., 23 September 2005, Loran D. Gibson

Family NYMPHALIDAE

4418 *Heliconius charithonia* (Linnaeus). Zebra Longwing

Two individuals were recorded on 12 Sep-

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tember 2001, at the Western Kentucky University farm, Warren Co., by Jackie Elmore and also were seen by David Roemer. Photographs were made of one of them. This is an unusual northern sighting of a species confined normally to coastal lowlands from North Carolina through Florida and along the Gulf Coast to Texas, straying north to Nebraska on rare occasions in the Mississippi Valley (Brock and Kaufman, 2003). Possibly brought north as larvae or pupae on cultivated *Passiflora*, the foodplant.

Family CRAMBIDAE

5135 *Mecyna submedialis* (Grote).

Common during daylight hours and also at blacklight traps and mercury vapor light on a limestone glade habitat, Larue Co., 24 August 2005, Loran D. Gibson. Determined by George J. Balogh.

5363 *Crambus saltuellus* Zeller.

Rowan Co., east side of Ky. Rt. 1274, 2 miles west of Ky. Rt. 519, 1 July 1995, Loran D. Gibson.

5450 *Parapediasia decorella* (Zincken).

Bullitt Co., south side of Rt. 480, 6.9 miles east of Rt. 61, 23 June 1989, Loran D. Gibson.

5460 *Argyria nummualis* Hübner.

Bullitt Co., east side of Rt. 1442, 8 miles east of Rt. 61, 22 July 1988; Meade Co., Lapland Road, 18 July 2005; both collected by Loran D. Gibson.

5489 *Haimbachia placidella* (Haimbach).

Rowan Co., east side of Ky. Rt. 1274, 2 miles west of Ky. Rt. 519, 8 July 2005, Loran D. Gibson; Rowan Co., Minor E. Clarke Fish Hatchery, 8 July 2005, Loran D. Gibson; Laurel Co., Daniel Boone National Forest, power line corridor, east side of southern end of road 775, 25 June 1997, Loran D. Gibson; Pike Co., South Williamson, 25 June 1999, Ron King.

Family PYRALIDAE

5596 *Pococera scortialis* (Lederer).

Laurel County, Daniel Boone National Forest, power line corridor, east side of southern end of Road 775, 25 June 1997, Loran D. Gibson. Determined by M. Alma Solis.

5791 *Sciota rubescentella* (Hulst).

Recorded in Neunzig (2003, p. 113) from "Meidahl Dam, Bracken Co., (August)." [The name should have been spelled "Meldahl."]

5818 *Actrix nyssaecolella* (Dyar).

Recorded in Neunzig (2003, p. 135) from "Laurel Co. (April, June, July)." Specimens collected by Loran D. Gibson.

5853 *Dioryctria amatella* (Hulst).

Three specimens collected in blacklight trap among cultivated longleaf pine, Livingston Co., Bissell Bluff Nature Preserve, 9 September 2005, Loran D. Gibson.

6022 *Cadra cautella* (Walker). Almond Moth

Adults were found in pecans in candy made by Old Louisville Candy Co., Louisville, Jefferson Co. The moths were returned to Louisville from Florida in March, 2006, where a recipient of the "Happy Balls" candy found them and claimed a bad taste and illness when consuming the infested candy. The species is commonly found infesting figs, dates, nuts and seeds and is worldwide in distribution (Mallis, 1990). Initial identification was by Matthew Vanderpool, Louisville Dept. of Public Health; verified by Charles V. Covell, Jr.

Family NOCTUIDAE

8480 *Phytometra ernestinana* (Blanchard).

Hardin Co., 15 August 2003, Loran D. Gibson and Ellis Laudermilk.

8586 *Massala obvertens* (Walker).

McCracken Co., Steetman property in a cane break, Massac Creek Bottoms, Hinkleville Road, Paducah, 29–30 November, 1998, William R. Black Jr. in bait trap.

8786.1 *Catocala atocala* Brou.

William R. Black Jr., Paul Waring, and Kevin, Craig and Ian Segebarth took six specimens of this recently described species at Columbus, Hickman Co., in 2 light traps on the night of 4/5 August 2004. Identification led to the discovery of an earlier specimen caught by Leroy Koehn at Paducah, McCracken Co., the night of 8 September 2001. See Black (2005).

8868 *Catocala titania* Dodge.

McCracken Co., Paducah, 24 June 2004; in bait trap at their home, Craig and Ian Segebarth.

9429 *Lemmeria digitalis* (Grote).

Graves Co., Crowell Rd. at Lick Creek, 21 October 2003, Craig Segebarth.

9482 *Papaipema speciosissima* (Grote and Robinson).

Pulaski Co., 8 October, 2003, Ellis Laudermilk; Calloway County, along Blood River, 15 October 2005, W. R. Black Jr.

9508 *Papaipema beeriana* Bird

Hardin County, in blacklight trap, both spotted and unspotted individuals, 6 October 2002, Loran D. Gibson and Ellis Laudermilk; determined by Loran D. Gibson, confirmed by Eric Metzler and M. C. Nielsen.

9579 *Hyppa contrasta* McDunnough.

Harlan Co., Black Mountain, junction of Black Mountain Ridge Road and State Road 160, 1,551 meters elevation, 7 July 2002, at light, Leroy C. Koehn.

9630 *Callopistria floridensis* (Guenée).

Paducah, McCracken Co., in home, 21 December 1997, William R. Black Jr.; Simpson Co., I−75 on Welcome Center wall, 1 November 2002, James K. Adams.

10190 *Cucullia speyeri* Lintner.

A mature larva found on the ground, 14 September 2003, in Scott Co., 3.7 miles NW of Midway. It was found and photographed by Kenneth V. Yeargan; the species was determined from the photo by David Wagner. Dr. Yeargan found a second partly grown larva on 23 June 2005, in Lexington, Fayette Co., on daisy fleabane (*Erigeron* sp.) and later released it on another fleabane plant and saw it eating its leaves.

10301 *Spirameter lutra* (Guenée).

Summit of Pine Mountain, above Cumberland, Harlan County, 21 May 2005, L. D. Gibson and E. Laudermilk, in light traps (Listed as *Lacnobia lutra* (Gn.) in Hodges et al. 1983).

10411 *Lacinipolia laudabilis* (Guenée).

McCracken Co., Paducah, in Grace Episcopal Church yard, 7 September 2002, Ian Segebarth, in blacklight trap.

11110 *Schinia septentrionalis* (Walker).

Hardin County, one male in blacklight trap, 5 October 2002, Loran D. Gibson.

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Benthic Diatom Species List and Environmental Conditions in the Little River Basin, Western Kentucky, USA

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ABSTRACT

Two hundred eighty-two taxa of diatoms (Bacillariophyta) were identified from composited benthic samples collected at 16 sites on the Little River in western Kentucky in 2000 and 2003. The Little River basin is heavily impacted by non-point source pollution consisting of high nutrient inputs and siltation from agricultural and urban runoff. Pennate diatoms dominated the flora comprising >96% of the total taxa throughout the basin. Commonly occurring pennate species included *Achnanthidium minutissimum, Amphora perpusilla, Cocconeis placentula* var. *euglypta, Gomphonema parvulum, Navicula cryptocephala, N. cryptotenella, N. menisculus, N. minima, N. seminulum, N. tripunctata, Nitzschia amphibia, N. dissipata, N. frustulum, N. palea, Planothidium lanceolata,* and *Sellophora seminulum.* Most common centric species were *Cyclotella meneghiniana* and *Melosira varians.* The number of taxa found in the Little River was similar to other eastern North American streams and typical of streams impacted by agricultural and urban non-point source pollution (organic and nutrient enrichment and high siltation). A species checklist of all diatom taxa identified in the Little River with currently accepted nomenclature is presented as a baseline for future comparisons.

KEYWORDS: benthic diatoms, streams, water quality, agricultural, North America

INTRODUCTION

Diatoms have been used since the early 20th century as indicators of water quality. Species assemblages in freshwaters reflect both ambient and historical physicochemical conditions within the water column and benthic environments (Lowe 1974; Patrick and Reimer 1966, 1975; Stoermer and Smol 1999; Wehr and Sheath 2003). Organic pollution and nutrient enrichment from human activity, particularly excessive nitrogen and phosphorus, result in shifts in diatom composition (Kentucky Division of Water 1993; Wehr and Sheath 2003). While changes in diatom community structure have proven valuable in assessing water quality, there is very limited information in the literature on species distributions for western Kentucky streams (Camburn 1982). The goal of this paper is to provide baseline taxa distributions for several sites in the Little River basin that can be used for future assessments. Currently accepted synonyms with proper citations are provided in the checklist. We also present data, although limited, on nutrients and other water quality parameters along with some brief comparisons of ecological conditions throughout the basin.

STUDY SITES

The Little River is located in the Lower Cumberland basin in western Kentucky and drains approximately 1190 km^2 (KDOW 1996). The basin is located in the Interior Plateau Ecoregion, also known as the Pennyroyal Bioregion—Interior Plateau (Omernik 1987). However, several other distinct aquatic ecoregions surround the Little River and include eastern temperate forest, central USA plains, south-eastern USA plains, and Ozark-Quachita-Appalachian forests (Omernik 1995). Land-use in the region is primarily agriculture

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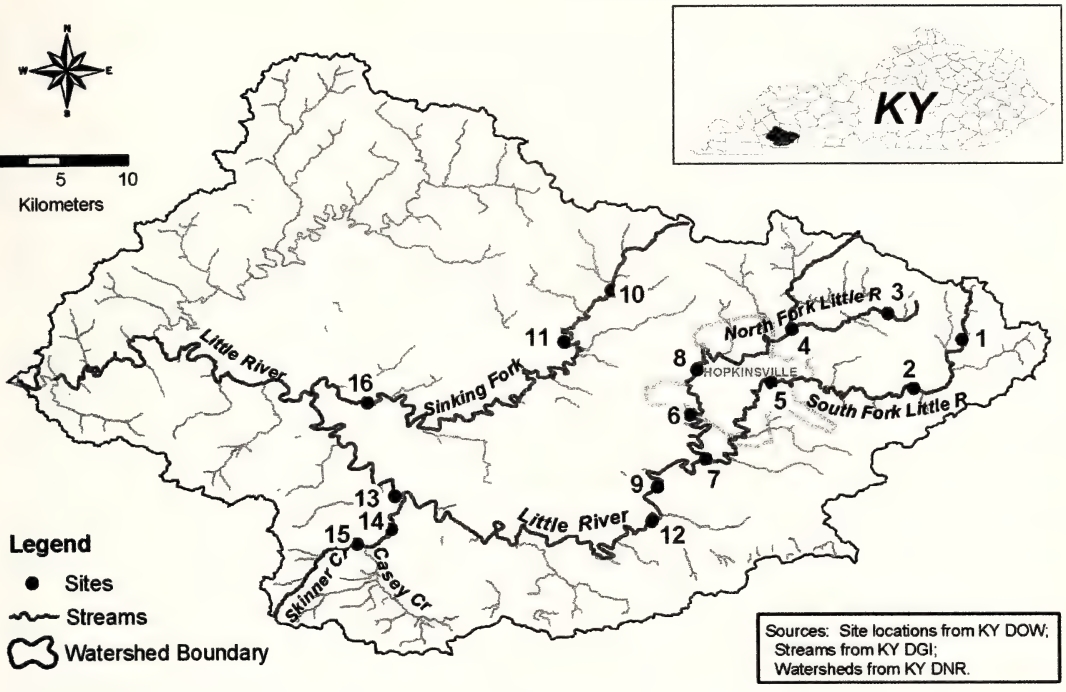

Figure 1. Study reaches in the Little River Basin. Sites 1, 2, and 5 are on the South Fork; sites 3, 4, 6, and 8 are on the North Fork; sites 7, 9, and 12 are on the main branch; sites 10, 11, and 16 are on Sinking Fork; sites 15, 14 and 13 are Casey/Skinner Creek.

consisting of row cropping and pasture. Considerable urban/suburban development has occurred in the headwater streams around Hopkinsville, KY, (population 40,000) and to a lesser extent around the town of Cadiz, KY. Nutrients, coliform bacteria, siltation, and urban and storm sewer runoff are the major non-point sources of serious impairment to the mainstem of the Little River (KWRRI 1999). Further, very little riparian corridor is left in the Little River drainage (KYGAP 2001).

Sixteen sites were sampled within the Little River and its tributaries in the Lower Cumberland River basin: three on Sinking Fork Creek, three on Skinner and Casey Creeks, three on the South Fork, four on the North Fork, and three on the Little River mainstem (Figure 1). Site numbers used in this study are those originally assigned by the Kentucky Division of Water for other assessment studies (KDOW 1996; White et al. 2001; Hendricks et al. 2006) and, although they are not in a sequence, they have been retained for future comparisons. Skinner/Casey Creek sites were chosen as references that represent relatively undisturbed conditions in the basin (White et al. 2001).

Geology in the basin is mostly karst, consisting primarily of limestone, sandstone, and shale. Because of the solubility of limestone, many springs, caves, and sinks are present (McGrain 1983). The springs produce a more constant base flow throughout the year; surface water temperatures in the summer tend to be variable yet cool for the spring–summer season (range 8–22°C). High alkalinities result in potentially higher biological productivity. Stream substrates varied from site to site, and were dominated by gravel, sand, bedrock and silt.

MATERIALS AND METHODS

Physicochemical measurements were recorded and benthic diatoms and water samples were collected at all Little River sites in June and September of 2000 and again in May and September of 2003.

Water Chemistry

Temperature, dissolved oxygen, pH, turbidity, and specific conductance were recorded at each site using a multi-parameter water quality monitoring instrument (YSI 6820). Stream discharge was measured using a Marsh McBirney 201 D PWCM flow meter. Water samples were filtered in the field (Swinnex GF/C filter-syringe system) into acid-cleaned linear polyethylene bottles and transported on ice to the laboratory where they were analyzed for soluble reactive phosphorus, nitrate+nitrite nitrogen, silica, chloride, and sulfate in accordance with APHA (1998) procedures.

Diatoms

Composite, qualitative algal samples were taken at all sites using methods outlined by KDOW (2002). All samples were collected from natural substrata when stream flow was normal to low. All major habitat and substrate types were sampled including riffles, pools, runs, rock, sand, plant, and woody debris. A micro-spatula was used to scrape substrates, and a turkey baster was used to suck materials from substrates. Algae were composited into 60 ml Nalgene™ bottles, preserved in 2% gluteraldehyde, and refrigerated until processed.

Diatom frustules were cleared of organic and intracellular material using a combination of the hydrogen peroxide/potassium dichromate oxidation method (APHA 1998) and the burn-mount method (Van Der Werff 1955). Five to 10 ml of sample were placed in a 1-liter beaker and oxidized with 100 ml of 30% peroxide (H_2O_2) for 24 hr. A micro-spatula of potassium dichromate (K_2Cr_2O) was added to the mixture, oxidizing all organic matter in 5 to 10 minutes and leaving only the diatom frustules. The mixture was allowed to settle for 24 hr, decanted, filled with distilled water, and allowed to settle again. The decanting-resettling process was repeated at least four times. Two to 6 ml of digestate containing cleared diatom frustules were evaporated onto glass coverslips and fixed on microslides in Zrax®, a highly refractive index medium dissolved in toluene (W.P. Dailey, University of Pennsylvania, dailey@sas.upenn.edu). A minimum of six slides was created for each sample. Because identification of taxa was qualitative, the transect method was used to assess the numbers of taxa and their relative abundances. Each coverslip was scanned from edge to edge, and valves were recorded until few or no new taxa were found. Scanning usually resulted in identification and enumeration of a minimum of 300–500 valves per slide (KDOW 1993).

Diatoms were keyed to species, and variety when possible, using standard taxonomic keys (Hustedt 1930; Patrick and Reimer 1966, 1975) and other references (Camburn et al. 1978; Crawford and Likhoshway 1999; Cumming et al. 1995; Håkansson 1993; Håkansson and Bailey-Watts 1993; Håkansson and Kling 1989, 1990; Håkansson and Chepurnov 1999; Hickel and Håkansson 1987; Krammer and Lange-Bertalot 1991, 1997; Round and Bukhtiyarova 1996). Nomenclatural changes (synonomies) were based on Stoermer et al. (1999), Guiry et al. (2005), and the California Academy of Sciences at http://www.calacademy.org/research/diatoms/genproject/ (Copyright 2001, last accessed November 2005). Taxa listed as species 1, 2, 3, A, B, C, etc. are commonly recognized by many taxonomists but are not yet described. All slides and preserved samples have been archived at the Hancock Biological Station for future reference.

RESULTS AND DISCUSSION

Physicochemical Conditions

Based on combined data from 2000 and 2003 (Table 1), discharge ranged from <0.05 m^3/s at upstream sites 1, 3 and 11 to >2.8 m^3/s at mainstem sites 9 and 12. Both gaining and losing reaches occurred throughout the Little River because of localized karst geology. Dramatic increases in discharge between sites 11 and 16 on the Sinking Fork resulted from a torrent spring emerging from a side tributary (Figure 1, Table 1). Basin-wide average water temperatures at the times of sampling ranged from 14.2°C at site 15 to 22.9°C at site 4. Lowest dissolved oxygen (DO) concentrations were found at site 4 (5.6 mg/liter) and highest at site 10 (10.9 mg/liter). pH was mostly neutral basinwide to slightly alkaline at site 13. Turbidity measurements reflected basin-wide suspended sediment inputs ranging from low turbidity at sites 11 and 14 (6–7 NTU) to high turbidity at site 1 (33 NTU). Specific conductance (SpC) ranged from a low of 186 µS at

Table 1. Physicochemical conditions at sixteen sites in the Little River basin. Sites are ordered from upstream to downstream within each reach (Fig. 1). Each mean is based on n = 3 or n = 4 measurements during summers of 2000 and 2003 unless otherwise noted (* denotes n = 2).

Site Codes	Discharge (m^3/s)	°C	DO (mg/L)	pH	Turb (NTU)	SpC (µS/cm)	SRP (mg/L)	$NO_3 + NO_2$ (mg/L)	SiO_2 (mg/L)	Cl (mg/L)	SO_4 (mg/L)
South Fork											
01	0.039	19.8	9.98	7.84	32.6	352	0.016	0.923	9.26	8.81	23.84
02	0.228	19.0	8.74	7.76	17.9	378	0.016	3.532	8.80	7.68	13.98
05	0.842	20.2	8.80	7.65	21.1	400	0.021	3.960	7.54	17.42	12.21
North Fork											
03	0.032	21.4	7.80	7.74	18.0	316	0.006	1.676	6.68	7.21	28.33
04	0.212	22.9	5.60	7.57	15.5	186	0.026	1.044	8.42	13.80	12.22
08	0.572	21.5	7.33	7.94	9.0	401	0.358	3.869	7.26	10.73	33.37
06	0.612	20.5	7.36	7.62	15.8	400	0.370	3.617	7.35	25.20	29.48
Mainstem Little River											
07	0.837	20.9	7.62	7.67	22.6	475	0.289	4.065	8.18	13.79	13.85
09	2.800	20.0	8.80	7.53	13.6	432	0.127	4.060	7.42	8.34	26.90
12	2.890	19.9	9.19	7.67	13.0	423	0.094	4.216	6.84	10.99	18.95
Sinking Fork											
10	0.076	20.3	10.90	7.83	18.6	310	0.017	1.889	8.39	6.83	20.45
11	0.024	16.0	7.84	7.74	7.2	343	0.016	2.405	8.40	7.81	18.88
16	2.098	19.2	9.42	7.73	17.6	334	0.030	4.728	8.17	6.08	6.03
Casey/Skinner Creek											
15	0.398	14.2	8.81	7.32	8.3	282	0.014	1.748	*7.18	*11.62	1.07
14	0.918	16.5	9.71	7.67	6.4	278	0.027	2.288	4.41	4.66	4.70
13	1.383	19.4	9.67	8.01	12.3	318	0.028	2.913	*6.56	*7.45	8.13

site 4 to a high of 475 µS at site 7 just downstream from Hopkinsville. The highest concentrations of soluble reactive phosphorus (SRP) occurred at sites 6–8 just downstream from Hopkinsville, while other sites had lower SRP concentrations more typical of streams with limestone parent geology. Nitrate+nitrite concentrations typically ranged from 1 to almost 5 mg/liter and indicated both impacts from urban and agricultural runoff. Silica (SiO_2) concentrations were typical of temperate zone streams and ranged from 6.5 to 9 mg/liter. Chloride concentrations reflected urban inputs and ranged from upstream concentrations around 7–8 mg/liter (sites 1–3) to concentrations of 10–25 mg/liter where urban development was the predominant land-use (sites 4–8). Sulfate was relatively high ranging from 12–33 mg/liter throughout the basin except at sites 14–16 where groundwater inputs, rather than surface water runoff, were of greater influence.

Algae

Two hundred and eighty-two diatom taxa were identified basin-wide in 2000 and 2003 combined (Table 2). Nine taxa identified to genus-only were noted; their species were unknown or were of uncertain identity. Several species, notably in the genera *Achnanthes, Gomphonema, Navicula, Nitzschia,* and *Surirella,* are known to occur, but have not yet been described; hence the notation 1, 2, 3 . . . or A, B, C . . . following genus.

Site 14 had the lowest number of taxa (72), while site 5 had the highest (125). Sites with >100 taxa include sites 4 (115 taxa), 6 (100 taxa), 7 (101), 8 (109 taxa), and 12 (103 taxa). Diatom taxa most commonly encountered at all 16 sites in the Little River basin included *Achnanthidium minutissimum, Amphora perpusilla, Cocconeis placentula* var. *euglypta, Gomphonema parvulum, Navicula cryptocephala, N. cryptotenella, N. menisculus, N. minima, N. seminulum, N. tripunctata, Nitzschia amphibia, N. dissipata, N. frustulum, N. palea, Planothidium lanceolata,* and *Sellophora seminulum.* Pennate diatoms dominated the flora (>96% of all taxa) throughout the basin. The two most common centric diatoms, *Cyclotella meneghiniana* and *Melosira varians* were found in 15 of 16 sites in the basin.

Table 2. Checklist of diatom taxa found in the Little River basin by site. Occurrences are noted from 2000 (x/) and 2003 (/x) or both (x/x). Sites are ordered from upstream to downstream in respective reaches and correspond with Figure 1.

	South Fork			North Fork				Little River			Sinking Fork			Casey/Skinner		
Sites	1	2	5	3	4	8	6	7	9	12	10	11	16	15	14	13
Taxa																
Achnanthes curtissima R.J. Carter		x/		/x		/x			/x		/x	/x	/x		/x	/x
A. linearis fo. *curta* H.L. Smith *ex* Boyer	x/	x/	x/	x/	x/	x/	x/		x/	x/	x/		x/	x/	x/	x/
A. lutheri Hust.							/x									
A. pusilla Grun. *in* Cleve & Grun.	x/x	/x	x/	x/		x/			x/x		x/x	x/x	x/x	x/x	x/x	/x
A. pinnata Hust.		/x	/x			/x		/x			/x					
Achnanthes species of unknown or uncertain identity															/x	
A. species 1	/x	/x									/x		x/		x/	/x
A. species 2	x/x	/x	x/x	x/	x/	x/	x/x	x/x	x/	x/	x/x			/x		x/x
A. species 3				/x			x/						/x			x/x
Achnanthidium lanceolata var. *frequentissima* (Cleve) Meister		/x											/x			/x
A. exiguum (Grunow) Czarn.			x/												/x	
A. exiguum var. *heterovalvum* (Krasske) Czarn.									x/							x/
A. microcephalum (Kütz.) *vide* Rebenh.		x/	x/										x/			
A. minutissimum (Kütz.) Czarn.	x/x	x/x	x/x	x/x	x/x	x/	x/x	x/x	x/x	x/	x/x	x/	x/	x/x	x/x	x/x
A. minutissimum var. *gracillima* (Meister) Lange-Bertalot	/x															
A. saprophilum (H. Kobayasi & Mayama) Round & Bukhtiy.	/x	/x		/x			/x		/x		/x	/x	/x	/x	/x	/x
Amphipleura pellucida (Kütz.) Kütz.		x/		/x						x/					x/	x/
Amphora inariensis Krammer			/x		/x											
A. ovalis (Kütz.) Kütz.			/x		x/							/x				
A. ovalis var. *affinis* (Kütz.) VanHeurck *ex* DeToni		x/	x/x	x/	x/									x/		
A. ovalis var. *pediculus* (Kütz.) VanHeurck *ex* DeToni			/x									/x				
A. perpusilla (Grunow) Grunow *in* VanHeurck	x/x	x/x	x/x	x/	x/	x/	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x
A. sabiniana C.W. Reimer										/x						
A. submontana Hust.	x/	x/	x/x	x/		/x		/x	/x	/x	x/x	x/x	/x			
Amphora species of unknown or uncertain identity		x/														
Asterionella formosa Hass.					/x	/x	/x									

Table 2. Continued.

	South Fork			North Fork				Little River			Sinking Fork			Casey/Skinner		
Sites	1	2	5	3	4	8	6	7	9	12	10	11	16	15	14	13
Aulacoseira ambigua (Grunow) Simonsen					/x	/x		/x								
A. distans (Ehrenb.) Simonsen						/x										
A. granulata (Ehrenb.) Simonsen					/x	/x	/x		/x	/x			/x			
A. granulata var. *angustissima* (O.Müll.) Simonsen					/x		/x	/x								
A. italica (Ehrenb.) Simonsen					/x											
Caloneis bacillum (Grunow) Cleve	/x	x/x	/x	/x	/x	x/x		x/x	/x	/x	/x	/x	/x	/x		
C. hyaline Hust.				x/		x/				x/	x/	/x				
C. lewissi var. *inflata* (Schultze) Patr.				/x												
C. ventricosa (Ehrenb.) F.Meister					/x											
Capartogramma crucicula (Grunow) R.Ross						/x										
Cocconeis pediculus Ehrenb.	/x	x/x	x/x	x/x	x/x	x/	x/	x/x	x/x	x/x	x/x	x/x	x/x			x/
C. placentula var. *euglypta* (Ehrenb.) Grunow	x/x	x/	x/x	/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	/x	x/x	x/x	
C. placentula var. *lineata* (Ehrenb.) VanHeurck	/x	x/x	x/	x/	x/	x/	x/	x/	x/	x/	x/	x/	x/	x/x	x/x	
Craticula cuspidata (Kütz.) D.G.Mann *in* Round, Crawford & Mann			/x	/x x/												
C. halophila (Grunow) D.G.Mann *in* Round, Crawford & Man					/x											
Ctenophora pulchella (Ralfs ex Kütz.) D.M.Williams & Round											/x					
Cyclostephanos dubius (Fricke) Round *in* Theriot, Håk., Kociolek, Round & Stoermer							x/	x/x		/x						
Cyclotella meneghiniana (Kütz.)	/x	x/x	x/x	x/x	/x	x/x	/x		/x	/x	x/x	x/x	/x	/x	/x	/x
C. ocellata Pant.									/x	/x						
C. pseudostelligera Hust.						/x	/x	/x	/x	x/		/x				
C. stelligera (Cleve & Grunow) VanHeurck					x/	/x		x/x								
Cymatopleura solea (Bréb. & Godey) W.Sm.		/x	x/	x/x	x/x									/x		
Cymbella cf. *affinis* Kütz.	x/	/x		x/x					x/x						x/	
C. cistula (Ehrenb. *in* Hemprich & Ehrenb.) Kirchn. *in* Cohn															x/x	x/

Table 2. Continued.

	South Fork			North Fork				Little River			Sinking Fork			Casey/Skinner		
Sites	1	2	5	3	4	8	6	7	9	12	10	11	16	15	14	13
C. elginsis Krammer				/x										x/		
C. hybrida Grunow										x/						
C. naviculaformis Auersw. *ex* Heib.	/x															
C. tumida (Bréb.) VanHeurck				/x				x/						x/x		
Cymbella species of unknown or uncertain identity	x/	x/														
Diadesmis confervacea Kütz.			x/		/x			/x				x/x	/x			
D. contenta (Grunow *ex* VanHeurck) D.G.Mann *in* Round, Crawford & Mann	/x		/x	/x	/x	/x	/x	/x	/x	/x			x/x	/x		/x
D. contenta var. *biceps* (Grunow *in* VanHeurck) Poulin					x/									/x		
D. perpusilla (Grunow) D.G.Mann *in* Round, Crawford & Mann												x/				
Diatoma vulgare Bory	/x															
Diploneis oblongella (Nägeli) R.Ross			x/	x/							x/					x/
Diploneis species of unknown or uncertain identity											/x					
Encyonema brehmii (Hust.) D.G.Mann *in* Round, Crawford & Mann						x/							/x			
E. mesianum (Cholnoky) D.G.Mann		x/	x/		x/					x/						
E. minutuma (Hilse *ex* Rabenh.) D.G.Mann *in* Round, Crawford & Mann	/x	/x	/x	x/x	/x		/x	/x	/x	x/x	/x	/x	/x	x/x	/x	/x
E. minutum **var.** *pseudogracilis* (Cholnoky) Czarn.									/x					/x		
E. silesiaca (Bleisch *ex* Rabenh.) D.G.Mann *in* Round, Crawford & Mann	/x	/x	x/x	x/x		x/				x/	x/			x/x	x/x	/x
E. triangulum (Ehrenb.) Kütz.				/x	x/	x/										
Entomoneis ornata (J.W.Bail.) C.W.Reimer					x/	x/										
Eunotia curvata (Kütz.) Lagerst.		x/														
E. tenella (Grunow) Hust.														/x		
Fallacia helensis (E.Schultz) D.G.Mann *in* Round, Crawford & Mann			/x		/x						/x	x/x				/x

Table 2. Continued.

	South Fork			North Fork				Little River			Sinking Fork			Casey/Skinner		
Sites	1	2	5	3	4	8	6	7	9	12	10	11	16	15	14	13
F. pygmaea (Kütz.) D.G.Mann *in* Round, Crawford & Mann			/x										/x			
F. subhamulata (Grunow *in* Van-Heurck) D.G.Mann *in* Round, Crawford & Mann	/x					/x										/x
Fragilaria capucina var. *mesolepta* Rabenh.					x/x			/x								
F. radians (Kütz.) D.M.Williams & Round				x/												
F. vaucheria (Kütz.) J.B.Petersen			/x					/x	/x	/x						
Frustulia rhomboides var. *capitata* (Mayer) R.M.Patrick										x/						
F. vulgaris (Thwaites) DeToni			/x			x/x				x/	/x			x/	x/	
F. weinholdii Hust.										x/						
Geissleria decussis (Østrup) Lange-Bert. & Metzeltin *in* Lange-Bert.	x/x	x/x	/x	x/x	/x				/x	/x		/x			/x	/x
Gomphoneis olivacea (Hornemann) P.A.Dawson *ex* R.Ross and P.A.Simms			/x				/x	/x	/x	/x		/x	/x			
Gomphonema acuminatum Ehrenb.															x/	
G. affine Kütz.		x/						x/			x/					
G. angustatum (Kütz.) Rabenh.	/x			/x	/x	x/		x/								
G. brasiliense Grunow			x/x			x/	x/x	x/x			/x	/x				x/x
G. gracile Ehrenb. emend. Van-Heurck	/x								/x							/x
G. intricatum var. *pulvinatum*	/x	/x	/x		x/x	/x	x/x	x/x	x/x	x/x		x/	x/x		x/	/x
G. minutum (C.Agardh.) C.Agardh.	/x	/x	/x	/x			/x	/x	/x	/x	/x	/x	/x			/x
G. parvulum (Kütz.) Kütz.	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/
G. sphaerophorum Ehrenb.											x/	x/				
G. subclavatum var. *mexicanum* (Grunow) R.M.Patrick									x/		x/					
G. truncataum Ehrenb.											x/					
Gomphonema species of unknown or uncertain identity															x/	
G. species 1												x/				
G. species 2									x/							
G. species 4					x/		x/									
Gyrosigma accuminatum (Kütz.) Rabenh.			x/				x/							x/		x/

Table 2. Continued.

	South Fork			North Fork				Little River			Sinking Fork			Casey/Skinner		
Sites	1	2	5	3	4	8	6	7	9	12	10	11	16	15	14	13
G. attenuatum (Kütz.) Rabenh.			x/			x/	/x	x/x								x/
G. obtusum (Sull. & Wormley) Boyer	x/	x/x	x/x	x/x	x/x	x/x	x/x	x/x	/x	x/x	x/x	x/x	x/x	x/x	x/x	
G. spencerii var. *curvula* (Grunow) C.W.Reimer	/x	/x	/x		x/x	x/	x/	/x			x/	/x				x/
Hantzschia amphioxys (Ehrenb.) R.M.Patrick			/x	x/x					/x		/x	/x		/x		
Hippodonta capitata (Ehrenb.) Lange-Bert., Metzeltin & Witkowski	x/x		/x	x/x	x/x	x/x		/x	x/x	x/x	x/	/x		/x		x/
Karayevia clevei (Grunow *in* Cleave & Grunow) Round & Bukht.				x/								x/				x/
Kobayasia subtilissima (Cleve) Lange-Bert.		x/	x/		x/											
Luticola mutica (Kütz.) D.G.Mann *in* Round, Crawford & Mann	/x	x/	/x		x/	/x			x/x				/x			x/
L. muticoides (Hust.) D.G.Mann in Round, Crawford & Mann						/x										
Melosira varians C.Agardh	x/		x/	x/	x/	x/	x/	x/	x/	x/	x/	x/	x/	x/	x/	x/
Meridion circulare (Grev.) A.Agardh	/x	/x	x/x	x/x		x/		x/		/x	x/	x/	/x	x/x	x/x	x/x
Navicula absoluta Hust.						x/										
N. atomus/subrotunda		x/	x/				x/	x/	x/	/x	x/		x/			x/
N. arvensis Hust.					x/						x/					x/
N. auriculata Hust.	/x	x/	x/			x/	x/	x/x		x/x	x/					
N. capitoradiata Germain	/x	/x	/x	/x	/x		/x	x/				x/x	/x	/x	/x	/x
N. cf. *caterva* Hohn & Hellermann										/x						
N. cryptocephela Lange-Bert.	x/x	x/x	x/x	x/x	x/x	x/x	x/x	/x	x/x	x/x	x/x	x/x	/x	x/x	x/x	/x
N. cryptocephela var. *veneta* (Kütz.) Rabenh.	/x		x/x	x/	/x				x/ x/x	/x				x/	x/	
N. cryptotenella Lange-Bert.	x/x	x/x	x/x	x/x	x/x	x/x	x/x	/x		x/x	/x	x/x	x/x	/x	x/x	x/x
N. erifuga Lange-Bert.			/x			/x							/x			
N. goeppertiana (Bleisch) H.L.Smith			x/x			/x	/x	x/x	/x	/x		/x	x/			x/
N. harderi Hust.								/x								
N. hustedtii Krasske					x/	x/	x/	x/					x/	x/	x/	x/
N. ingenua Hust.					/x	/x	x/x	x/x	/x							x/
N. integra (W.Sm.) Ralfs			/x							/x						
N. kotschyi Grunow							/x					/x				
N. laterostrata Hust.																x/
N. lenzii Hust.				x/	x/											
N. menisculus Schum.	/x	x/	x/	x/	/x	x/x	x/x	x/x	/x	/x	x/x	x/x	x/x	x/	x/x	x/x

Table 2. Continued.

	South Fork			North Fork				Little River			Sinking Fork			Casey/Skinner		
Sites	1	2	5	3	4	8	6	7	9	12	10	11	16	15	14	13
N. menisculus var. *upsaliensis* (Grunow *in* Cleve & Grunow) Grunow *in* VanHeurck	/x	/x	/x			x/		/x		x/x	/x		/x		/x	
N. minima Grunow	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x
N. minusculoides Hust.	/x															
N. mitigata Hust.								/x								
N. molestiformis Hust.	/x				/x											
N. notha J.H.Wallace			x/		x/								/x			
N. paucivisitata R.M.Patrick				x/	x/											
N. phyllepta Kütz.		/x		/x		/x			/x	/x				x/		
N. cf. *phyllepta*			x/													
N. pseudoreinhardtii R.M.Patrick									x/					/x		
N. pupula var. *nyassensis* (L. Müller) Lange-Bert.	/x															
N. rhynchocephala Kütz.			x/	x/						x/						
N. viridula var. *germainii* (J.H.Wallace) Lange-Bert.		x/	x/			x/	x/	x/			x/	x/			x/	
N. saxophila Bock ex Hust.	x/	x/	x/		x/				x/		x/	x/			x/	x/
N. saprophila Lange-Bert. & Bonik			x/					x/	x/							
N. schadei Krasske	/x	x/	x/x		/x	x/		/x	x/		x/x	x/x	/x		x/	/x
N. schmassmannii Hust.	x/			x/						x/						x/
N. schroeteri F. Meister	/x	/x	x/x	/x	/x	x/x	x/x	x/x	x/	/x	x/	/x	/x			/x
N. schroeteri var. *escambia* R.M.Patrick	x/		x/	x/						x/						x/
N. secreta var. *apiculata* R.M.Patrick	/x		/x	x/x	x/	x/x	x/x	x/x	x/x	x/x	/x	/x	x/	/x	/x	x/x
N. soodensis Krasske					/x											
N. subatomoides Hust.	x/	x/		x/												x/
N. sublucidula Hust.							/x									
N. subminuscula Hust.	/x	/x	x/x	x/x	x/x	x/x	x/	x/x	x/	x/	x/x	x/	x/x		x/	x/
N. submuralis Hust.						/x		/x								
N. symmetrica R.M.Patrick							x/									
N. tantula Hust.	/x	x/x	/x		/x		x/	/x	/x				/x	/x		/x
N. tenera Hust.		x/	x/x		x/	/x		/x						x/	x/x	x/
N. tennelloides Hust.	/x		x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/	x/	x/x	/x		
N. tripunctata (O.F.Müll.) Bory	/x	x/x	x/x	x/	x/x	x/x	x/x	x/x	x/x	x/x	/x	/x	x/x	x/	x/x	/x
N. trivialis Lange-Bert.	/x	x/x	/x	x/x	x/x	x/x	x/x	x/x	/x	/x		/x	/x	x/x	x/x	/x
N. veneta Kütz.	/x														x/	
N. viridula (Kütz.) Ehrenb.			/x		x/x				/x	x/x	/x	/x		/x		/x
N. viridula var. *linearis* Hust.	x/		x/	x/	x/	x/				x/						

Table 2. Continued.

	South Fork			North Fork				Little River			Sinking Fork			Casey/Skinner		
Sites	1	2	5	3	4	8	6	7	9	12	10	11	16	15	14	13
N. viridula var. *rostellata* (Kütz.) Cleve		/x	x/x	x/x	/x	/x	x/x	/x		x/	x/	x/	/x		/x	/x
N. viridula var. *viridula* (Kütz.) Kütz. Emend. V.H.							x/									
Navicula species of unknown or uncertain identity	/x		/x				/x	/x								
N. species 1			/x					x/		x/			/x	/x		
N. species 2													/x			
N. species 3		x/	/x	x/	x/	x/							x/x	/x		
N. species 4			x/x	x/	x/			x/	/x		x/					/x
N. species 6			x/													
N. species 7			x/	x/	/x											
N. species 8	x/		x/													x/
N. species 9a	/x	/x	/x		x/x		/x	x/x	x/							x/
N. species 10						x/	x/	x/					x/			
N. species 11													x/			
N. species 12			x/		x/						x/					
N. species 13																
N. species 14								x/								
N. species 15									x/							
N. species 16								x/								
Neidium affine (Ehrenb.) Pfitz.					/x									/x		
Neidium affine var. *longiceps* (W.Greg.) Cleve							/x									
Neidium binodis (Ehrenb.) Hust.			x/			x/x		x/								
Nitzschia acicularis (Kütz.) W.Sm.				/x	/x		/x							/x	/x	
N. amphibia Grunow	x/x	x/x	x/x	x/	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/	x/x	x/	x/
N. capitellata Hust.	/x	/x	x/		x/	x/x	/x		/x		/x	/x				/x
N. clausii Hantzsch	/x				/x		/x									
N. c.f. *commutata* Grunow		/x														
N. constricta (Kütz.) Ralfs	/x	/x		/x	/x	/x			/x	/x	/x	/x				
N. denticula Grunow				x/x			/x		/x		/x					
N. dissipata (Kütz.) Grunow	/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x
N. dissipata var. *media* (Hantzsch) Grunow						/x	/x	/x								/x
N. flexa Schum.										x/						
N. fonticola Grunow	/x		/x				x/			/x	/x	/x		x/x	x/x	/x
N. frutulum (Kütz.) Grunow	x/x	x/x	x/x	x/	x/	/x	x/x	x/x	x/x	x/	x/x	x/x	x/x	x/x	/x	x/x

Table 2. Continued.

	South Fork			North Fork				Little River			Sinking Fork			Casey/Skinner		
Sites	1	2	5	3	4	8	6	7	9	12	10	11	16	15	14	13
N. gracilis Hantzsch			x/	/x						/x				/x		
N. hantzschiana Rabenh.									/x							
N. ignorata Krasske								/x		/x						
N. linearis (C.Agardh) W.Sm.	/x		/x	x/x	x/	x/	/x	x/x		x/x	x/	/x		x/x	x/x	
N. incurvata var. *lorenziana* R.Ross						x/										
N. palea (Kütz.) W.Sm.	x/x	/x	x/x	x/x	/x	/x	/x	/x	/x	x/x	/x	x/x	x/x	x/x	x/x	/x
N. palea var. *tenuirostris* Grunow				/x												
N. parvula W.Sm.	/x	/x				/x						x/	/x	/x		x/
N. perminuta (Grunow) M.Perag.			/x	/x	x/	x/	x/			x/				x/	x/	
N. recta Hantzsch		x/x					x/			/x						
N. sigma (Kütz.) W.sm.								/x								
N. sigmoidea (Nitzsch) W.Sm.			x/		x/								x/			
N. sinuata var. *tabellaria* (Grunow) Lange-Bert.			/x	x/x	x/						/x		x/			
N. vermicularis (Kütz.) Hantzsch			x/			x/						x/			x/	
Nitzschia species of unknown or uncertain identity																
N. species 1			x/													x/
N. species 2			x/	x/			x/	x/		x/	x/					
N. species 3	/x						x/									
N. species 4	/x	x/	x/x	/x	x/	x/	x/			x/	x/x	x/x		x/	x/	x/
N. species 5		x/	x/x		x/	x/x		x/	/x	x/x	x/	/x	x/x		/x	x/
N. species 6							x/	x/								
N. species A		x/	x/	/x		x/	x/		x/							x/
N. species B																/x
N. species C	x/	x/x	x/x	x/x	x/	x/x	x/x	x/	x/	x/x			x/	/x	x/	x/
N. species D			x/	x/					x/							
N. species E		x/	x/x	x/	/x	x/			x/							x/
N. species F	x/x	/x		/x	x/x	/x	/x	x/	/x	/x			x/	x/x	x/	
N. species G						/x							x/			
N. species H	/x			/x										/x		
Pinnularia microstauron (Ehrenb.) Cleve	/x							/x								
P. biceps W.Greg.						x/x						/x				
P. legumen (Ehrenb.) Ehrenb.										/x						
P. nodosa (Ehrenb.) W.Sm.														/x		
P. subcapitata W.Greg.							/x									

Table 2. Continued.

	South Fork			North Fork				Little River			Sinking Fork			Casey/Skinner		
Sites	1	2	5	3	4	8	6	7	9	12	10	11	16	15	14	13
P. subcapitata var. *paucistriata* (Grunow) Cleve														/x		
Pinnularia species of unknown or uncertain identity					x/											
Placoneis clementis (Grunow) E.J.Cox						/x						/x				
P. elginensis (W.Greg.) E.J.Cox					/x			/x		/x						
P. gastrum (Ehrenb.) Mersechk.							x/									
P. placentula (Ehrenb.) Heinzerl.						/x										
Planothidium hauckianum (Grunow) Round & Bukht.		x/	x/	x/		x/	x/	x/								x/
P. lanceolata (Bréb.) Round & Bukht.	x/x	x/x	x/x	x/x	x/x	x/x	x/	x/x	x/x	x/x	/x	/x	x/x	x/x	x/x	x/x
P. dubium (Grunow) Round & Bukht.		x/x	x/x		/x			x/	x/	x/	x/x	x/x	x/x	x/x	x/x	/x
Psammothidium abundans fo. *rosenstockii* (Lange-Bert. *in* Lange-Bert. & Krammer) Bukht.		/x	/x								/x	/x	/x	x/x	x/x	x/
Reimeria sinuata (W.Greg.) Kociolek & Stoermer				x/		x/x	x/x	x/x	/x	/x	/x		x/	/x	x/x	/x
Rhoicosphenia curvata (Kütz.) Grunow	x/x	x/x	x/x	/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	x/x	/x		x/x
Rhopalodia gibba var. *ventricosa* (Kütz.) Perag. & M.Perag.											x/					
Sellaphora mutata (Krasske) Lange-Bert.					x/					/x						
S. paraapupula Lange-Bert.														/x		
S. pupula (Kütz.) Mereschk.	x/	x/	x/x		x/x	x/x	x/	x/x	x/x	x/x	/x	x/x			/x	/x
S. pupula var. *elliptica* (Hust.) Poulin *in* Poulin, Hamilton & Proulx										/x						
S. seminulum (Grunow) D.G.Mann	/x	/x	x/x	/x	/x	x/x	x/x	x/x	/x	/x	/x	/x	x/x	/x	x/x	x/x
Stauroneis anceps Ehrenb.				/x										/x		
S. ignorata var. *rupestris* (Skv.) Reim.													/x			
S. smithii Grunow			/x	x/	/x	x/x		/x	/x	x/x		/x	/x	x/		
Staurosira construens Ehrenb.															x/	
Staurosirella leptostauron (Ehrenb.) D.M.Williams & Round								/x		/x					/x	/x
Stephanodiscus hantzschii Grunow					/x		/x	/x								
S. hantzschii fo. *tenuis* (Hust.) Håk. & Stoermer					/x		/x	/x		/x						
Surirella augusta Kütz.	/x	/x	x/x	x/x	x/x	x/x	/x		/x	x/x	x/	/x	x/	x/	/x	

Table 2. Continued.

	South Fork			North Fork				Little River			Sinking Fork			Casey/Skinner		
Sites	1	2	5	3	4	8	6	7	9	12	10	11	16	15	14	13
														x/x		
S. brebissonii Krammer & Lange-Bert.	x/x	x/x	x/x	x/x	x/x	x/x	/x	x/	/x	x/x	/x	/x			x/x	/x
S. linearis W.Sm.					x/					x/		x/				
S. linearis var. *helvetica* (Brun) F.Meister			/x			/x							/x			
S. minuta Bréb. *in* Kütz.			/x			/x	/x									/x
S. ovalis Bréb.						x/x				x/						
S. ovata var. *apiculata* W.Sm.						/x			/x		/x	/x		/x	/x	
S. ovata var. *pinnata* (W.Sm.) Rabenh.	/x		x/x	/x	/x	x/x	/x	x/	/x	x/				x/x	x/x	
S. tenera var. *nerosa* W.Greg.										x/						
Surirella species of unknown or uncertain identity																
S. species 1						x/	x/			/x				x/		
S. species 2					/x											
Synedra acus Kütz.	/x		/x	/x	/x					x/	x/					
S. delicatissima W.Sm.										x/						
S. miniscula Grunow *in* VanHeurck															/x	
S. parisitica var. *subconstricta* (Grunow) Hust.	/x	/x			x/		x/									
S. pulchella var. *lucenata*							x/									
S. rumpens Kütz.		x/			x/									x/		
S. rumpens var. *familiaris* (Kütz.) Hust.		x/x	/x	/x	x/x	/x	x/x	/x	/x	x/				x/x	x/	
S. rumpens var. *fragilariodes* Grunow							x/	/x								
S. meneghiniana					x/											
S. socia J.H. Wallace				/x										/x	x/x	
S. ulna (Nitzsch) Ehrenb.	x/x	x/x	x/x	x/x		x/	/x	/x	/x	/x	x/	x/x		x/x		
Tryblionella apiculata W.Greg.			/x	/x	/x	x/	/x	/x		/x		/x		x/		
T. gracilis W.Sm.			x/			x/	x/		x/							
T. hungarica (Grunow) D.G.Mann	x/						x/	x/x	/x							
T. levidensis W.Sm.					x/											x/
T. victoriae Grunow			x/	x/		x/			x/	x/						x/
Total number of Taxa	89	87	125	99	115	109	100	101	89	103	82	78	76	82	72	91

Some taxa occured in one year, but not the other, and some taxa occured at almost all sites within the basin during both sampling years. We have no explanation for this phenomenon except that sample composites made in May and September of 2003 may have been more representative of the total flora than those collected in June and September of 2000. A previous survey of the Little River diatom flora in 1988 identified 182 diatom taxa during one sampling period (KDOW 1996). Combined 2000 and 2003 data in the present study identified 100 additional taxa. The effect of combining all data from two sampling periods for the two years increased the total number of taxa encountered. For any single sampling period, however, total taxa encountered were very similar, e.g., 185 and 203 taxa in June and September of 2000, respectively, and 156 and 177 taxa in May and September of 2003, respectively. Further, unlike the previous study, the present study included additional species of unknown or uncertain identity in the total taxa count. Over 20% of the total taxa were encountered rarely in the samples, e.g., only once in either year. Several species of *Navicula* and *Pinnularia* fell into this rare category.

Camburn (1982) amassed a list of 513 taxa from Kentucky that included both benthic and planktonic forms from a variety of aquatic habitats including lakes, large rivers, streams, reservoirs, and wetlands. The number of benthic diatom taxa in the Little River appears to be more typical of eastern temperate/deciduous forest streams than of streams within other ecoregions. For example, 215 taxa were identified in eastern temperate forest streams in contrast with 156 taxa from Ozark-Quachita-Appalachian forest streams, 113 taxa from central USA plains streams, and 174 taxa from the south-eastern USA plains streams (Potapova and Charles 2002). Stevenson and Hashim (1989) found 233 taxa in a northern Michigan stream while Cooper et al. (2004) found 155 taxa in the Upper Ohio River basin and selected tributaries. Although the Little River shows greater abundance of diatom taxa than any of the streams cited above, high taxa numbers may be an artifact of the numerous samples collected within the basin and the amount of time spent scanning the prepared slides.

Along the North-South 'latitude optima' of Potapova and Charles (2002), two northern taxa occurred in the Little River: *Synedra parasitica* var. *subconstricta* at 4 sites and *Navicula tantula* at 10 sites. Three southern taxa occurred: *Synedra delicatissima* at one site, *Achnanthidium exiguum* var. *heterovalvum* at 2 sites, and *Gomphonema gracile* at 3 sites. The Little River appears to be sensibly strattling the divide between North and South in biogeographical representation of the latitude optima taxa.

CONCLUSIONS

Many of the 282 taxa found in the Little River are known to be tolerant of high nitrogen loads, organic pollution, and silt, particularly several *Navicula* and *Nitzschia* species (Lowe 1974; Patrick and Reimer 1966, 1975). With the exception of Casey and Skinner Creeks, the Little River is a highly disturbed system having had the riparian canopy opened for agriculture and urban development along much of its course and having increased non-point source nutrient inputs. A 1988 study revealed not only high nitrogen inputs during April and August, but also very high phosphorus loads (e.g., up to 0.63 mg/liter orthophosphate and 1.2 mg/liter total phosphorus in the North Fork and up to 1.58 mg/liter total phosphorus in the South Fork (KDOW 1996)). Our nutrient data confirm the findings of the 1988 study (Table 1). Further, sites with the highest number of taxa were also sites with high nitrate+nitrite nitrogen concentrations.

Although the Little River is a generally degraded riverine system with many non-point sources of pollution resulting in siltation, high turbidity, and high nutrient loading, the high number of taxa found basin-wide indicated that factors other than non-point inputs of silt and nutrients are controlling the diatom flora of the river. High nutrient loading at certain times of the year and a higher amount of sunlight may actually stimulate diatom growth and diversity in certain reaches. We do not completely understand the factors controlling diatom diversity in lotic systems (Potapova and Charles 2002; Mazor et al. 2006). Where relationships between diatoms and excessive nutrients, light, and channel and riparian disturbances are unclear, predicting stream water and habitat quality from diatom diversity alone should be viewed cautiously. However, we view this species checklist to be a springboard

for further studies of diatom species assemblages in the Little River that may lead to greater understanding of their role as water quality indicators in similar Kentucky streams and rivers within an ecoregion context.

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Status and Changes of Ohio River Fish Assemblages around William H. Zimmer Power Plant, Moscow, Ohio

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ABSTRACT

As a great river, the Ohio is an important natural resource. It is crucial that we understand the implications that human disturbances are having on the biological integrity of this ecosystem. By monitoring current conditions and the health of this ecosystem, we may be able to identify causes of degradation and potentially determine the stability of the ecosystem to human and natural alterations. In this study, we analyzed fish data collected in 1982–1986 and 2001–2005 to characterize the current fish assemblage around William H. Zimmer Power Plant, Moscow Ohio and investigate any long-term (past 20 years) and short-term (past 5 years) effects of disturbance in this area. During these two 5-year study periods, over 30,000 individuals were collected comprising 12 families and 60 species. We found that many metrics of the Ohio River Fish Index have improved over the past 20 years and the fish assemblages have remained stable over the past 5 years. Despite apparent stability, we found a decrease in invertivores and detritivores over the past 20 years and a declining trend in the Shannon-Weiner Diversity Index over the past five years. Data suggest a potential negative trend in the biological integrity of this area. The need for more data concerning the possible negative impacts of human disturbance on fish assemblages in this area of the river is apparent.

KEY WORDS: Ohio River, fish assemblages, electrofishing, great river, Ohio River Fish Index

INTRODUCTION

Increasing human populations and their demand for large amounts of clean water have degraded our nation's waterways, resulting in a need for protection of this country's aquatic ecosystems. In the United States, large floodplain rivers (referred to as great rivers) comprise the largest quantity of freshwater lotic aquatic resources. However, most of the largest rivers in the United States, such as the Ohio River, have been disproportionately degraded due to human disturbance (Benke and Cushing 2005; Karr et al. 1985). The Ohio River begins at the confluence of the Monongahela and Allegheny rivers. It flows in a southwestern direction until it joins the Mississippi River in Cairo, Illinois. Nearly 10% of the United States population (roughly 25 million people) resides along the Ohio River basin (Emery et al. 2003b). Currently, 20 high lift dams provide a 2.75 meter minimum depth for commercial navigation where about 250 million tons of cargo are transported each year (Emery et al. 2003b). As a great river, the Ohio has been affected by human presence in numerous ways. Prior to 1950, water quality in the Ohio River was in a continual decline. This degradation is attributable deforestation, agriculture, mining, industrialization and urban sprawl (Emery et al. 2003a). Starting in 1950, with the wide spread use of sewage treatment, and the passage of the Clean Water Act of 1972, improvements in water quality (including dissolved oxygen, pH, and total and dissolved metals) and biological integrity (fish populations) were noted within the Ohio River (Cavanaugh and Mitsch 1989; Emery et al. 1998; Thomas et al. 2005).

Human disturbances can alter water quality, habitat structure, hydrological regime, energy flow, and biological interactions of large river ecosystems (Karr and Dudley 1981; Sparks 1995; Ward and Stanford 1989). Biological

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monitoring can be used to assess human disturbance, describe the current condition or health of a river and adjacent landscape, diagnose causes of degradation, determine needs for restoration, and assess the results of current restoration plans (Karr 1999). The Ohio River contains approximately 150 species of fish (Pearson and Pearson 1989). One of the best ways to assess human effects a large river ecosystem is to understand changes in the temporal and spatial composition and relative abundance of fish assemblages (Kwak and Peterson 2004; Karr 1999). Long-term biomonitoring may be one of the best ways to collect such data parameters.

In this study, we describe the current (2001–2005) fish assemblage in the Markland Pool of the Ohio River. Further, we compare these data with historic data (1982–1986) to examine potential impacts related to the William H. Zimmer Power Plant that began operation in 1991.

MATERIALS AND METHODS

Over the past 30 years, Thomas More College's Center for Ohio River Research and Education has been working with the Cinergy Corporation to examine fish assemblages in proximity to two power plants located on the Ohio River upstream from Cincinnati, Ohio (William H. Zimmer Power Plant near Moscow, Ohio and the W. C. Beckjord Power Plant near New Richmond, Ohio). Sites are located in the Markland Pool; however, the fish assemblage analyses focused on data collected at the William H. Zimmer Power Plant located approximately at river mile 444 (715 rkm).

Fishes were collected annually from 2001–2005 at four sample sites (two upstream and two downstream to the William H. Zimmer Power Plant). The upstream sites, 1 and 2, were located the same distance upstream as the downstream sites, 3 and 4, were located downstream, respectively. Each site was 500 meters in shoreline length, similar to the protocol of the Ohio River Valley Water Sanitation Commission (ORSANCO) for boat mounted electrofishing (ORSANCO 2000).

Because sampling methods are biased with respect to taxa, habitat morphology, and water conditions (Emery et al. 2003b); we used several methods including hoop nets, gillnets, and electrofishing to obtain a representative sample of the fish assemblage at each site. All samples were collected during late June to early August when flow conditions are usually stable. Electrofishing was preformed at least once a year at each site, while gillnets and hoop nets were left in the water for twenty days during each sampling period. Gillnet and hoop net locations were the same in all samples and were selected for comparable habitat and depth. Nets were set at similar distances from shore to allow for consistency among sites. Nets were checked twice daily over a 20-day period. Electrofishing was performed on the entire 500 meter site moving upstream in a serpentine pattern in order to incorporate all available habitats (Simon and Sanders 1999). ORSANCO (2000) found that 500 meters was a sufficient distance to achieve a sufficient catch per unit effort and characterize biological integrity, however, not sufficient enough to characterize biological diversity. Electrofishing was conducted at night because night samples have been shown to be more representative of species richness and abundance (Simon and Sanders 1999). All fish were identified to species, weighed, measured and were checked for deformities, erosions, lesions, and tumors (DELTS). One individual of each species was kept as a voucher specimen. Historically, the accepted method of determining the effect of an outfall on a stream was to compare the impacted area to an upstream, unimpaired site (Emery and Thomas 2003). However, in large rivers such as the Ohio, the assumption that the comparative sites contain the same microhabitats is hard to satisfy. Therefore, we treated the four sites as replicates rather than two upstream sites and downstream sites. Additionally, Qualitative Habitat Evaluation Index (Rankin 1989) scores were similar between all sites and throughout all five years (42–51), suggesting that habitats and subsequently fish assemblages should be similar among all sites.

The 2001–2005 data were analyzed using several indices developed to determine variations in fish assemblage structure. Structural indices such as species richness, species evenness (relative abundance), and Shannon-Weiner Diversity Index were calculated in order to describe the fish assemblage structure. Diversity indexes such as the Shannon-Weiner

Index are a combination of species richness and evenness. Although the Shannon-Weiner Diversity Index combines species richness and evenness, these were also evaluated separately in order to account for the effects of both. The Ohio River Fish Index score is an index of biological integrity (IBI) developed for the Ohio River that takes into account all the previously mentioned indices (Emery et al. 2003b). These indices are well documented for their effectiveness in detecting changes or status of fish assemblages associated with human or natural disturbances to aquatic ecosystems. The Ohio River Fish Index was applied to each site from all five years to determine any possible trends in fish assemblage structure over the years (Emery et al. 2003b). In order to determine differences in all of the above stated indices between sites and among years, an analysis of variance was used (PROC GLM: SAS Institute 1999).

In order to determine any potential long-term changes in fish assemblages following the operation of the power plant, fish assemblages observed in 2001–2005 were compared with those from 1982–1986. Collection methods were not consistent in the two study periods, notably in the 1982–1986 samples day shocking instead of night shocking, and no gillnet or hoop net sampling. Despite these differences, we believe that both time periods accurately represent the fish communities during these times and are useful in assessing major trends in fish assemblages.

RESULTS

In this study, over 30,000 fish were collected in all years (1982–1986, 2001–2005), comprising 12 families and 60 species (Table 1). Specifically from 2001–2005, 60 species offish from 12 families were collected. From 1982–1986,32 species from 10 families were collected (Table 1). Of all species collected in the 2001–2005 samples, the families Clupeidae and Cyprinidae comprised the majority of individuals and species present (>74%). The most abundant fishes collected in these later samples included gizzard shad *(Dorosoma cepedianum),* emerald shiner *(Notropis atherinoides),* freshwater drum *(Aplodinotus grunniens),* longnose gar *(Lepisosteus osseus),* channel shiner *(Notropis wickliffi),* and skipjack herring *(Alosa chrysochloris)* (Table 2). All other species comprised less than 5% of the relative abundance each year. Species richness over the past five years, ranged from 19 to 31 species (Table 3).

From 2001–2005, the assemblage remained consistent from year to year. We did not detect differences in species richness ($F_{4,24} = 1.65$; $P = 0.193$; Table 3) or species evenness ($F_{4,24} = 1.28$; $P = 0.305$; Table 3) among years. The total number of individuals collected (2001 = 279.5; 2002 = 743.1; 2003 = 415.8; 2004 = 467.2; 2005 = 760.5) varied from year to year, but differences were not significant ($F_{4,24} = 1.05$; $P = 0.401$; Table 3). We also did not detect any differences in Ohio River Fish Index scores among years ($F_{4,24} = 0.69$; $P = 0.603$; Table 3). Conversely, we found a decreasing trend in the Shannon-Weiner Diversity Index as the years progressed from 2001–2005, however the decrease was not significant ($F_{4,24} = 1.84$; $P = 0.155$; Table 3).

Of all species collected from 1982–1986, the families Clupeidae and Cyprinidae comprised the majority of individuals and species present (>91%) similar to the 2001–2005 samples. The six most abundant species in samples from 1982–1986 included emerald shiner, gizzard shad, skipjack herring, river carpsucker *(Carpiodes carpio),* freshwater drum, and longnose gar (Table 2). All other species comprised less than 1 % of the relative abundance each year. During both time periods (1982–1986; 2001–2005), the two most prevalent species were emerald shiner and gizzard shad.

Despite the many consistencies between the two time periods, differences in fish compositions were also apparent. We noted an increase in the percentage of redhorses *(Moxostoma spp.)* between 1982–1986 and 2001–2005 (1982–1986 = 0.3%; 2001–2005 = 1.0%). We also noted an increase in the total number of centrarchid species in the later time periods relative to the earlier periods (1982–1984 = 5 species; 2001–2005 = 11 species). The same trend is apparent in the number of intolerant species (1982–1984 = 6 species; 2001–2005 = 11 species), number of great river species (1982–1984 = 5 species; 2001–2005 = 10 species), percentage of nonnative individuals (1982–1984 = 0.2%; 2001–2005 = 2.2%), percentage of piscivores (1982–1984 = 5.2%; 2001–2005 = 19.6%),

Table 1. Summary of the fish species collected between 1982–1986 and 2001–2005 among sites located around the William H. Zimmer Power Plant, Moscow, Ohio (715 rkm).

Species	1982–1986	2001–2005
Silver Lamprey (*Ichthyomyzon unicuspis*)		X
Paddlefish (*Polyodon spathula*)		X
Shortnose Gar (*Lepisosteus oculatus*)		X
Longnose Gar (*Lepisosteus osseus*)	X	X
Goldeye (*Hiodon alosoides*)	X	X
Mooneye (*Hiodon tergisus*)	X	X
Skipjack Herring (*Alosa chrysochloris*)	X	X
Gizzard Shad (*Dorosoma cepedianum*)	X	X
Threadfin Shad (*Dorosoma petenense*)		X
Central Stoneroller (*Campostoma anomalum*)		X
Grass Carp (*Ctenopharyngodon idella*)		X
Spotfin Shiner (*Cyprinella spiloptera*)		X
Steelcolor Shiner (*Cyprinella whipplei*)		X
Common Carp (*Cyprinus carpio*)	X	X
Bighead Carp (*Hypopthalmichthys nobilis*)		X
Striped Shiner (*Luxilus chrysocephalus*)		X
Silver Chub (*Macrohybopsis storeriana*)	X	X
Golden Shiner (*Notemigonus crysoleucas*)		X
Emerald Shiner (*Notropis atherinoides*)	X	X
River Shiner (*Notropis blennius*)		X
Spottail Shiner (*Notropis hudsonius*)		X
Sand Shiner (*Notropis ludibundus*)		X
Silverband Shiner (*Notropis shumardi*)		X
Channel Shiner (*Notropis wickliffi*)	X	X
Suckermouth Minnow (*Phenacobius mirabilis*)		X
Bluntnose Minnow (*Pimephales notatus*)		X
Creek Chub (*Semotilus atromaculatus*)		X
River Carpsucker (*Carpiodes carpio*)	X	X
Quillback (*Carpiodes cyprinus*)	X	X
Highfin Carpsucker (*Carpiodes velifer*)	X	X
Northern Hogsucker (*Hypentelium nigricans*)		X
Smallmouth Buffalo (*Ictiobus bubalus*)	X	X
Bigmouth Buffalo (*Ictiobus cyprinellus*)	X	
Black Buffalo (*Ictiobus niger*)	X	X
Silver Redhorse (*Moxostoma anisurum*)	X	X
River Redhorse (*Moxostoma carinatum*)	X	X
Black Redhorse (*Moxostoma duquesnei*)	X	X
Golden Redhorse (*Moxostoma erythrurum*)	X	X
Shorthead Redhorse (*Moxostoma macrolepidotum*)		X
Blue Catfish (*Ictalurus furcatus*)		X
Channel Catfish (*Ictalurus punctatus*)	X	X
Flathead Catfish (*Pylodictis olivaris*)	X	X
White Bass (*Morone chrysops*)	X	X
Striped Bass (*Morone saxatilis*)	X	X
Hybrid Striped Bass (*Morone chrysops* × *saxatilis*)		X
Rockbass (*Ambloplites rupestris*)		X
Green Sunfish (*Lepomis cyanellus*)		X
Pumpkinseed Sunfish (*Lepomis gibbosus*)		X
Orangespotted Sunfish (*Lepomis humilis*)		X
Bluegill (*Lepomis macrochirus*)	X	X
Longear Sunfish (*Lepomis megalotis*)	X	X
Smallmouth Bass (*Micropterus dolomieu*)	X	X
Spotted Bass (*Micropterus punctulatus*)	X	X
Largemouth Bass (*Micropterus salmoides*)	X	X
White Crappie (*Pomoxis annularis*)		X
Black Crappie (*Pomoxis nigromaculatus*)		X
Rainbow Darter (*Etheostoma caeruleum*)	X	
Greenside Darter (*Etheostoma blennioides*)		X
Logperch (*Percina caprodes*)	X	X
Sauger (*Sander canadensis*)	X	X
Walleye (*Sander vitreus*)		X
Freshwater Drum (*Aplodinotus grunniens*)	X	X

Table 2. Percent relative abundance of the seven most common species for 1982–1986 and 2001–2005 among sites located around William H. Zimmer Power Plant, Moscow, Ohio (715 rkm).

Species	Percent relative abundance	
	1982–1986	2001–2005
Longnose Gar (*Lepisosteus osseus*)	0.95	7.78
Skipjack Herring (*Alosa chrysochloris*)	2.20	4.42
Gizzard Shad (*Dorosoma cepedianum*)	44.14	28.13
Emerald Shiner (*Notropis atherinoides*)	45.52	21.91
Channel Shiner (*Notropis wickliffi*)	0.21	6.77
River Carp sucker (*Carpiodes carpi*)	1.24	0.99
Freshwater Drum (*Aplodinotus grunniens*)	1.16	10.39

and percentage of simple lithophilic individuals (1982–1984 = 0.6%; 2001–2005 = 9.2%). We also noted a decrease in the percentage of tolerant individuals (1982–1984 = 0.6%; 2001–2005 = 0.07%), percentage of invertivores (1982–1984 = 46.2%; 2001–2005 = 29.4%), and number of detritivores (1982–1984 = 46.5%; 2001–2005 = 31.0%) in the later time period.

DISCUSSION

Karr and Dudley (1981) define biotic integrity as the ability to support and maintain "a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region." Systems with biotic integrity are more resistant and resilient to natural disturbances and may withstand substantial human influences (Kwak and Peterson 2004). Since the channelization and impoundment of the Ohio River occurred before many of today's more advanced research methods were developed, it is hard to understand what the structure of the Ohio River fish population once was other than what species were present (Pearson and Pearson 1989). Currently, we know the structure of the fish assemblages only after many years of both natural and anthropogenic disturbance have occurred.

We believe that the data collected between 2001 and 2005 accurately characterize the fish assemblages near the William H. Zimmer Power Plant today. Since we did not detect any differences in species evenness, richness, Shannon- Weiner Diversity Index, or IBI scores, we suspect that the fish assemblage structure of this site has remained relatively consistent over the past five years. This is not surprising, because this stretch of the Ohio River has remained relatively unchanged with no major alterations due to human disturbance during this time period.

Table 3. Mean Ohio River Fish Index (ORFIn), species evenness, species richness, Shannon-Weiner Diversity Index, and total number of individuals for 2001–2005 for all sites (1–4) located around the William H. Zimmer Power Plant, Moscow, Ohio (715 rkm).

Year	ORFIn	Species evenness	Species richness	Shannon-Weiner diversity	Total individuals
2001	35.5	0.74	26.0	2.43	1118
2002	36.0	0.70	26.6	2.29	2974
2003	39.0	0.65	26.5	2.14	1663
2004	38.2	0.62	22.4	1.93	2110
2005	37.8	0.60	23.9	1.89	3043

Biotic indices were developed to describe or quantify ecological integrity utilizing known or suspected relationships between indicator species and their environment (Kwak and Peterson 2004). The particular biotic index used in this study was specifically designed for the Ohio River and was corrected for the river mile of the sites (Emery et al. 2003b). This index has been used by ORSANCO for several years and is efficient at detecting changes in the fish assemblages around outfall areas and other areas of disturbance caused by human activity (Emery and Thomas 2003). The Ohio River Fish Index is a multimetric index that takes into account several aspects of what a healthy Ohio River fish assemblage should display. The 13 metrics cover multiple areas of fish assemblage structure including species richness, pollution tolerance, breeding habit, feeding habits, fish health, and abundance (Emery et al. 2003b). These six areas were chosen to reflect biological and habitat integrity, trophic complexity, and future restoration and recovery (Emery et al. 2003b). Using the multiple metrics of the index allows us to better understand potential changes in the fish assemblages near the power plant over the past 20 years.

When comparing the fish assemblage data

from 1982–1986 (i.e., before the power plant became operational and the introduction of zebra mussels) to the past five years, there is an increase in the number of total species, redhorses, centrarchids, intolerant species, great river species, and percentage of simple lithophilic breeders. The switch from day to night electrofishing may account for some of these changes. Night sampling can yield a greater diversity of fishes as compared to day sampling (Sanders 1992). In addition, an increase in these metrics suggests a general overall improvement in fish assemblages recovering from prior disturbances. Similar results were also found in a 4–5 year lockchamber study on the Ohio River. Thomas et al. (2005) found a positive correlation among time and number of species, number of catostomids, number of intolerant species, number and percentage of great river species, percent piscivores, and total biomass. In addition, a negative correlation was found among time and percent tolerant species, percent nonindigenous species, percent simple lithophils, percent detritivores, and percent invertivores.

Although these metrics show a positive trend in fish assemblages, there was an increase in the percentage of nonnative species (especially among the piscivores). This may be due to stocking of several nonnative game species such as striped bass *(Morone saxatilis)* and hybrid striped bass *(M chrysops* × *M saxatilis).* The presence of these nonnatives could have negative impacts on fish populations due to increased predation and competition, however, more research is necessary (Valdez and Leibfried 1999). We also noted a decrease in the number of invertivores and detritivores during the 2001–2005 period. This decline appears to be attributed to a decrease in the number of individuals of the dominant species (gizzard shad). The introduction of striped bass and hybrid striped bass was in part to initiate biological control of gizzard and threadfin shad, and these species have been shown to be effective predators of gizzard and threadfin shad (Dettmers et al. 1998; Ostrand et al. 2001; Walter and Austin 2003). The decrease in gizzard shad numbers may be attributed to the introduced predators. In addition, because striped bass and hybrid striped bass occupy open water habitat, similar to emerald shiners, they may also effectively prey on this native fish species. However, the noted decrease in gizzard shad and emerald shiners also could be attributed to the introduction of zebra mussels.

Zebra mussels have been documented to cause declines in phytoplankton (Nalepa and Fahnenstiel l995) and zooplankton (Bridgeman et al. 1995), the primary food source of invertivores such as emerald shiners. In addition, zebra mussels are thought to cause shifts in organic matter from pelagic to benthic, ultimately disrupting the primary productivity necessary for many fish (Jude and Leach 1999) such as gizzard shad, a pelagic detritivore species. Increased barge traffic associated with the power plant also could cause decreases of zooplankton and phytoplankton by increasing erosion and turbidity. Increases in turbidity negatively impact sight feeding invertivores (i.e., emerald shiners), resulting in lower abundances (Bonner and Wilde 2002). Increased siltation also results in loss of suitable habitat for many invertebrates relying on rock beds and riffle zones (Heruey et al. 2000). While overall turbidity levels in the Ohio River have decreases partially due to no-till agriculture, the turbidity levels around the power plant have not due to the nearby barge traffic. Therefore, these changes in the Ohio River (Le., introduction of zebra mussels and increased barge traffic) could be negatively impacting these species that require certain conditions in order to effectively obtain food.

Besides resulting in declines of several native species, the introduction of zebra mussels also may provide an increased food source for other native species such as the freshwater drum. It has been shown that in areas where zebra mussels were abundant, freshwater drum preyed heavily upon them (French and Love 1995). This higher food availability could ultimately cause an increase in freshwater drum populations as seen between the 1980s and the present.

Although, the differences in collection methods and individuals collecting between the two time periods could cause some of the above differences, we believe that data collected accurately characterize the fish assemblages near the William H. Zimmer Power Plant, and therefore, we conclude that the trends seen are accurate representations of the fish community. It is important to note

that our study is limited in geographic range and time span, and more extensive research is needed to further determine the effects human and natural disturbance are having on the biotic integrity of other sites along the Ohio River.

SUMMARY

Karr et al. (1986) defined an aquatic ecosystem as healthy when its inherent potential is realized, conditions remain stable, it is able to regenerate after disturbance, and minimal external help is needed to sustain these. In this area of the Ohio River, there is a great deal of disturbance with the presence of a coal-burning power plant and the introduction of nonnative species such as zebra mussels. From this study, it can be suggested that fish assemblages in this area have been stable in the past five years and have rebounded in many metrics over the past 20 years. Despite this, there is some indication of a decline in biological integrity, with the decrease in invertivores and detritivores over the past twenty years and a declining trend in the Shannon-Weiner Diversity Index over the past five years. The need for more research on the biological integrity of this great river becomes essential in order to understand the potential impacts human disturbance is having on this large river. Because there are very few large rivers and all have been highly impacted by human disturbance, there is a great need to not only protect these aquatic resources, but to understand the complex biological interactions and the effects human activity are having on them.

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Abstracts of Some Papers Presented at the 2005 Annual Meeting of the Kentucky Academy of Science

Edited by Robert J. Barney

LANDSCAPE DYNAMICS IN THE BLUEGRASS REGION OF KENTUCKY

Thursday Evening Symposium

Landscape dynamics in the Bluegrass Region of Kentucky. RYAN W. MCEWAN, Department of Environmental and Plant Biology, Ohio University, Athens, OH 45701.

The Bluegrass Region of Central Kentucky contains vegetation that E. L. Braun described as "unlike any existing forest" in the eastern United States. This vegetation has been described as "Savanna-Woodland" and is characterized by large trees such as bur oak (*Quecrus macrocarpa*) and historically had an understory in which giant cane (*Arundinaria gigantea*) and running buffalo clover (*Trifolium stoloniferum*) were prominent. This ecosystem has been practically destroyed by human practices such as agriculture and shopping mall development. Much research has been done on this ecosystem over the last twenty years; however, a consensus as to the original composition of the system and the ecological factors that led to its formation (e.g., burning by Native Americans) has not been reached. The need to synthesize the existing body of knowledge on the landscape ecology of central Kentucky has been heightened by the ongoing efforts at several Kentucky sites to restore "Bluegrass Savanna-Woodland." Successful restoration is more than creating galleries of large interesting trees; these efforts must address ecosystem structure and function. Restoration efforts, therefore, depend upon establishing reference conditions for the central Bluegrass Region. This, in turn, requires a condensation of the existing knowledge on this system into a clear ecological picture. The following series of abstracts resulted from a symposium entitled *Landscape Dynamics in the Bluegrass Region of Kentucky*, which was an attempt to synthesize the current body of knowledge about "Bluegrass Savanna-Woodland" and to lay the groundwork for ongoing restoration efforts.

Pre-history of the Bluegrass Region: Pre-settlement. A. GWYNN HENDERSON, Kentucky Archaeological Survey, 1020A Export Street, Lexington, KY 40506–9854.

Humans have inhabited the Bluegrass Region of Central Kentucky for over 10,000 years. Therefore, the term "pre-settlement" should to be amended to "pre-*European* settlement" when researching this unique landscape's original composition and the factors involved in its formation. The most relevant prehistoric period of human impact to target for this research is ca. A.D. 1600 to 1780, the time of indigenous and early colonial agrarian peoples. The earliest prehistoric hunter-gatherers would have left little trace in the environment. But after 1000 B.C., hunter-gatherer-gardeners would have begun to manipulate the environment through their gardening and mound/earthwork building activities. However, the prehistoric farmers would have had the most impact on the Bluegrass environment. These Fort Ancient groups hunted and gathered, as had their ancestors. But they also built villages and planted fields of predominantly corn, beans, and squash in Central Kentucky for about 700 years, until the first smallpox pandemic arrived in the region, decimating these native groups. These swidden horticulturalists used fire to clear the land and moved their communities about every 25–30 years, enhancing the forest edge environment. Multi-disciplinary research consisting of consulting ethnographic and ethnohistoric sources and incorporating additional archaeological survey of targeted areas in the Bluegrass will help contribute important new insights into this fascinating topic.

The largely forested Bluegrass plains of 1770–1780: fertile ground for advancing dynamic models. JULIAN CAMPBELL, The Nature Conservancy, 642 West Main Street, Lexington, KY 40508.

Multiple lines of evidence are used to investigate the vegetation that occurred on more fertile plains and rolling uplands of the central Bluegrass Region during the 18th Century. Interpretation of the paleoecological and archaeological context, historical accounts, early land surveys, early botany, current remnants, dendrochronology, and changes in land use, strongly suggests that this area was originally covered by woodland that varied from shady forest to savanna-like canelands. This gradient was probably controlled by patterns of disturbance, including ungulates, human effects and perhaps weather events. The most common woody species typical of relatively closed, shady (mesic) forest, covering about 30–40% of the landscape, were sugar (& black) maple and bitternut hickory, with minor amounts of northern red oak and basswood ("lin"), plus scattered ironwood (*Ostrya/Carpinus*) and spicebush in the understory. Trees typical of intermediate (submesic) woods, covering about 50% of the landscape, were Ohio buckeye, black walnut, hackberry, elms (white & red), ashes (white & blue), oaks (especially chinkapin & shumard) and shellbark hickory, with minor (but distinctive) amounts of mulberry and coffee tree, plus locally abundant pawpaw in the understory. These intermediate woods can be divided into a walnut/buckeye type and an ash/elm type, suggesting a secondary gradient related to palatability. Trees and shrubs typical of more open, brushy woodland, covering about 10% of the landscape, included bur oak, honey locust, black locust, cherry, plum, prickly ash and cane, which was dominant over several square miles on Cane Ridge and other areas.

Blue ash-oak savanna-woodland: then, now and? WILLIAM S. BRYANT, Department of Biology, Thomas More College, Crestview Hills, KY 41017.

At the time of European settlement of the Bluegrass Region of Kentucky, the upland landscape was a mosaic of several closed and open vegetation types. The blue ash-oak savanna-woodland, a type thought to have encouraged settlement, is still a puzzle to ecologists. Even though a number of pieces to that puzzle are known, the processes for maintenance of that system are still in question. Over 100 sites containing savanna-woodland remnants were located in the Inner Bluegrass, and a few in the Outer Bluegrass. In many of these remnants, all trees currently present were measured. Three species, blue ash, bur oak, and chinkapin oak, were clearly dominants of those remnants; however, as many as 21 tree species were found. Other than having the same dominants, other coincidences found were soil types (Maury or Lowell silt loams) and topography (<12% slopes). A resample of two of the savanna-woodland stands reported in 1980 showed an >80% similarity, however, a number of other stands were being lost for various reasons. If these communities were so prominent in the Bluegrass Region at the time of settlement, why were they not thoroughly described while they were still viable communities? The most probable answer is that those people who saw them mistook their openness to be a result of land use practices, rather than representing a natural system, thus there may have been a bias to describe the closed woodland communities.

Current vegetation cover and extent of Bluegrass savanna-woodland remnants in the Bluegrass Region. MARC EVANS* and BRIAN YAHN, Kentucky State Nature Preserves Commission, Frankfort, KY 40601.

The existing land use and vegetation cover of the Bluegrass Region reflects the intense human use of the past two centuries. Today, very little of the original vegetation cover exists. Of the 5.8 million acres that make up the Bluegrass Region, almost 47% has been converted to pasture while 64% of the Inner Bluegrass has been converted to pasture. The purpose of this survey was to document the extent and distribution of remnant Bluegrass savanna-woodland in the Bluegrass physiographic region. Current land use and vegetation cover of the Bluegrass was also examined. Occurrences of remnant savanna trees were located by aerial and vehicle surveys. Criteria for tree selection were based on species, size and shape. Only massive trees (over 90 cm DBH) with large, low spreading limbs of species typical of the blue ash—oak savanna community type (burr oak, chinkapin oak, white oak and blue ash) were recorded. Preliminary results show that 163 occurrences of remnant savanna sites were scattered within the Inner Bluegrass with very few located in the Hills of the Bluegrass or Outer Bluegrass. Additional surveys are needed in the Outer Bluegrass since this area was not covered as thoroughly. If these trees are remnants of a pre-settlement savanna-woodland landscape, then this unique community type was common and widespread within the Inner Bluegrass.

Where do we go from here? The Griffith Woods Restoration Project. JOHN J. COX, Department of Forestry, University of Kentucky, Lexington, KY 40506.

Considered the largest remnant and perhaps best example of the bluegrass savanna-woodland ecosystem in Kentucky, the 735-acre property known as Griffith Woods was purchased by The Nature Conservancy in 2003. The site currently includes a mixture of rare bluegrass savanna-woodland, old farm fields, and mesic woodlands. In 2004, over half the farm was purchased by the University of Kentucky, and has since been managed by the Griffith Woods Management Committee (GMAC), which includes representatives of the Kentucky State Nature Preserves Commission, The Nature Conservancy, and the University of Kentucky. The mission of GMAC is to preserve existing and restore missing ecological components and processes of the site, and to increase our knowledge, understanding, and appreciation of this globally endangered system through research, education, and extension—activities vital to its regional conservation. To accomplish this mission, a number of research and management challenges must be addressed. These include elucidation of key pre- and post-settlement factors that influenced the ecology of the savanna-woodland (e.g., disturbance regimes), implementation of a biotic inventory and subsequent establishment of monitoring protocols, identification of missing biota and determination of their reintroduction feasibility, and development of suitable methods to control exotic species, maintain existing desirables, and reestablish and promote extirpated biota. As Griffith Woods is restored, it will not only serve as the flagship for conservation of the Licking River watershed, it will generate information applicable for restoration of other areas of the globally endangered Bluegrass savanna-woodland ecosystem.

Temporal disturbance dynamics of Inner Bluegrass vegetation with special emphasis on Bluegrass savanna. MARTINA HINES, Kentucky Nature Preserves Commission, 801 Schenkel Lane, Frankfort, KY 40601.

The Inner Bluegrass region of Kentucky is characterized by rolling plains and fertile, deep, calcareous soils; a landscape ideally suited to support rich and diverse forests. However, based on early pioneer reports and botanical evidence, it has been speculated that at least some portions of this region pre-historically might have been dominated by oak savanna, a community type generally associated with xeric, thin soils. The reasons for this apparent paradox have been a source for speculation and attracted attention from many botanists. Over 200 years of intense agriculture and development in the region have resulted in a drastically altered landscape that provides few clues to structure and composition of pre-settlement plant communities. However, previous studies have described pre-settlement vegetation remnants and suggested a number of possible disturbance factors maintaining Bluegrass savanna, including grazing by large ungulates, drought, and natural and anthropogenic fires. Several disturbance factors were analyzed to determine under what

circumstances they could have contributed to the creation and maintenance of savanna in the Inner Bluegrass region during prehistoric times, and how this disturbance regime could have changed with European settlement and resulted in the landscape that exists here today.

Tree-ring analysis of remnant bur oak-blue ash vegetation in the Bluegrass Region of Kentucky. RYAN W. MCEWAN and BRIAN C. MCCARTHY, Department of Environmental and Plant Biology, Ohio University, Athens, OH 45701.

The Bluegrass Region of Central Kentucky contains vegetation characterized as "Savanna-Woodland," that is typified by the presence of large trees such as bur oak (*Quercus macrocarpa*), chinkapin oak (*Quercus muehlenbergii*) and blue ash (*Fraxinus quadrangulata*). Restoration of "Bluegrass Savanna-Woodland" has recently been initiated in several locations; however, little is known about the ecological factors that led to the formation of this ecosystem. We used tree-ring analysis to investigate the historical ecology of "Bluegrass Savanna-Woodland." Our objectives were *i)* to document the fire history of the Bluegrass Region of Kentucky, *ii)* to elucidate establishment dynamics in the remnant stands and *iii)* to examine patterns of suppression and release in existing trees as a proxy measure of historical canopy conditions. The oldest of the remnant trees were chinkapin oak and bur oaks that originated circa 1600, while blue ash stems from remnant tracks typically originated after 1750. Fire scars were not found on any of the stems sampled. All stems sampled that were older than 1780 exhibit a period of suppression extending from the pith of the sample and ending in dramatic release events that occurred in the early to mid 1800s. These events typically resulted in a tripling of the annual radial growth rate from levels typical of oaks suppressed under a forest understory (<1 mm/yr) to levels typical of open-grown stems (>3 mm/yr). This change in growth rate suggests a region-wide alteration of forest structure coincident with European settlement of central Kentucky.

Measuring vertical structure changes at Griffith Woods with LiDAR. ANDREW BERRY, Department of Biology, University of Kentucky, Lexington, KY 40506.

LiDAR is now emerging as a valuable tool for ecological research and forestry applications. LiDAR is a laser remote sensing technique that is used to record latitude (x), longitude (y), and elevation (z) of intercepted surfaces within a landscape. Photoscience, Inc. (Lexington, KY) conducted the inaugural LiDAR flight at Griffith Woods (Harrison Co., KY) in January of 2005. LiDAR was used to create a digital elevation model (1.28 m^2 pixel resolution) of the ground surface and a woody vegetation dataset (0.32 m^2 pixel resolution). The woody vegetation dataset was reclassified into 1.6 m height intervals in order to create vertical structure profiles for areas 50 m^2 based upon a grid overlay. A second LiDAR flight in January 2006 will enable change detection in the vertical structure profile over one year. Vertical accuracy and horizontal precision of the change detection will be tested on five sites: invasive shrub removal in a woodlot, invasive shrub removal in a savanna-woodland, beaver tree felling disturbance, georeferenced posts and branches, and controls. These tests will be used to determine if LiDAR can detect either positive or negative changes in vertical structure. This research will facilitate our ability to detect and measure changes in forest structure that are difficult to survey using traditional methods. Replication of spatially explicit vegetation data through successive LiDAR flights provides the capability to project 3-D (x,y,z) forest models into the 4-D (x,y,z, + time), allowing for a greater understanding of ecosystem processes and responses.

Factors that influence growth and survival of blue ash, *Fraxinus quadrangulata* (Oleaceae), in the Inner Bluegrass of Kentucky. K. J. WILKINSON*, P. H. CROWLEY and S. K. GLEESON, Department of Biology, University of Kentucky, Lexington, KY 40506.

The fitness and survival of transplanted blue ash, *Fraxinus quadrangulata* (Oleaceae), seedlings with control and no-competition treatments were measured in a degraded blue ash-oak savanna and an adjacent woodland habitat in the Inner Bluegrass of Kentucky. The lack of fire and replacement of the understory with introduced cool season grasses has altered the vegetation of the region. Restoration efforts are critical for the maintenance of the natural vegetation in the blue ash-oak savanna-woodland. *F. quadrangulata* is a native species of this region that has limited regeneration. The objectives of this study are to 1) quantify the differences in soil quality, light availability, and species composition between the three selected locations in a savanna-woodland habitat, 2) compare the effects of removal of competition to non-removal of competition on *F. quadrangulata* seedling performance within each treatment combination, and 3) determine how the structure of the community facilitates/inhibits *F. quadrangulata* growth and survival. Removal of competition should accelerate seedling establishment and this effect will vary across the fragmented landscape.

The development of "Woodland-Pasture" and "Savanna-Woodland" after settlement of the largely forested Bluegrass Plains in 1770–1780. JULIAN CAMPBELL, The Nature Conservancy, 642 West Main Street, Lexington, KY 40508.

After settlement, most native vegetation on the largely forested plains of the central Bluegrass Region was cleared for farmland and much of the remaining woodland became thinned out for "woodland pastures." Within remnants, sugar maple, bitternut hickory and other species typical of deeper shade declined greatly. Some species of intermediate woodland also declined eventually, including buckeye and pawpaw. Oaks and ashes, with lesser amounts of shellbark hickory and white elm, were left in woodland-pastures, allowing them to grow 2–3 times faster and develop widely spreading branches. White elm, white ash,

and to a lesser extent shellbark hickory and bur oak, are able to regenerate in modern farmland, but red elm, blue ash, chinquapin oak and perhaps shumard oak appear to prefer moderately shady, or perhaps less grazed, conditions for good regeneration. Black walnut, hackberry, cherry and black locust increased greatly in young successional woods. However, some species of more open conditions did not fare so well; honey locust, hawthorn, plum and other shrubby species have been reduced in farmland and are somewhat slow to recover. Almost all of the cane was converted to farmland and is rarely able to recover from remnants.

AGRICULTURAL SCIENCES

Capsaicinoids content of five hot pepper species. GEORGE F. ANTONIOUS, Kentucky State University, Land Grant Program, Department of Plant and Soil Science, 218 Atwood Research Facility, Frankfort, KY 40601.

The use of plant extracts for protecting crops has its roots in traditions from many cultures over along periods in history. The genus *Capsicum* (Family: Solanaceae) contains five commonly cultivated species. Literature suggests that extracts or powders from the fruit of pungent pepper varieties possess insecticidal activity due to a group of compounds collectively known as capsaicinoids. Limited information is currently available on the capsaicinoids content of the fruits of hot pepper accessions. Ninety hot pepper accessions were screened for their capsaicinoids content using gas chromatography (GC/NPD). Fresh fruits of *Capsicum chinense, C. frutescens, C. baccatum, C. annuum,* and *C. pubescens* were extracted with methanol, and analyzed for capsaicin, dihydrocapsaicin and nordihydrocapsaicin. Mass spectrometry of the fruit crude extracts indicated that the molecular ions at m/z 305, 307, and 293 which correspond to capsaicin, dihydrocapsaicin, and nordihydrocapsaicin, respectively, have a common benzyl cation fragment at m/z 137 that can be used for monitoring capsaicinoids in hot pepper fruit extracts. Concentrations of total capsaicinoids varied from not detectable to 11.2 mg fruit^{-1}. Statistical analysis revealed that accession PI-441624 (*C. chinense*) had the highest capsaicin content (2.9 mg g^{-1} fresh fruit) and accession PI-497984 (*C. frutescens*) had the highest dihydrocapsaicin content (2.3 mg g^{-1} fresh fruit). Accessions PI-439522 (*C. frutescens*) and PI-497984 contained the highest concentrations of total capsaicinoids. Quantification of capsaicinoids in the selected accessions allowed the identification of genotypes with high levels of total capsaicinoids and enabled the prediction of the amount of each component that can be obtained per kg and per acre of hot peppers produced. Accessions PI-441624, PI-497984, and PI-439522 were identified as potential candidates for the mass production of capsaicinoids, or for breeding of varieties having greatest capsaicin content.

Variations in antioxidant compounds among *Capsicum* accessions. DADDY N. BOATENG[1]*, GEORGE F. ANTONIOUS[1] and TEJINDER S. KOCHHAR[2], [1]Land Grant Program, Department of Plant and Soil Science, and [2]Department of Biology, Kentucky State University Frankfort, KY 40601.

Hot pepper (*Capsicum* species) is a source of dietary antioxidant compounds like phenols, ascorbic acid, and capsaicin. Many pepper species and cultivars have not been analyzed for the quantities of these important compounds. The objective of this investigation was to screen and select candidate accessions of hot pepper having high concentrations of phenolic compounds, ascorbic acid, and capsaicin for use as a source of phytochemicals of antioxidant activity or as parents in breeding programs. Mature fruits of seventeen hot pepper accessions of *Capsicum chinense* (PI-387833, PI-387836, PI-438622, and PI-585253), *C. baccatum* (PI-633754, PI-633755, PI-633756, PI-633757, PI-633834), *C. annuum* (PI-414729, PI-419133, PI-430490, Grif-14486, Grif-14487, and Grif-14513), and *C. frutescens* (PI-387834 and Grif-9320) were analyzed for their composition of total phenols, ascorbic acid, reducing sugars, and capsaicinoids (capsaicin and dihydrocapsaicin). Pronounced differences in capsaicinoids concentrations (from 0.6 to 10.6 mg fruit^{-1}) were found among accessions. Capsaicinoids concentrations were greatest (1.3 mg g^{-1} fruit) in PI-438622 and lowest (0.002 mg g^{-1} fruit) in Grif-9320. Accession Grif-14513 had the greatest fruit weight (37.6 g) and greatest concentration of total phenols, ascorbic acid, and reducing sugars. Fruit of this accession contained only 1.2 mg of capsaicinoids. The highest concentration of capsaicinoids (10.64 mg Fruit^{-1}) was found in accession PI-438622 of *C. chinensi.* Concentrations of total phenols (1.4, 1.3, and 1.3 mg g^{-1} fruit) and ascorbic acid (1.6, 1.2, and 1.3 mg g^{-1} fruit) were significantly higher in accessions PI-633757, PI-387833, and PI-633754, respectively, compared to other accessions analyzed. Our data suggest that great variability exists within and between *Capsicum* species for numerous phytochemicals with health-promoting attributes, and suggest that these traits might be manipulated via plant breeding to produce fruit with value-added traits.

Profitability of small scale freshwater prawn (*Macrobrachium rosenbergii*) processing. SIDDHARTHA DASGUPTA, BRANDON WILLIAMS* and ADESUWA B. OSUNDE, Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601.

Freshwater prawn production in Kentucky is a small industry that has neither access to large scale seafood processing facilities nor the necessary production volume to justify large scale processing. Hence, freshwater prawn producers have turned to small scale hand-processing facilities catering to retail and direct to consumer markets. This study evaluates the profitability of small scale freshwater prawn processing in Kentucky; our results were based on data obtained from four small scale freshwater prawn processors in Kentucky. Using this data, we developed a model of optimal management and resource allo-

* = presenter.

cation for an assembly line processing system. This model assumed that prawn processing occurred in four stages: 1) inspection and de-heading, 2) rinsing, 3) chilling, and 4) packaging. The resulting model generated a total operating cost of freshwater prawn processing of $5.75 for whole prawns; the finished product, frozen prawn tails, had a total operating cost of $13.76. The processing rate was approximately 41 lb/hr (whole) or 17 lb/hr (tails). Based on the data from this study and an estimated 52 available days for prawn harvest per year, one small scale processor could go through 10.82 MT of whole prawns per year. The value added premium prawn processing yields is $2.39—a substantial increase in value to recoup via resale. Vertical integration of production and processing could dramatically enhance profitability, especially using pre-existing certified kitchens instead of purpose-built structures, based on the results of the study.

Off-site movement of dimethoate residues from broccoli foliage. REGINA R. HILL*, ZACHARY M. RAY and GEORGE F. ANTONIOUS, Kentucky State University, Land Grant Program, Department of Plant and Soil Science, 218 Atwood Research Facility, Frankfort, KY 40601.

Environmentally compatible pest-control agents are needed. The mobility of any pesticide in soil is one of the principal parameters controlling the extent to which a pesticide may represent a risk for surface and subsurface water contamination. Dimethoate [O, O-dimethyl-S-(N-methyl-carbamoyl-methyl) phosphorodithioate] is a broad-spectrum systemic insecticide currently used world-wide and on many vegetables in Kentucky. Dimethoate is a hydrophilic compound (log K_{OW} = 0.7) and has the potential of off-site movement from the application site into runoff and infiltration water. The persistence and dissipation pattern of dimethoate residues were studied in soil and water under field conditions. Following foliar application of Dimethoate 4E on broccoli foliage at the rate of 0.47 L $acre^{-1}$, dimethoate residues were monitored in soil, runoff water collected down the land slope, and in infiltration water collected from the vadose zone. The study was conducted on a Lowel silty loam soil under three soil management practices: 1) soil mixed with municipal sewage sludge, 2) soil mixed with yard waste compost, and 3) no-mulch rototilled bare soil used for comparison purposes. The main objective of this investigation was to study the effect of mixing native soil with municipal sewage sludge or yard waste compost, having considerable amounts of organic matter, on off-site movement of dimethoate into runoff and infiltration water following spring rainfall. Dimethoate residues in the 0–15 cm top soil were greater (0.27 $\mu g. g^{-1}$ dry soil) in soil mixed with sewage sludge than yard waste and no mulch soil (0.085 and 0.19 $\mu g. g^{-1}$ dry soil, respectively). Runoff water and dimethoate residues in runoff water from the no mulch treatment were higher than sewage sludge treatment.

Repellency of hot pepper extracts to the two-spotted spider mite, *Tetranychus urticae* Koch. JANET E. MEYER, GEORGE F. ANTONIOUS[1], RICHARD R. THACKER[2] and JOHN C. SNYDER[2], [1]Land Grant Program, Department of Plant and Soil Science, Kentucky State University, Frankfort, KY 40601 and [2]University of Kentucky, Department of Horticulture, Lexington, KY 40546.

Fruit extracts of hot pepper may provide a promising alternative to synthetic pesticides. The potential of using phytochemicals from the fruit of hot pepper accessions for repellency of spider mites is explored in this study. Crude extracts from the fruits of twenty-four *Capsicum* accessions were prepared in methanol. The efficiency of the extracts was tested against gravid female spider mites, *Tetranychus urticae*, using a "diving board bioassay". The diving board assembly was prepared using paper clamps and filter paper strips of 0.5 × 1.5 cm and 0.2 × 1.5 cm. The assembly allows filter papers to be suspended above a mirror so that mites can be observed from above and below the filter paper strips and have freedom to choose exit route. An aliquot of pepper extract was applied to the 0.5 × 1.5 cm paper strip against pure methanol. Methanol was allowed to evaporate completely from the treated and untreated paper strips before placing bridges. One gravid female mite (n = 30) was placed in the center of each bridge and given the freedom to exit onto treatment or control. Time (min:sec) of exit from the bridge and exit route towards the treated vs. untreated controls was recorded for each of thirty mites per treatment. Significant repellency of spider mite was observed in accessions PI-224424, POG-191, POW-47, POW-62, and PRG-25 at various dilutions. Concentrated extracts increased spider mite repellency in all accessions tested.

Yield and quality of tomato grown in soil amended with sewage sludge. ZACHARY M. RAY* and GEORGE F. ANTONIOUS, Kentucky State University, Land Grant Program, Department of Plant and Soil Science, 218 Atwood Research Facility, Frankfort, KY 40601.

The use of sewage sludge as a soil amendment provides not only a means for sewage sludge disposal, but can also improve soil fertility and physical properties of soil. Nutrients in sewage sludge are used to replace a supplement commercial fertilizer, while sewage sludge organic matter can improve crop yield and quality. The objective of this study was to compare tomato quality and yields from three soil management practices. The three soil management practices were 1) municipal sewage sludge mixed with native soil at 30 t $acre^{-1}$, 2) municipal sewage sludge mixed with yard waste compost (1:1 ratio) at 30 t $acre^{-1}$, and 3) rototilled bare soil used for comparison purposes. Field studies were conducted on a Lowell silty loam at Kentucky State University Research Farm, Franklin County, KY. Six replicates of each soil treatment were established in 18 plots of 22 × 3.7 m each. Tomato, *Lycopersicon esculentum* var. Mountain Spring were planted in rows at 12 inches apart. Mature tomatos were harvested (6 harvests during the summer season) from each plot, weighed, and graded according to USDA standards for grades of fresh

tomato. Total harvest weight and number of U.S. #1, U.S. #2, and U.S. #3 were obtained from each soil treatment. Results indicated that sewage sludge provided the nutrients needed to meet USDA standards for tomato production.

Determination of safe concentrations of hydrogen peroxide (H_2O_2) for algal and pH control in freshwater prawn ponds. LAURETTA OSUNDE*, SHAWN COYLE, LEIGH ANNE BRIGHT and JAMES TIDWELL, Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601.

In pond production of the freshwater prawn, high concentrations of algae can cause the pH to rise to lethal levels (>10) for freshwater prawn. Algaecides have been used to manage the algae in ponds for other species. However, most commercially available algaecides are copper based, which is highly toxic to prawns. Hydrogen peroxide (H_2O_2) does not contain copper and has been demonstrated as useful for the management of algae and submersed aquatic weeds. The objective of the current research was to determine safe levels of hydrogen peroxide for the use with freshwater prawn; separate trials were conducted to evaluate and narrow the range of concentrations. In each experiment, five juvenile freshwater prawn (average weight = 0.01 g for post-larvae and approximately 0.5g for nursed juveniles) were stocked into each of 24 aquaria, each containing 8 liter of water from a common source. The appropriate amount of Green Clean Pro™, a granular algaecide with H_2O_2 as its active ingredient, was added to the aquaria to achieve the desired concentrations. The numbers of live and dead shrimp were determined for each aquarium every 24 hours and each experiment was conducted over 96 hours. Based on these experiments, the maximum safe concentration of hydrogen peroxide for freshwater prawn post-larvae is approximately 5 mg/liter. Older nursed juveniles appear to be able to tolerate concentrations as high as 10 mg/liter. These data suggest that concentrations greater than 10 mg/liter hydrogen peroxide should not be used as a pond treatment in freshwater prawn ponds.

How does length of the nursery phase effect subsequent pond production of freshwater prawn? KYLE SCHNEIDER*, SHAWN D. COYLE, JAMES H. TIDWELL and LEIGH ANNE BRIGHT, Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601.

In temperate culture, freshwater prawns are typically stocked as nursed juveniles, which have been grown indoors to advanced sizes of 0.25–0.5 g, over a 45–60 day nursery period. However, the production economics during the nursery period are directly related to the duration of the nursery period based on higher energy costs, allowable stocking densities, and impacts on survival. A 110-day study in earthen, temperate ponds was conducted to compare the growth and survival rates of juvenile prawn stocked as 30 day nursed juveniles (0.05 g) vs. 60 day nursed juveniles (Control) (0.81 g). Prawn were stocked at a rate of 62,000/ha into each of six, 0.04 ha ponds, with three replicate ponds per treatment. At harvest, prawn stocked as 60 day juveniles had significantly ($P < 0.05$) higher average harvest weight (g) (37.1 ± 1.3), survival (%) (96.2 ± 3.4), and production (kg/ha) (2497.1 ± 35.1) than prawns stocked as 30 day juveniles, averaged 24.4 ± 3.7 g, 73.8 ± 7.8% survival, and 1271.6 ± 316.6 kg/ha total production, respectively. These data indicate that 30 day nursed juveniles cannot achieve the sizes and production rates of 60 day juveniles within the temperate grow-out period. However, if the cost reduction of 30 day juveniles were of sufficient magnitude or if the market was primarily for processed tails which allows for a smaller target size, financial conclusions could differ.

Analysis of processing paddlefish (*Polyodon spathula*) utilizing mathematical programming in sequencing and resource allocation. BRANDON WILLIAMS* and SIDDHARTHA DASGUPTA, Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601.

Kentucky has a nascent paddlefish meat industry which would require processing fish into fillets and/or steaks for market acceptability. This study evaluates the profitability of paddlefish processing based on data related to processing costs obtained from small scale fish processors in Kentucky. The model allocates fish between a fillet and steak production line based on resource availability, technical parameters, and a profit maximization objective. The processing rate was approximately 46 fish/hr (at an assumed average size of 6 lb/fish and with a profit-maximizing mix of filleting and cutting steaks) and 277 lbs of whole fish/hr; the processing rate for finished product was 54 lbs fillets/hr and 131 lbs steaks/hr. The total operating cost of whole paddlefish was $1.61/lb, the total operating cost for fillets was $5.36/lb, and the total operating cost for steaks was $3.22. The value added premium for fillets was $2.70/lb and for steaks it was $2.62/lb. The model was designed to dynamically select between fillets or steaks at assumed prices of $7/lb and $5/lb respectively, the model followed a 3:2 fillet-steak ratio to maximize profit. Vertical integration of production and processing could have a substantial effect on profitability; utilizing extant facilities to process paddlefish instead of capital investment is vital for profitability.

Impact of substrate color, material, surface area, and mesh size on survival and growth of freshwater prawn, *Macrobrachium rosenbergii*,reared in pond microcosm tanks. JAMIE GREENE*, JAMES H. TIDWELL and SHAWN D. COYLE, Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601.

The use of plastic mesh as artificial substrate in freshwater prawn ponds has been shown to increase pond production and average weight of harvested prawn. The objective of this study was to evaluate the effects of different types of substrate with different characteristics, in terms of surface area, mesh size, color, and material on growth

and survival of freshwater prawn. Juvenile prawn were graded to a common size (0.40g), stocked at a rate of 12 prawn/m^2 of surface area into twenty-one 19,000-L tanks. Seven different types of substrate material were evaluated: Treatment 1, 2.5 × 3.8 cm plastic mesh; Treatment 2, 2.5 × 3.4 cm mesh; Treatment 3, 3 × 3 cm nylon seine; Treatment 4, 10.2 × 10.2 cm mesh; Treatment 5, 4.5 cm × 8.9 cm green mesh; Treatment 6, 4.5 cm × 8.9 cm orange plastic mesh; and Treatment 7, received no added substrate (Control). There were three replicate tanks per treatment. After 110 days, all prawn were removed, weighed and counted. The Control treatment (no substrate) was significantly ($P < 0.05$) lower than all substrate treatments in terms of average harvest weight (9.5 g), production (1342 kg/ha), and FCR (2.5). Among substrate treatments, there were no significant differences for average harvest weight (g), production (kg/ha) and FCR which averaged 13.4g, and 2404.2 kg/ha, and 1.3, respectively. These data indicate that the presence of substrate increased prawn average weight by 41% and total production by approximately 80%. The most appropriate substrate material should be chosen based on relative cost.

Can freeze dried krill be replaced in the feed training phase of largemouth bass, *Micropterus salmoides*? NATHAN COCHRAN[1]*, NICHOLAS A. SKUDLAREK[1], MIKE LARIMORE[2], STEVE MARPLE[2], SHAWN COYLE[1] and JAMES H. TIDWELL[1], Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601 and [2]Kentucky Department of Fish and Wildlife, Pheiffer Fish Hatchery, Frankfort, KY 40601.

Largemouth bass fingerlings are typically pond reared on natural foods and then moved into tanks and feed-trained using freeze dried krill. The cost of krill (>$50/kg) can be a significant expense in the feed training phase. An experiment was conducted to compare different methods of feed training largemouth bass to see if krill could be eliminated or reduced. The bass used in this experiment were 6.3 cm in length with an average weight of 2.3 g. Bass were stocked in 50 gallon tanks at 150 fish per tank. Four treatments with four replicates each were compared. Treatment 1 (Control) fingerlings were fed freeze dried krill then gradually weaned to a commercial pellet. Treatment 2 was fed only the dry commercial pellet. For Treatment 3 the commercial pellets were moistened with water prior to feeding; and in Treatment 4 pellets were top dressed with fish oil. There was no significant difference ($P > 0.05$) in the average weights of fish at the end of the study (5.4 g). However, in terms of percentage of fish which successfully feed-trained, Treatment 2 had a significantly lower ($P \leq 0.05$) success rate (82%). There were no significant differences ($P > 0.05$) in feed training success, with the control treatment resulting in 98% feed trained, the moist pellet treatment 93% feed trained, and top-dressed with oil 92%. Even though feed training percentages in the moist and oil treatments were slightly lower than the Control, they may well be economically advantageous due to lower feed cost.

A comparison of individual algal species as food for the juvenile freshwater mussel, *Villosa taeniata* (Bivalvia: Unionidae). FRITZ E. VORISEK*, MONTE A. McGREGOR and JAMES H. TIDWELL, Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601.

The decline of North American freshwater mussels in the last century has led to proactive research into their propagation culture. This study examines the growth and survival of juvenile mussel species (*Villosa taeniata*) using five algal diets. Four species of algae were cultured for trial diets: two green (*Neochloris oleoabundans* and *Bracteacoccus grandis*), two diatoms (*Phaeodactylum tricornutum* and *Cyclotella meneghiniana*), and one commonly used algae used to propagate marine bivalves, *Nannochloropsis*. All four algal species were cultured from stock obtained from the University of Texas. The control was Licking River water filtered to 35 microns. The trials were conducted in 24 individual recirculation systems, with 50 specimens in each. Juvenile mussels were housed in each system, between two 150-micron screens coupled in 3.2 cm PVC. At the end of 60 days, survival was less <1% for all treatments fed a pure algal diet. However, the control had 8% survival and 1000 microns in growth after 60 days. These results suggest that algal diets tested did not improve the survival and growth of *Villosa taeniata*, and other factors may be responsible for juvenile mussel survival. Other alga species may be required to obtain adequate survival rates.

Use of passive solar heating to stabilize and increase water temperature for spawning of largemouth bass, *Micropterus salmoides*. NICHOLAS A. SKUDLAREK[1]*, SHAWN COYLE[1], MIKE LARIMORE[2], STEVE MARPLE[2] and JAMES H. TIDWELL[1], Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601and [2]Kentucky Department of Fish and Wildlife, Pheiffer Fish Hatchery, Frankfort, KY 40601.

Production of feed-trained largemouth bass (LMB) fingerlings involves three stages. Spawning normally occurs in ponds during April–May, then fry are transferred into fertilized ponds for 3–4 weeks to feed on natural foods until they reach 4–5 cm, when they can be trained to feed on commercial diets. However, the number of fish produced each year has been unpredictable as weather changes can dramatically affect spawning success. While pond temperatures cannot be manipulated on a practical basis, LMB can be induced to spawn in tanks. This could allow the use of passive solar methods to increase and stabilize water temperatures. This could produce earlier and more reliable reproduction. Four pairs of bass broodstock were stocked into nine 19,000 liter fiberglass tanks filled to 0.7 m depth. Each contained four spawning mats. Three treatments with three replicates each were used in the experiment. Treatment 1 (Control) was uncovered and maintained ambient water temperature. In Treatment 2 tanks were covered with clear plastic stretched over PVC pipe to create a "greenhouse." In Treatment 3 the water

surface was covered with a solar swimming pool cover. Fish were observed daily and when spawning was observed spawn mats containing eggs were transferred into 380-liter tanks indoors for incubation. Tank covers had a large impact. Bass in the "greenhouse" tanks spawned three weeks before the uncovered controls and bass in the solar cover tanks spawned approximately two weeks before the controls. These studies are preliminary to a more comprehensive research project on largemouth bass fingerling production.

Effects of dietary carbohydrate level on growth and survival of largemouth bass, *Micropterus salmoides*. AKUA AMOAH*, LEIGH ANNE BRIGHT, SHAWN D. COYLE and JAMES H. TIDWELL, Aquaculture Research Center, Kentucky State University, Frankfort, KY, 40601.

Excess carbohydrates in diets for largemouth bass may produce glycogen accumulation in hepatocytes resulting in dysfunction of the liver. This study evaluated the effect of graded dietary carbohydrate levels on growth and survival of largemouth bass juveniles. One hundred feed trained largemouth bass (125 g) were stocked into each of twelve 3,400-liter polyethylene tanks. Tanks were randomly assigned one of four experimental diets containing different carbohydrate levels (10, 15, 20 and 25% of diet). There were three replicates per treatment. Bass were fed to satiation 2x/day for 148 days. At harvest, survival was significantly higher ($P < 0.05$) for fish fed the 10 and 15% CHO diets (89 and 90%, respectively) compared to those fed the 25% CHO diets (82%). Fish fed the 20% carbohydrate diet were not significantly different ($P > 0.05$) from any other treatment (85%). Average harvest weight for fish fed the 10% CHO diet (380 g) was significantly greater ($P < 0.05$) than for those fed the other diets. In addition, average harvest weight for fish fed the 15% CHO diet (347 g) was greater than for fish fed either the 20 or 25% CHO diet (315 and 310 g, respectively). Feed conversion ratio was significantly reduced for fish fed the 10 and 15% CHO diets (2.4 and 2.3, respectively) compared to those fed the 20 and 25% CHO diets (3.5 and 3.6, respectively). These data indicate that largemouth bass do not utilize dietary carbohydrate efficiently. Their apparent low tolerance for carbohydrate may necessitate specially formulated diets.

Replacement of fish meal and fish oil in practical diets for the largemouth bass, *Micropterus salmoides*. RUSSELL NEAL*, LEIGH ANNE BRIGHT, SHAWN D. COYLE and JAMES H. TIDWELL, Aquaculture Research Center, Kentucky State University, 103 Athletic Road, Frankfort, KY 40601.

Most largemouth bass in commercial production are fed high protein (>40%) and high fat (>15%) salmonid diets based primarily on availability rather than nutritional suitability. Additional nutritional research is needed as an essential component to the development of efficient aquaculture production of fish >100 g. A series of feeding trials were conducted with juvenile largemouth bass (*Micropterus salmoides*) in aquaria to evaluate alternative plant and animal source proteins and lipids for their ability to replace fish meal and fish oil, respectively, in prepared practical diets. In each trial, feed-trained largemouth bass (3–5 g) were randomly stocked into 114-liter glass aquaria at 20–25 fish per aquarium. Fish were fed to apparent satiation twice daily. The control diet for each trial contained 30% fish meal, 35% soybean meal and 10% fish oil. There were three replicate aquaria per dietary treatment. The duration of each trial was twelve weeks. In the fish meal replacement trial, fish fed diets containing poultry by-product meal as the primary protein source performed as well as those fed the control diet (CTL) containing 30% fish meal. It appears that poultry by-product meal can completely replace fish meal in diets for juvenile largemouth bass. In the lipids study, fish fed diets containing corn oil and sunflower oil performed as well as those fed fish oil. These data indicate that it may be possible to replace fish meal and fish oil with less expensive alternatives in diets for juvenile largemouth bass without impacting growth, feed efficiency, or body composition.

Total phenolic content and antioxidant capacity of pawpaw (*Asimina triloba* L.) pulps. HIDEKA KOBAYASHI*, CHANGZHENG WANG, and KIRK W. POMPER, Human Nutrition Program, Kentucky State University, Frankfort, KY 40601.

Pawpaw (*Asimina triloba* L.) is native to the eastern U.S., and research has been conducted at Kentucky State University since 1990. The objectives of the study were to optimize the conditions for Folin-Ciocalteau and Ferric Reducing Ability of Plasma (FRAP), and to screen ten different cultivars for measuring total phenolic content (TPC) and antioxidant capacity (AC). Sample extraction of pawpaw was achieved by separately adding three different solvents, acetone, methanol, and double deionized water (DDH_2O) (2 ml/1 g of sample), and the mixture of both sample and solvents were vortexed (30 sec) and sonicated (15 min), prior to centrifugation (15 min) twice at 2987 $\times$ *g*. After adding 10 µl of pawpaw extracts, 1N Folin-Ciocalteau reagent (25 µl) was added to wells of the 96-well pate, followed by additions of 20% sodium carbonate (25 µl) and DDH_2O (140 µl) after a 10 min incubation. A freshly prepared FRAP solution (175 µl) was added to wells of the 96-well plate containing pawpaw extracts (25 µl). Absorbance readings for both Folin-Ciocalteau (760 nm) and FRAP (595 nm) assays were recorded up to 2 hrs. It was found that both TPC and AC were the highest in the acetonic extract. Of the 10 cultivars that were screened, the cultivar Taylor had the highest TPC (gallic acid eq. 128.8 mg/100 g of fresh weight) and AC (Trolox eq. 11.5 µmol/g of fresh weight). The current findings suggest the existence of the diversity among pawpaw cultivars, and may be valuable in developing cultivars with increased antioxidant components.

ANTHROPOLOGY AND SOCIOLOGY

Scribbles, scratches, and ancient writing: pseudoarchaeology in the Ohio Valley Region. DONALD B.

BALL, US Army Corps of Engineers (retired), Louisville, KY 40208.

Beginning in the early 19th century and continuing until the present, numerous grandiose claims have been made that various Old World cultures (including Welsh, Irish, Libyans and Hebrews) explored or occupied the Ohio Valley Region. An examination of a sampling of these contentions indicates that such claims have been based upon either outright forgeries of individual artifacts (e.g., Tennessee's Bat Creek stone, West Virginia's Grave Creek stone, and Newark, Ohio's "Holy stones") or highly questionable and unverified "interpretations" of legitimate prehistoric petroglyphs (e.g., rock carvings in Kentucky and West Virginia). Routinely, such baseless claims are never submitted for critical review by either knowledgeable archaeologists or scholars in ancient languages and are characterized by chronically poor scholarship, isolated facts and comparative data liberally and irresponsibly taken out of cultural and chronological context, and haphazardly documented sources. Consistently, those who perpetrate or espouse such claims are seemingly oblivious of the fact that literally thousands of legitimate regional archaeological investigations have yielded not one iota of supporting evidence in the form of corroborating artifactual evidence. It is concluded that such pseudo-scientific claims are without substantive merit.

Megalithic passage tombs of Neolithic Ireland. ASHLEY N. WALTERS, Department of Anthropology, Sociology, and Social Work, Eastern Kentucky University, Richmond, KY 40475.

While ancient Ireland may today be associated with the complex agricultural societies of the Celts, such a rich, technologically advanced Iron Age culture did not develop overnight. This presentation explores the longer term development of human societies in Ireland from its first peopling through the Neolithic which sets the stage for the arrival of the Celts around 600 B.C. Around 7500 B.C. the foragers of the Mesolithic were the first to arrive on land that had not yet become the island of Ireland. Around 4500 B.C. the first farmers arrived, bringing wheat, barley, oats, and rye that were first domesticated in the Fertile Crescent. With farming, social stratification soon set in, bringing about the construction of large stone monuments, as best exemplified by Newgrange. Like the pyramids of Egypt, the largest of the tombs in Ireland were built for the important members of society while the other community members had much smaller tombs. As time passes, the increasing degree in which the society is stratified becomes more and more noticeable in the tombs. This presentation summarizes three main pre-Celtic cultures and emphasizes the importance of social stratification in the development of the megalithic passage tombs of the Irish Neolithic Period. It also discusses the labor investment estimates required for tomb production to emphasize the development of government.

Public perception of research topics in nutrition and health. CECIL BUTLER*, CHANGZHENG WANG, LINGYU HUANG, MARTHA MARLETTE and SUSAN TEMPLETON, Human Nutrition Program, Kentucky State University, Frankfort, KY 40601.

Chronic diseases place a heavy burden on the health care system. Many of these diseases are related to nutrition and lifestyles in some ways. Nutritional research holds the promise for the prevention of the diseases. The objective of this project was to survey the public opinions of selected research topics in nutrition and health. Visitors to the 2005 Kentucky State Fair filled out a survey questionnaire before they were given a free analysis of their body composition (body fat %). They ranked the topics on a 1–5 scale on their perceived importance. On average, they gave high ranks (4 or higher) to research on obesity, osteoporosis, benefits of fruits and vegetables, health effects of eating habits, cancers and cardiovascular diseases. Although the ranks were lower (between 3 and 4) for research on antioxidants, value-added products, non-dairy sources of calcium, health effects of farming practices, these topics were considered somewhat important. People with a college education tended to give higher ranks to all the research topics. Whether the person suffers from any health problems did not affect their perception of the research topics. To ensure continued public support, researchers should focus on priority issues of the most public concern. In the meantime, researchers also need to help the public to understand the issues, which they consider critical based on their professional knowledge. The results from this study will be helpful to administrators and researchers responsible for setting the directions of nutrition research programs.

Knowledge, attitude and behaviors related to body weight status of children participating in the National Youth Sports Program. BORAM LEE*, CHANGZHENG WANG, LINGYU HUANG, JO SLOANE and WILLIAM GRAHAM, JR., Human Nutrition Program, Division of Health, Physical Education and Recreation, Kentucky State University, Frankfort, KY 40601.

National Youth Sports Program provides opportunities for children from low-income families to participate in sport activities in the summer. The prevalence of overweight among these children is relatively high. The objective of the study was to study the critical knowledge, attitude and behaviors related to the body weight status of children participating in the National Youth Sports Program. A survey questionnaire was filled out by the children after they were examined for their blood pressure, body weight and height. Their body fat percent was measured with a Tanita TBF-521 body composition analyzer. Body mass index (BMI) was calculated from the body weight in kg divided by the square of body height in meters. Majority of the children had positive view of milk, vegetables, fruits and physical activities, but 25% of the children consumed one cup or less of milk per day, 31% of them consumed one or fewer servings of vegetables,

30% of them consumed one or fewer servings of fruits and 16% of them had one hour or less of activities. Majority of the children had positive views of soft drinks and TV watching. Over 80% of them had 2 or more soft drinks and watched TV for two or more hours per day. It appears that the low consumption of milk, vegetables and fruits, high intake of soft drinks and lengthy periods of TV watching may help to explain the relatively high incidence of overweight among these children. Preventive programs are needed to modify their attitudes about the adverse effects of soft drinks and TV watching, in addition to their access to sports activities.

CELLULAR & MOLECULAR BIOLOGY

Pak 1 expression during 7,12 dimethylbenz[α]anthracene-induced mammary carcinogenesis in the Sprague Dawley rat. MICHAEL DONAWORTH*, JONATHAN KOOP, CAITLIN MAYNARD, LARRY E. DOUGLASS and JULIA H. CARTER, Wood Hudson Cancer Research Laboratory, Newport, KY 41071.

Induction of mammary carcinomas in female rats by 7,12 dimethylbenz[α]anthracene (DMBA) is used as a model for human breast cancer. DMBA-induced breast tumors are similar to those found in women. Factors affecting tumor induction and growth have been studied in the DMBA model; however, cellular and molecular changes occurring within days of carcinogen administration are not well characterized. DMBA alters tissue homeostasis in the mammary gland within one week. Pak 1 is a serine/threonine kinase associated with cell growth, survival, and motility. Our studies of human breast cancers linked Pak 1 with metastasis. Here we studied Pak 1 expression during breast cancer development. Sprague Dawley rats (n = 146) were sacrificed at 1 or 7 days and 1 to 6 months after an intragastric dose of 20 mg DMBA or vehicle at 50 days of age. Some animals were pretreated with the anti-estrogen tamoxifen before DMBA administration to determine its effect on DMBA-induced changes in mammary glands. Some tumor bearing animals were ovariectomized to determine the effect of estrogen deprivation on Pak 1 expression in breast tumors. Tissues were fixed in formalin, and paraffin embedded. Pak 1 expression was determined immunohistochemically in histologic sections of mammary glands and breast tumors. Pak 1 expression in developing mammary glands was reduced by both the carcinogen DMBA and the anti-estrogen tamoxifen. Pak 1 was expressed in breast carcinomas in intact, but not in ovariectomized, animals. These data imply that the established role of estrogen in breast carcinogenesis may be mediated in part by Pak 1.

Role of TGFBR1 genetic variants in human cervical carcinogenesis. BRIAN WHEELER*, EMILY KELLNER, MICHAEL MARKEY, LARRY DOUGLASS, BRUCE COLLIGAN, JULIA H. CARTER and TAIPING CHEN, Cancer Genetics Lab, Wood Hudson Cancer Research Laboratory, Newport, KY 41071.

Cervical cancer is the second most common malignancy in women worldwide. Human papilloma virus (HPV) DNA has been found in more than 90% of cervical cancers. Despite infection with high-risk HPV, not all pre-malignant lesions will progress to invasive cervical carcinoma. Other genetic events are suspected to play a role in cervical carcinogenesis. An intronic variant Int7G24A of the transforming growth factor-β type I receptor (TGFBR1) has been identified as a potential genetic marker associated with several human cancers in our recent studies. We hypothesize that this variant may facilitate HPV infected cells to progress from pre-malignant lesion to invasive cervical cancer. Finding an association of the TGFBR1 variant with patients having an invasive cervical cancer will provide a good opportunity to test a series of questions related with cervical carcinogenesis. In the pilot study, we utilized the polymerase chain reaction (PCR) and restriction fragment length polymorphism (RFLP) and analyzed DNA samples derived from formalin-fixed, paraffin-embedded archival tissues of patients with cervical cancer. A total of 101 patients were analyzed for the variant allele. Twelve of 33 (36%) patients with pre-malignant lesions of cervix and 41of 68 (60%) patients with invasive and metastatic cervical cancer were heterozygous and homozygous for the variant allele. Compared to 26% of the frequency found in non-cancer female control, TGFBR1 variant is strongly associated with patients having an invasive cervical cancer ($P < 0.0001$). Additional studies are warranted to determine if TGFBR1 variant is required in the HPV positive cell for tumor progression.

Pak1 expression in human breast cancers and breast cancer cell lines. STEPHANIE PINKSTOCK*, REED SPAULDING, RYAN BALDRIDGE, JULIA H. CARTER, AND BONNIE L. RICHMOND, Wood Hudson Cancer Research Laboratory, Newport, KY 41071

The p21-activated serine/threonine kinase (Pak1) is associated with both normal cellular activities and with cancer progression. Pak1 is stimulated by both GTP-bound forms of the small G proteins Rac and Cdc42, and by GTPase independent mechanisms. Phosphorylation of Pak1 (one of six Pak proteins) may promote tumor progression and metastases through its association with numerous cellular functions including cytoskeletal assembly and reorganization, cell cycle control, apoptosis, gene expression, and intracellular signaling through MAPK/p38MAPK/JNK/NF-kB pathways. Pak1 expression is associated with anchorage independent growth and invasiveness of breast cancer cells. Based on the necessity of cell motility for invasion and metastasis, we examined Pak1and phosphorylated Pak1 expression in six human breast cancer cell lines and in primary human mammary epithelial cells (HMECs) by immunoblotting. Cells were also stained using immunocytochemistry to determine the subcellular distribution of Pak1 in breast cancer lines versus HMECs. Further, Pak1 and phosphorylated Pak1 expression were determined in eight primary human breast carcinomas using immunoblotting. Pak1 expression in the eight primary breast carcinomas was evaluated immuno-

histochemically. Results indicate increased Pak1 expression in the breast cancer cell lines and increased Pak1 expression in a cell line established from fibrocystic disease relative to first passage normal HMECs. Further, variable Pak1 and phosphorylated Pak1expression in the eight human breast carcinomas was observed relative to adjacent benign breast disease. Future experiments will continue to examine the functional role of Pak1 in invasive breast cancers.

CHEMISTRY

Effects of extraction time on calcium concentration of bone soup. LINGYU HUANG* and CHANGZHENG WANG, Human Nutrition Program, Kentucky State University Frankfort, KY 40601.

The importance of adequate calcium intake is well recognized for supporting bone growth in children and in preventing bone loss in postmenopausal women. Calcium requirement can be easily met for people who consume dairy products. However, a significant proportion of the population cannot or will not consume dairy products either because they have adverse reactions to dairy products or because they are worried about the cholesterol and fat content of dairy products. Bone soup can be an alternative source of calcium. The objective of this study was to determine the effects of extraction time on the calcium content of bone soups. Soups were made by cooking 100 g of meat-free bones for 1 hour in 200 ml of distilled water containing 2.5, 5, 10 or 20% of white vinegar. Samples were taken at 0, 1 or 14 hours after cooking and the soup brought to room temperature. The concentration of calcium and magnesium in the soup was determined with an atomic absorption spectrophotometer. Addition of vinegar significantly increased the concentration of calcium and magnesium. Extending the time of extraction by keeping the soup with the bones in the refrigerator resulted in significantly higher concentrations of calcium and magnesium. These results indicate that bone soups can be a significant source of calcium for some people if the soups were prepared with an adequate amount of vinegar and allowed enough time for extraction of calcium.

ECOLOGY AND ENVIRONMENTAL SCIENCE

Old-growth forests: databanks of natural history information. NEIL PEDERSON, Department of Biological Sciences, Eastern Kentucky University, Richmond, KY 40475.

Old-growth forests are rich databanks of the natural history for species and ecosystem. Dendrochronology, or tree-ring analysis, is an excellent tool for tapping into these databanks. One example is a study of old-growth and old, second-growth chestnut oak (*Quercus montana*), white oak (*Q. alba*) and yellow-poplar (*Liriodendron tulipifera*) populations from Alabama to Michigan and New York state. Results show that individual tree-growth rates do not slow down as trees age and suggests that trees can persist in the landscape while maintaining the ability to respond vigorously to improved growth conditions when old, which contradict models of old-growth forests. A second example is the discovery of tree ages that are much older than widely accepted maximum ages. For example, cucumbertree (*Magnolia acuminata*) was found to be 348 years old, which is 150 years greater than that listed in the Silvics Manual of North America (Burns and Honkala, 1990). Similarly, sweet birch (*Bentula lenta*) was found to live up to 361 years. Given Kentucky's biodiversity and the potential natural history information that can be gained from studies of old-growth forests, I propose the creation of a scientific and citizen organization to locate, characterize and confirm lesser well-known old-growth forests in Kentucky. I suggest naming this group the Kentucky Old-Growth Society (KOGS). Formation of this society would engage a diverse group of people while transmitting successive motive force to the conservation of Kentucky's natural heritage.

Temporal land cover change in Kentucky between the 1990's and the 2000's: when are apples more like pears than oranges? DEMETRIO P. ZOURARAKIS, Kentucky Division of Geographic Information, Frankfort, KY 40601.

The newest suite of land cover/land use classification products for Kentucky (i.e. land cover, imperviousness and canopy closure) was finalized and published by the U.S. Geological Survey (USGS) (http://seamless.usgs.gov). Thus, two near-decadal National Land Cover Dataset (NLCD) versions exist for Kentucky: the 1992 dataset (NLCD92), based on Landsat 5 Thematic Mapper imagery from ca. 1990, and the 2001 dataset (NLCD01), based on Landsat 7 Enhanced Thematic Mapper Plus imagery from ca. 2000, the existence of which brings forth extremely tempting possibilities for the analysis and creation of temporal change detection products. Several issues conspire against a straightforward pixel-based, before/after raster calculation, most importantly: 1) different methodologies were used to arrive at the two NLCDs; 2) the two NLCDs have contrasting accuracy levels; 3) the two NLCDs use different classification schemes albeit similarly based [USGS-modified Level II Anderson (1976)]; and 4) cross-walk schemes between the two classification schemes are typically unspecified. A cross-walk between NLCD92 and NLCD01 Level I and II classes is presented, exploring the sensitivity of the results of temporal Level I-based contrasts to variations in the scheme.

GEOLOGY

Provenance of the Corbin Sandstone Member of the Grundy Formation (Lower Pennsylvanian) in East-Central Kentucky. MIMI K. SHEAR* and ROBERT T. LIERMAN, Department of Earth Science, Eastern Kentucky University, Richmond, KY 40475.

The Corbin Sandstone is a member of the Grundy Formation (Pennsylvanian) in eastern Kentucky. It is a fine-medium grained, buff to reddish colored, quartz arenite to sublitharenite. The Corbin is also cross-bedded and contains concentrations of rounded quartz pebbles. This

study is an attempt to determine the provenance of the Corbin Sandstone Member. Provenance refers to the origin of sedimentary particles. It is a determination of the location and composition of the parent rocks from which sediments were derived. Eighty-eight samples were collected from nine localities across east-central Kentucky. Thin-sections were cut and point counts made of the various types of quartz present in each sample. Quartz was grouped into a number of distinct classes according to the scheme suggested by Basu, et al. (1975). Two types of quartz grains dominate the assemblage: (1) monocrystalline quartz showing an undulose extinction and (2) polycrystalline grains composed of more than three subunits. The larger, quartz pebbles were mainly vein quartz. This assemblage suggests a low-rank metamorphic source area for most of the quartz in the Corbin. The pebbles are believed to be derived from hydrothermal quartz veins that must have also been present in the source area. A heavy-mineral separation was conducted on these samples to further aid in the determination of their provenance. The assemblage was dominated by rounded grains of zircon, rutile, and tourmaline. Angular grains of pale brown tourmaline were also observed. The presence of pale brown, angular tourmaline grains also supports a low-rank metamorphic origin for these sediments. In addition, rounded zircon, rutile and tourmaline hint at a source area that must included a considerable amount of reworking.

A geologic record of methane consumption associated with methane gas hydrates at Blake Ridge region (continental rise, offshore southeastern United States). WALTER S. BOROWSKI*, KATHRYN G. TAKACS and MATTHEW K. THOMPSON, Department of Earth Sciences, Eastern Kentucky University, Richmond, KY 40475.

Geochemical signals locked within sedimentary rocks are a record of earth processes. Sulfide minerals (elemental sulfur, iron monosulfides, and pyrite) are formed within marine sediments by several different geochemical processes mediated by microbes. Investigating the concentration and sulfur isotopic composition ($\delta^{34}S$) of sulfide minerals gives clues about the relative importance of these competing geochemical processes. Marine sediments of the Blake Ridge (offshore South Carolina and Georgia) contain sulfide minerals that point to anaerobic methane oxidation (AMO) as an important diagenetic process both today and in the recent geological past (Miocene). At the present-day methane-sulfate interface, upward-diffusing methane is consumed by reaction with downward-diffusing sulfate, producing a geochemical environment that promotes the authigenic precipitation of sulfide minerals. These sulfide minerals, mainly pyrite, are enriched in the heavy isotope of sulfur (^{34}S), whereas sulfides higher in the sulfate reduction zone contain more ^{32}S. This result is consistent with larger fluxes of methane in the region being produced by methane gas hydrate deposits. The sedimentary record back to the Late Miocene (~6.2 Ma) shows that changing depositional conditions seems to progressively favor sulfate reduction over AMO. Sulfide mineral amounts change from baseline values of 0.2 weight percent to 0.4 to 0.6 wt %. Baseline values of ($\delta^{34}S$) also increase from −45‰ to −30‰. Geochemical conditions today favor AMO whereas conditions in the past responded to loading of sedimentary organic matter—conditions necessary to produce the amount of methane gas hydrates within the Blake Ridge region.

A preliminary comparison of the sulfur geochemistry between two gas hydrate terranes. MICHAEL SPICER* and WALTER S. BOROWSKI, Department of Earth Sciences, Eastern Kentucky University, Richmond, KY 40475.

Gas hydrates are present in two different geologic terranes—the accretionary wedge of the Cascadia continental margin (offshore Oregon) and the passive margin of the Blake Ridge region (offshore southeastern US). We expect diagenetic processes effecting authigenic sulfide mineral formation (elemental sulfur, iron monosulfides, and pyrite) within these sediments to respond to differing geologic conditions at each location. In both settings, methane diffuses upward from gas hydrates to the methane-sulfate interface (SMI), where it is consumed by reaction with sulfate by anaerobic methane oxidation (AMO). This microbially-mediated, diagenetic process produces an interstitial environment conducive to authigenic sulfide mineral formation, so that sulfide minerals tend to be concentrated near the SMI and contain more heavy sulfur (^{34}S). Sulfate reduction also occurs in both settings when sulfate is consumed by microbes utilizing sedimentary organic matter as a foodstuff. In this case, more sulfide mineralization occurs above the SMI, and so that sulfide minerals should contain more ^{32}S. These competing sulfate-depleting processes potentially produce different vertical distributions of the concentration and sulfur isotopic composition ($\delta^{34}S$) of sulfide minerals preserved within the sedimentary record. Preliminary geochemical results from ODP Site 1244 show a shallower SMI, large concentrations of dissolved sulfide, significant levels of dissolved iron only where dissolved sulfide is low to absent, larger amounts of sulfide sulfur in the sediments, and a similar $\delta^{34}S$ profile as compared to Blake Ridge sediments. Because methane is consumed by AMO in both settings, we hypothesize that sulfate reduction results in increased sulfide mineralization within Cascadia sediments.

A comparison of Jacobs Chapel Shale macrofaunal diversity and abundance between two localities in Lewis County, Kentucky. TABITHA K. MASON* and CHARLES E. MASON, Department of Physical Sciences, Morehead State University, Morehead, KY 40351.

The Jacobs Chapel Shale is located at the base of the Henley Bed of the Farmers Member of the Borden Formation. This study was a comparative study to that of Stewart's (2001) study 3 miles to the northeast along Kentucky Highway 10. All 363 kg of material processed for

this study was collected along Kentucky Highway 9, located 0.7 miles south of its junction with the AA Highway in Lewis County, Kentucky. Bulk samples were collected and taken to the lab for processing. First the samples are placed in the ovens to remove water. Samples were then weighted into 5-kg amounts, placed in buckets, and immersed in kerosene for a 24-hour period. The kerosene was then decanted off and the sample placed in water. Samples set in water for a period of 24 hours to allow the sample to disaggregate. The disaggregated sample was then washed through a number 20 U.S. standard sieve. Residues caught on the sieve were dried and weighed. The residues were then picked for macro invertebrates using a binocular microscope. Picked macro invertebrates were then identified and tabulated. A total of 578 identifiable specimens were recovered, equaling approximately 1.6 specimens/kg of sample run, as compared to Stewart's study which processed 130 kg of sample with 0.82 specimens/kg. The most abundant species in both studies was the globose *Gattendorfia*. Overall, the macro fauna of the Jacobs Chapel Shale in both studies was dominated by mollusks in both diversity and abundance. This study also shows that by increasing sample size, both diversity and abundance of fossil macro invertebrate recovery will be increased.

A new sampling technique applied to the Jacobs Chapel Shale, Brightman Cemetery Section, Lewis County Kentucky. BRAD WILLIAMS* and CHARLES E. MASON, Department of Physical Sciences, Morehead State University, Morehead, KY 40351.

The Jacobs Chapel Shale is located at the base of the Henley Bed of the Farmers Member of the Borden Formation. It is placed in the Lower *crenulata* conodont zone (Sandberg et. al. 2002) of the Upper Kinderhookian Series of the Mississippian Subsystem. This study was a continuation of a study by Stewart (2001) and it was designed to test a "new" sampling technique. Here ammonoid recovery was used to test if precision location of bulk samples would enhance ammonoid numbers per kilogram of sample processed. The first set of bulk samples were carefully collected as to their precise location and each site was processed separately. When examining the results of the first suite of samples, the sites that contained the highest abundance of ammonoids were noted. These localities were then re-sampled to see if the same or better results could be attained. Some areas that produced low numbers of ammonoids were recollected again to use as controls. After processing the second set of samples, each site was then compared with itself for the first and second runs of samples to see if the abundance of ammonoids had increased, decreased, or stayed the same. For the first set of samples, in which 136.4 kg of sample was run, 10.4 kg of residue yielded 93 ammonoid specimens. In the second run of samples, in which the "new" sampling technique was employed, 112.4 kg was processed that yielded 148 ammonoid specimens out of 11.3 kg of residue. These results strongly suggest that the sampling technique employed in this study enhances the recovery of select fossil entities. Additionally, this study increased the abundance of fossils from the Jacobs Chapel Shale by 473 and its diversity by 17 species.

HEALTH SCIENCES

Pesticides in the diet induce copper retention in kidneys of rats. FREDERICK N. BEBE* and MYNA PANEMANGALORE. Nutrition and Health Program, Kentucky State University, Frankfort, KY 40601.

The excessive use of pesticides to improve crop production has increased the risks and consequences of exposure in occupationally exposed humans, especially farm workers. The objective of this study was to determine the potential of pesticides to influence trace metal homeostasis in the tissues of rats. Male SD rats, weighing 175–200 g, 6/group were fed A1N 93M diet (CON) or diets containing 500 mg Ca (LCa), 7 mg Zn (LZn), 2 mg Cu (LCu), 60 mg Zn (HZn) or 12 mg Cu (HCu)/kg diet in the following combinations: Control (CON), LowCa+LowZn (LC+Z), LowCa+LowZn+LowCu (LC+Z+C) or HighZn+HighCu (HZ+C) without or with pesticides mixture (PM); Endosulfan, Thiram and Acephate were added to the diets at 25% of LD_{50}/kg. Rats were fed for 2 weeks (small intestinal changes) or 4 weeks (tissues changes). Plasma Zn was 47% lower than CON in the experimental groups. Plasma Cu and ceruloplasmin concomitantly decreased the LC+Z+C group and increased with the addition of PM. Kidney Cu was 40% lower in LC + Z +C group than CON and increased by 31% with PM; in HZ+C+PM group kidney Cu was 38% higher than the HZ+C group. Mucosal (M) and small intestines Ca declined by 47% in all experimental groups; PM increased M Zn in the LC+Z+C and HZ+C groups; PM further decreased intestinal and M Cu retention in LC+Z+C and HZ+C groups. Data suggest that low levels of PM in the diet can induce Cu accumulation in the kidney when dietary Zn and Cu are either low or high.

Outcomes of a workplace wellness program: the Take 10 ... Fit It In pilot phase. SUSUAN TEMPLETON*, Human Nutrition Research, VIVIAN BIBBS and STELLA MOUNTAIN, Cooperative Extension Program, Kentucky State University, Frankfort, KY 40601.

Nearly 63% of adult Kentuckians are obese or overweight. Over one-third get no daily physical activity. Kentucky ranks sixth in the nation for excess body weight and first for adult inactivity. Overweight is a major risk for cardiovascular disease, diabetes, and cancer. Kentucky spends $1.1 billion/year on obesity-related medical expenses, 9th highest in the nation. A workplace wellness program was implemented in 2005 to promote increased physical activity among Kentucky State University faculty and staff. The program awarded incentives for meeting self-determined goals; one point was earned for each 10-minute period of moderate-vigorous physical activity. Twenty-seven teams were established and 315 participants enrolled; the midpoint retention rate was 88%. Partici-

pants kept a Personal Activity Log for 10 weeks. Voluntary height, weight, and percent body fat measurements were conducted at the beginning (n = 200) and end (n = 134) of the program. Initial weight status was classified as Underfat (2%), Healthy (22%), Overfat (29%), or Obese (47%) based on published standards for age, gender, and percent body fat. Healthy participants had significantly higher goals (196 points) than those classified Underfat (72 points, $P < 0.05$) or Obese (129 points, $P < 0.01$). The mean goal of Overfat participants (162 points) was not significantly different. Nearly 84% of Healthy participants met their goal; 77% of Overfat and 72% of Obese participants also met their goals. Healthy participants lost an average of 1.1 pounds; Overfat and Obese participants lost 0.9 and 0.5 pounds respectively. These differences were not statistically significant. More substantial impact is expected as additional phases are completed.

Assessing body composition as part of a healthy weight outreach promotion. MARTHA MARLETTE* and SUSUAN TEMPLETON, Human Nutrition Research, Kentucky State University, Frankfort, KY 40601.

Kentucky ranks sixth highest in the nation with 63% of adults being overweight or obese and ranks as 9th highest in the nation for obesity-related medical expenses of over $1 billion a year. During the eleven days of the 2005 Kentucky State Fair, attendees passing through the Health Horizons exhibit were solicited to have their weight and BMI assessed. Interested volunteers were screened to eliminate anyone pregnant or with a pacemaker. Body Fat Analysis by bioelectrical impedance analysis was conducted for 1313 adults and Body Mass Index (BMI) was calculated for 147 children. Each participant was counseled regarding health implications and how to insure adequate nutrient intake and improve or maintain his or her body weight. Based on percent body fat, the incidence of overweight and obesity among adult volunteers at the State Fair (59.4% of males, 43.3% of females) was lower than BMI-based rates published for Kentucky (70.7% males, 54% females) and the U.S. (66.9% males, 50.3% females). These differences illustrate the limitations of using convenience sampling and reflect the observed reluctance of overweight individuals to be measured. Weight status for children (age < 21) was classified using BMI for age standards; overweight (BMI > 95th percentile) was more prevalent among male than female children (24% vs. 5.3%), but more female children (23.2% vs. 20%) were "at risk of overweight" (BMI between 85th and 95th percentile).

Occupational exposure to pesticides and micronuclei frequency in lymphocytes of farm workers. APRIL NEWSOME*, AVINASH TOPE and MYNA PANEMANGALORE, Human Health and Nutrition, Land Grant Program, Kentucky State University, Frankfort, KY 40601.

Chronic low level exposure to synthetic pesticides is implicated in many health conditions that result from the induction of oxidative stress, including cytogenetic damage. The objective of this study was to assess the risk of genotoxicity using micronuclei (MN) formation in lymphocytes as an indicator in farm workers through a longitudinal survey. Blood and urine samples were collected once a month during the growing season for six months (June to November 2003) from farm workers (n = 15) and urban unexposed controls (n = 10). Lymphocytes from blood were separated by density gradient centrifugation using Histopaque and cultured using the standard technique. There was no significant difference in the cytokinesis blocked proliferation index (CBPI) of lymphocytes between the farm workers and the control group, but there was a 76% increase in average MN frequency in lymphocytes of the farm worker group ($P = 0.05$). In addition, MN frequency peaked during August compared to the other months and the controls ($P = 0.05$). These preliminary data suggest that the farm workers may be at a greater risk of developing genotoxicity due to continued exposure to pesticides.

High prevalence of overweight among children participating in the National Youth Sports Program. HARMONY MARLETTE*, CHANGZHENG WANG, LINGYU HUANG, JO SLOANE and WILLIAM GRAHAM, JR, Human Nutrition Program, Division of Health, Physical Education and Recreation, Kentucky State University, Frankfort, KY 40601.

The National Youth Sports Program serves economically disadvantaged children by providing instruction, skills training and competition in a variety of sport activities designed to improve physical fitness and health habits in the summer. The objective of this study was to evaluate the body weight status of the participants in the program administered by Kentucky State University. A total of 180 children were examined for their blood pressure, body weight and height. Their body fat percent was measured with a Tanita TBF-521 body composition analyzer. Body mass index (BMI) was derived from the body weight in kg divided by the square of body height in meters. Children with BMI above the 95% percentile for their gender and age is classified as overweight and children with BMI between 85–95% percentile were considered at risk for overweight. On average, 32% of the children were overweight and nearly 26% of the children were at risk for overweight. The body fat percent and prevalence of overweight were higher for girls than for boys. Body fat percent tended to decline in boys but increased for girls as the age increased from 10 to 14. Compared with the state and national averages, the rate of overweight among these children is significantly higher. These results suggest that children from economically disadvantaged families are at increased risk for obesity. Specific preventive strategies should be developed to help these children to overcome this risk.

Effects of National Youth Sports Program on the body weight status of participating children. JO SLOANE*, CHANGZHENG WANG, LINGYU HUANG and WIL-

LIAM GRAHAM, JR., Human Nutrition Program, Division of Health, Physical Education and Recreation, Kentucky State University, Frankfort, KY 40601.

The National Youth Sports Program provides opportunities for children from low-income families to participate in sports activities in the summer. The objective of the study was to determine the effects of participation in the program on the body weight status of children 10–14 years old. The program provided a half day of guided sports activities including basketball, volleyball, flag football and swimming for 6 weeks. At the beginning and the end of the program, the participating children were examined for their body weight and height. Their body fat content was measured with a Tanita TBF-521 body composition analyzer. Body mass index (BMI) was derived from the body weight in kg divided by the square of body height in meters. On average, the body weight, body fat percent and BMI declined slightly for the boys but stayed about the same as the initial values for the girls. It appears that the program helped to improve or maintain their body weight status, which could have gotten worse in the summer, because the children probably would have little opportunities for sports activities due to their limited resources. These results suggest that the National Youth Sports Program is valuable to overcoming the high risk of overweight among children from low-income families.

PHYSICS AND ASTRONOMY

Half Metallic Ferromagnets. AMER S. LAHAMER and PATRICK MONO*, Department of Physics, Berea College, Berea, KY 40404.

Half metals are metals where the conduction charge carriers are of one particular spin. To have a 100% spin polarized charge carriers of one particular spin requires that a band gap between the two spin states exists where one of the spin states falls on the Fermi energy level (i.e. becomes insulating). In reality there is no direct measurement of the degree of half metalicity in compounds. Hence, most of the experimental work relies on the predictions of numerical band calculations of compounds such as that of NiMnSb and $Fe_{1-x}Co_xSi$ which were predicted to be half metals. In general, half metalicity (100% spin polarization) is difficult to achieve at finite temperatures due to thermal agitation and crystal defects. So, the search is on for half metals with high spin polarization as they hold the potential for great breakthroughs in the new field of spintronics.

The predicted half metals NiMnSb and the $Fe_{1-x}Co_xSi$ compounds were synthesized using the solid state method. Their crystal structures were identified using X-ray diffraction technique. The results of the Resistivity and the Hall-effect measurements at room and liquid nitrogen temperatures were presented.

New opportunities in the designated Kentucky Space Grant Consortium and Kentucky NASA EPSCoR Program. KAREN HACKNEY*, RICHARD HACKNEY, ROGER SCOTT, KEITH ANDREW, DAVID BARNABY, CHRIS BASSEY, MICHAEL CARINI, RICHARD GELDERMAN, SERGEY MARCHENKO, CHARLES McGRUDER and RICO TYLER, Kentucky Space Grant Consortium and NASA EPSCoR, Department of Physics and Astronomy, Western Kentucky University, Bowling Green, KY 42101.

In a recent national competition, the Kentucky Space Grant Consortium achieved NASA's highest Space Grant distinction of "Designated Space Grant Consortium." KSGC member colleges and universities will be designated by NASA as "Space Grant Colleges," and the annual consortium budget will be approximately double its previous level as a "Capability Enhancement" program. With expanded opportunities will come some shifts in emphasis—particularly in increasing student research involvement, workforce development, and building direct connections between NASA and Kentucky's students, teachers, and higher education faculty. We will describe future emphases and opportunities, including the next consortium-wide proposal competition that will be posted at www.wku.edu/ksgc/ in January 2006. We encourage everyone to participate in some way, to bring the widest possible benefit of the program resources to Kentucky. We will also briefly discuss what may currently be known about NASA's plans for the next round of national competition for NASA EPSCoR programs.

Insights from a WKU spectroscopy workshop for teachers. KEITH ANDREW*, RICO TYLER, ROGER SCOTT, LARRY BYRD, KAREN HACKNEY, and RICHARD HACKNEY, Department of Physics and Astronomy, and Department of Chemistry, Western Kentucky University, Bowling Green, KY 42101.

We have developed a spectroscopy workshop for physical science teachers based upon a model utilized at the New Jersey Governor's School for the Sciences at Drew University. The workshop reviews the principles of spectroscopy within the context of the Bohr model of the atom and then focuses on the collection of digital data and the interpretation of the observed spectral lines. Applications from chemistry, physics and astronomy included collecting spectra from emission sources, collecting solar spectra and collecting stellar spectra utilizing the WKU TCCW Observatory. Image analysis and modeling software was used to process the images and to understand the formation of stellar spectra by looking at an atmospheric model that solves the coupled Saha and Boltzmann equations to yield the location and shape of the spectral lines. Laboratory exercises included using diffraction gratings and Project Star spectrometers with the Lab Aids 111 Flame test sources, the emission tubes for Hydrogen, Helium, Neon, and Mercury, Coronado H-alpha Solar Telescope, the SBIG Deep Space Spectrograph DSS-7, SBIG CFW-8A UVBIR Filter wheel, and a dual CCD SBIG ST-2000 XM camera. We will review some of the successes and failures of the program as we prepare to offer another such workshop. This work supported in part by WKU PIE Grant 2–570506 and a KY NASA Space Grant.

NASA Space Grant Aerospace workforce development experiences in Kentucky. RICHARD HACKNEY*, KAREN HACKNEY, ANDREW HACKNEY, SUZANNE SMITH, JACK LEIFER, JAMES ROGERS, ROGER SCOTT, and LORI WILSON, Kentucky Space Grant Consortium, HQ—Department of Physics and Astronomy, Western Kentucky University, Bowling Green, KY 42101.

We describe Kentucky Space Grant projects that provide student experiences, beyond the usual individual study and research, to prepare them more directly for future participation in the scientific and technological workforce. The projects typically involve several students working together in teams, learning to contribute cooperatively to sizable R&D projects. Projects resemble NASA missions, with student teams planning the project/mission, developing, constructing and testing components, integrating them into mission hardware, executing the mission, and analyzing and reporting the results. We discuss past and present projects to emphasize the benefits for the students, with a goal of inspiring others to develop such projects with Space Grant support.

Astronomy and Space Science Workshop 2005. ROGER SCOTT*, RICO TYLER, KAREN HACKNEY, and RICHARD HACKNEY, Western Kentucky University, and CATHERINE POTEET, Greenwood High School, Bowling Green, KY, 42101.

Beginning in the summer of 1992 a one-week Astronomy and Space Science Workshop for Kentucky science teachers has been offered at Western Kentucky University's Hardin Planetarium. Middle school teachers are targeted, but many teachers of other grades have participated as well. The workshop has evolved over the years and includes a balance of content knowledge and teaching techniques that focus on the science core content for the grade levels taught by the participants. The presentation will include photographs of various workshop activities and projects, and announce an opportunity to participate in the 2006 workshop. The 2005 workshop was funded by the Kentucky Space Grant Consortium (KSGC).

PHYSIOLOGY AND BIOCHEMISTRY

Calcium content of bone soups prepared with a pressure cooker. MARQUISHA PAUL*, CHANGZHENG WANG, and LINGYU HUANG, Human Nutrition Program. Kentucky State University, Frankfort, KY 40601.

Bone soup can be an alternative source of calcium for people who can not consume dairy products. A pressure cooker can increase the inside temperature to nearly 120°C and significantly shorten the time needed for making bone soups. The objective of this study was to determine the calcium content of bone soups prepared with a pressure cooker. Soups were made by cooking 100 g of bones for 1 hour in 300 ml of distilled water containing 5, 10 or 20% of white vinegar. Soup samples were taken at 0, 1 or 14 hours after cooking and the soup brought to room temperature. The concentration of calcium and magnesium in the soup increased with increasing amounts of vinegar added before cooking. When 5% of vinegar was added, soaking the bones without cooking resulted in higher concentration of calcium than cooking the bones in the pressure cooker for 1 hour. Addition of vinegar after cooking lead to lower initial calcium content, which increased significantly after 1 hour. The pH of the soup was higher after cooking, indicating acetic acid from the vinegar was evaporated during pressure cooking. For most effective extraction of calcium, the bones need to be pressured-cooked before vinegar is added and allowed enough time for extraction with the bones in the soup.

Effects of preparation procedures on the quality of paddlefish caviar. CHANGZHENG WANG*, STEVEN D. MIMS, RICK ONDERS, and LINGYU HUANG, Human Nutrition Program, Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601.

Caviars are in high demand in the market place because the supply from Russian sturgeon is almost depleted. The potential is great for paddlefish eggs to be made into caviars for the benefits of both the consumers and producers. Various procedures for caviar preparation have been used and their effects on product quality are not well defined. The objective of this study was to determine the effects of salt concentration and washing the eggs on the quality of paddlefish caviar. Eggs from two mature paddlefish were hand-pressed through a stainless steel screen so that the eggs were separated from each other. The connective tissues were discarded. The eggs were divided into batches of 200 g placed in clear plastic containers. Half of the batches were not washed, whereas the other half was washed with tap water before salt was added into the eggs. The amount of salt added was 2.5, 3.5 or 4.5% of the egg weight. The salt was mixed into the eggs evenly before the containers were covered and placed at 4°C. The color, texture and salt content were determined within a week. A taste panel of chefs experienced with caviar evaluated the products. The water-phase salt content was above 3.5% for caviars prepared with the lowest level of salt added (2.5%). Higher amount of salt resulted in much higher salt content in the products and a saltier taste. However, the visual and other taste profiles of the products were not significantly affected by the preparation procedures. Therefore, washing the eggs is optional for caviar preparation. Adding salts above 2.5% of the egg weight will result in salty caviar.

PSYCHOLOGY

Convergence of the Internalized Restlessness Scale with popular AD/HD rating scales. NATHAN RATLIFF* and SEAN P. REILLEY, Department of Psychology, Morehead State University, Morehead, KY 40351.

Overt hyperactive behaviors are common symptoms of children with Attention Deficit/ Hyperactivity Disorder (AD/HD). Adults with AD/HD, however, appear to exhibit less of these overt hyperactive behaviors. Instead, hyperactivity increasingly may become more covert, often taking the form of internalized feelings of restlessness and

tension. Using a spectrum approach, college student (n = 127) scores on the Internal Restlessness Scale (IRS), a new measure of internalized AD/HD hyperactivity symptoms, were compared with narrow band (DSM-IV based) symptoms of hyperactivity derived from the Adult AD/HD Self Report Scale and the Conners Adult AD/HD Rating Scale. In addition, relations between the IRS and broad band (non-DSM-IV) measures of hyperactivity from the Brown Attention Deficit Disorder Scales and the short form of the Wender Utah Rating Scale were inspected. Results indicated moderate to strong correlations ($r > 0.50$) between the IRS and more established narrow and broad band self report measures of hyperactivity and lower correlations ($r < 0.20$) with the Wender Utah Rating Scale. Potential implications for understanding the range of hyperactivity expression in adult AD/HD and subclinical populations are discussed. This research work was funded in part by the Kentucky Statewide EPSCoR program.

The impact of elevated arousal, test, and math anxieties on math and non-math tests. BARBARA ROBERTS* and SEAN P. REILLEY, Department of Psychology, Morehead State University, Morehead, KY 40351.

Test anxiety is common and frequently leads to academic underachievement. Math anxiety, a specific form of test anxiety, has been less studied despite high prevalence and increasing needs for remedial math education. Arousal theory has been used as one model for explaining why individuals with test anxiety perform poorly in evaluation situations. It predicts that individuals with high levels of test anxiety suffer from chronic high arousal, which during evaluation situations leads to increased negative self-cognitions and negative effect which taxes working memory and degrades performance. The arousal-performance hypothesis, however, has produced mixed results for math anxiety. One reason is the lack of separate assessments of test anxiety, math anxiety, and arousal and/or use of laboratory performance measures which are non-standardized or assess a restricted range of math performance. In the present study, a quasi-experimental design was used to compare the math and non-math performance of normal college students with those who had individually elevated arousal (Trait Anxiety Scale), test anxiety (Test Anxiety Inventory), or math anxiety scores (Abbreviated Math Anxiety Scale), or combinations of these elevations. Performance assessments included tests of Nonverbal Reasoning Ability, Basic Math Calculation, and Math Application from the Scholastic Abilities Test for Adults. Consistent with expectations, test anxious individuals, unlike those with math anxiety, had significantly lower Nonverbal Reasoning scores. Math anxiety, however, in combination with test anxiety was related to lower math calculation performance, but not math application difficulties. Research work was funded in part by the Institute for Regional Analysis and Public Policy.

Initial Psychometric Characteristics of the Adult Self Report Scale for University and Community College Students. JOSHUA SHEETS*, SEAN P. REILLEY, Department of Psychology, Morehead State University, Morehead, KY 40351, and WARREN LAMBERT, Somerset Community College, Somerset, KY 42501.

Attention rating scales are frequently used in the diagnostic process for adult Attention Deficit/Hyperactivity Disorder (AD/HD). Eli Lilly and Company in conjunction with the World Health Organization have provided a free, narrow band attention AD/HD screening instrument, the Adult Self-Report Scale for medical and mental health providers. To date, limited psychometric data are available for the general population and little published data are available for university and community college samples. Given its potential for widespread use in a college population, initial psychometric data for the ASRS was collected from adults enrolled at a 4-year university (n = 410) or at a regional community college (n = 224). Total ASRS scores for the university (M = 26.6) and community college samples (M = 27.0) were higher than the published data for the adult general population (M = 17.2), despite similar internal consistency estimates (Cronbach alpha coefficients > 0.80). In addition, students with an existing diagnosis of AD/HD (n = 12) and without additional mental or physical health conditions scored significantly higher on the ASRS than a similarly matched group without AD/HD (n = 12). Implications for use of this instrument in assessing AD/HD symptoms in a college population are discussed. This research work was funded in part by the Kentucky Statewide EPSCoR program and the Institute for Regional Analysis and Public Policy at Morehead State University.

SCIENCE EDUCATION

Teacher Education Model Program (TEMP): a standards-based master's degree program in elementary education. KERRIE MCDANIEL*, HEATHER JOHNSON, ROBIN AYERS and WANDA WEIDEMANN, Departments of Biology and Mathematics, Western Kentucky University, Bowling Green, KY 42101.

The 10th annual report on science education in America conducted by the Bayer Corporation, found that only 14% of teachers rated their pre-service science education as an "A." Few of these teachers had received training from actual scientists. Most of the teachers surveyed stated that elementary education programs should include more courses in science and how to teach science to children. Western Kentucky University is developing a new Master's Program in Elementary Education that will provide more training in science content and mathematics. These classes will be taught in the science college at the university. The courses will be designed to assimilate Kentucky Internship (KTIP) demands, National Board certification elements with an emphasis on inquiry learning, integration of mathematics into science, and technology. All content will be centered on the Kentucky Core Content items provided by the state Department of Educa-

tion. In addition, the program will provide 18 hours of pedagogy including 13 embedded web modules to help teachers perform well on the KTIP tasks. This program should help teachers succeed in their KTIP year, prepare them for National Boards in the future, and provide foundations in the academic content areas of mathematics and science.

An attempt to assess classroom learning in community college biology courses. JOHN G. SHIBER, Division of Health Sciences & Related Technologies, Kentucky Community & Technical College System, Big Sandy District, Prestonsburg, KY 41653.

End-of-semester surveys of eastern Kentucky community college biology students who are given teacher-prepared instructional objectives to complete during the semester suggest strong support for this approach to learning course material and studying for tests. With the goal of better understanding how much learning these students experienced, the survey also asked them to estimate the percentage of course material they believe they had learned. A consistent correlation was observed between the percentages of course material students felt they had learned over the semester and their final grades. Furthermore, comparisons between their pre-entry and post-exit test scores, with respect to range and mean percentages, readily show overall student learning improvement. Attendance also seemed to be a factor in material learned and the grade earned. It is concluded that these four parameters, i.e. pre/post testing scores, students' perceptions of how much they learned, attendance record, and final course grade, are helpful in assessing student classroom learning. It is suggested that pre/post testing be adopted as standard procedure in post-secondary institutions, especially two-year colleges.

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* = presenter.

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NOTES

The Mantisflies of Kentucky (Neuroptera: Mantispidae): An Annotated Checklist–During the past 41 years as a professor and entomologist in Kentucky, I have been entranced by the various insects that come to black lights that I have used to collect moths throughout the Commonwealth. One of the most fascinating and rather small groups is the neuropteran family Mantispidae—the mantisflies. These predaceous insects have the general size of green lacewings (Neuroptera, Chrysopidae), but their thoraces are extended, and the front legs are raptorial, resembling preying (praying) mantises (Mantodea).

I have accumulated a small collection of these insects over the years and have checked the University of Kentucky Insect Collection for further records. Several specimens also were borrowed from Charles Wright. I had waited for some time to present the records as I had not yet found *Zeugomantispa minuta* (Fabricius), a green species, in the state. I now have records of this species from two western counties and believe that most of the possible Kentucky species are now represented by definite records, hence the annotated checklist.

Nomenclature has been modified recently by Hoffman (**1**). Most of the specimens annotated below were determined by the late Ellis MacLeod, a specialist in this family and by Oliver Flint, U.S. National Museum of Natural History. Most of the specimens from which the data were taken are now in the collection of the Department of Entomology, University of Kentucky, Lexington, KY, and the small remaining collection at the University of Louisville. The check list uses the following format: scientific name and author of species, Kentucky counties from which the species was recorded (listed alphabetically), localities, dates of capture, method of capture if included, and collector's names.

I thank Oliver Flint, U.S. National Museum of Natural History, for his assistance in correct nomenclature and identifications, Charles Wright of Frankfort, Kentucky, for the loan of several specimens, Michael Sharkey, Department of Entomology, University of Kentucky for access to the University of Kentucky insect collection, and the late Ellis MacLeod for identifying many of the specimens.

CHECK LIST

Genus *Dicromantispa* Hoffman

Dicromantispa interrupta Say.
Metcalf Co., 1 September 1974, Jenene Parks; Nicholas Co., 20 September 1984, Rudy A. Scheibner; Robertson Co., 17 August 1969, Winston Swango; Russell Co., Lake Cumberland State Park, 14 August 1979, Carl C. Cornett; Trigg Co., Land Between the Lakes, 24 June,1971, Charles V. Covell Jr.

Dicromantispa sayi (Banks).
Franklin Co., Vietnam Memorial, 12 September 1994 and 24 July 1999, Charles Wright; Hart Co., Hamilton Valley, 26 August 2001, Charles Wright; Henderson Co., 11 September 1982 (collector unknown); Jefferson Co., Louisville, 16 November 2005, Matthew Vanderpool; Valley Station, 5 and 29 July 1974, Alan J. Brownell, 2 July, 1974, Steve Mann, 13 August 1974, Leroy Isaacs, and 27 August 1974, Jack C. Lesshafft; Lyon Co., Land Between the Lakes, near Dickerson Cemetery, 10 September 2005, at black light, Charles V. Covell Jr.; Russell Co., Lake Cumberland State Park, 14 August 1978, in light trap, Carl C. Cornett; Trigg Co., Land Between the Lakes, 15 and 16 July 1969, Charles V. Covell Jr.; Whitley Co., Corbin, 14 August 1995, Charles Wright.

Genus *Leptomantispa* Hoffman

Leptomantispa pulchella (Banks)
Henderson Co., Sloughs Wildlife Management Area, 10 September 1983, at black light, Charles V. Covell Jr.; Meade Co., 27 July 1979, Thomas Johnson; Whitley Co., Corbin, 14 August,1995 Charles Wright.

Genus *Zeugomantispa* Hoffman

Zeugomantispa minuta (Fabricius) (formerly *Mantispa viridis* Walker.)
Carlisle Co., Wesvaco Wildlife Management Area, September 2003, at black light, Charles V. Covell Jr.; Lyon Co., Land Between the Lakes, near Dickerson Cemetery, 10 September 2005, at black light, Charles V. Covell Jr.

Genus *Climaciella* Enderlein

Climaciella brunnea (Say).
Hardin Co., I-65 at Elizabethtown, 31 July 1989, Rose Isgrigg; Hopkins Co., Madisonville, 16 June 1972, in sweep sample, Roger Robinson; Jefferson Co., Anchorage, 25 July 1976, Burt L. Monroe Jr.; Waverly Park, Valley Station, 14 August 1974, Alan J. Brownell; McCracken Co., Paducah, 28 May 1987, Greg Thompson; Nicholas Co., 19 June 1986, Rudy A. Scheibner; Rockcastle Co., Renfro Valley, 10 July 1972, Roger Robinson.

LITERATURE CITED. (**1**) Hoffman, K. in N. D. Penny (ed.). 2002. A guide to the lacewings (Neuroptera) of Costa Rica. Proceed-

ings of the California Academy of Science 83: 161–457.—**Charles V. Covell Jr.** Professor Emeritus, Department of Biology, University of Louisville, Louisville, KY 40292-0001 and Curator of Lepidoptera, McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History, Gainesville, FL 32611-2710. E-mail: covell@louisville.edu. KEY WORDS: Insecta, Neuroptera, Mantispidae, Kentucky.

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Guidelines for Contributors to the Journal

All manuscripts and correspondence concerning the Journal should be addressed to the Editor:

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B. Except for scientific names of genera, and of infrageneric taxa, which should be typed in italics, the same type (roman) should be used throughout (i.e., one type size only – 12pt is best; bold only for paper title).
C. Sequence of sections in papers should, where appropriate, be as follows: title of paper, name/address of author(s), abstract, 5–6 key words (may repeat words in the title), body of paper, footnotes, table captions, figure captions (all the preceding on consecutively numbered pages), tables, and figures.
D. The running head (top right) should give name(s) of author(s), a short version of paper title, and page number of total (please limit to a total of 60 characters and spaces).
E. The first page should include the running head and, centered near the top of the sheet, the paper's title and the name and address of author(s). These should be followed immediately by the abstract and key words. (The first page should look as much as possible like the first page of articles in J-KAS.) The e-mail address of the corresponding author should be at the bottom of the first page as a footnote under a short line, e.g.,

E-mail of corresponding author: john.smith@rbu.edu.

F. The abstract, not to exceed 200 words, should be concise, descriptive, and complete in itself without reference to the paper (literature is not cited in the abstract).
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Introduction, Materials and Methods, Results, Discussion, Summary (optional), Acknowledgments, and Literature Cited.

H. No more than three levels of headings should be used: level 1, in capitals, centered; level 2, in capitals/lowercase, flush left; level 3, in italics, a paragraph indent with initial capital only (except proper nouns and adjectives), and followed by a period, the text then starting after one blank space.

I. Personal communications (avoid if possible) should be indicated in the text as follows: (name, affiliation, pers. comm., date) e.g., (O.T. Mark, Wainwright College, pers. comm., 5 Jun 1995).

3. STYLE

A. In text, spell out one-digit numbers unless they are used with units of measure (four oranges, 4 cm) and use numerals for larger numbers; do not begin any sentence with a numeral.

B. Use no footnotes except those for title page and tables. Footnotes, identified by consecutive superscript numbers, should be entered on a separate sheet.

C. Measurements should be in metric and Celsius units. Define lesser-known symbols and give the meaning of acronyms at first use. Express time of day in the 24-hour system. Dates should be written day, month (abbreviated to three letters), year without internal punctuation. Units with multiple components should have individual components separated by a virgule (e.g., g/m^2/yr).

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E. Useful guides for contributors to J-KAS are the following: *Scientific style and format: the CBE manual for authors, editors, and publishers,* 6th ed., Cambridge University Press, 1994; *The Chicago manual of style,* 14th ed., University of Chicago Press, 1993; *The ACS style guide,* American Chemical Society, Washington, DC, 1986; and *AIP style manual,* American Institute of Physics, New York 1990.

4. IN-TEXT CITATION OF LITERATURE

A. Cite publications in the text by author(s) and date—e.g., (Readley 1994); multiple citations should be in chronological order and separated by semi-colons—e.g., (Foster 1976; Ashley 1987; Brown 1994); multiple citations of works by one author(s) should be in chronological order—e.g., (Jones 1978, 1983); publications by one author(s) in the same year should be distinguished by a, b, c, etc.—e.g., (Smith 1994a, 1994b). For in-text references to works with one or two authors use names of both authors—e.g., (Jones and Williams 1991); for works with three or more authors use name of the first author followed by et al.—e.g., (Lee et al. 1985).

B. Do not include any reference unless it has been published or accepted for publication ("in press"; see below).

5. LITERATURE CITED

A. List all authors of each entry.

B. Do not abbreviate journal titles.

C. The first line of each reference should be typed flush left; the remaining lines should be indented five spaces.

D. Examples of common types of references are given below.

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Lacki, M. J. 1994. Metal concentrations in guano from a gray bat summer roost. Transactions of the Kentucky Academy of Science 55:124–126.

BOOK

Ware, M., and R. W. Tare. 1991. Plains life and love. Pioneer Press, Crete, WY.

PART OF A BOOK

Kohn, J. R. 1993. Pinaceae, Pages 32–50 in J. F. Nadel (ed). Flora of the Black Mountains. University of Northwestern South Dakota Press, Utopia, SD.

WORK IN PRESS

Groves, S. J., I. V. Woodland, and G. H. Tobosa. n.d. Deserts of Trans-Pecos Texas. 2nd ed. Ocotillo Press, Yucca City, TX.

WORLDWIDE WEB SITES

(Listing of web sites in the Literature Cited is not encouraged, but if it is needed, please follow the guide below.)
Smith, A. W. 1999. Title of web site. Web site address. Date accessed (06/12/2005)

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Each table and its caption must be double-spaced, numbered in Arabic numerals, and set on a sheet separate from the text. The caption should begin with a title relating the table to the paper of which it is a part; it should be informative of the table's contents and should be self-explanatory without reference to the text. Statistics presented in the table should be explained in the captions (e.g., means are presented + SE, n = 7). Tables should be submitted in hard copy only; they need not be included on a disk.

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