The Great Smoky Mountains National Park All Taxa Biodiversity Inventory: A Search for Species in Our Own Backyard
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Great Smoky Mountains National Park's First Lichen Bio-Quest

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Abstract - The first Lichen Bio-Quest was held at the Great Smoky Mountains Institute at Tremont near Townsend, TN, on 19–20 June, 2004. More than 30 participants included high school teachers and students, Park volunteers and staff, area residents, and professional lichenologists. The primary goal was first to provide an educational component, including lichen morphology, growth forms, terminology, and identification using lecture and video-microscopy presentations, followed by a field component collecting lichens in different habitats. H. Thorsten Lumbsch, an expert on crustose lichens, and Steven B. Selva, an expert on calicioid (stubble) lichens, served as instructors, foray captains, and helped identify specimens. Lower-elevation collection sites were located in the Tremont area (Lumber Ridge Trail and Spruce Flats Falls Trail) and ranged from 405–550 m. High-elevation sites (Indian Gap, Spruce-Fir Nature Trail, and the Balsam Mountain Road area) ranged from 1094 to 1706 m. Eighty-eight lichen and lichenicolous fungi species were identified, including 10 new published Park and Tennessee records. The new lichen records were: *Aspicilia caesiocinerea, Calicium glaucellum, Chaenotheca brunneola, Placynthiella icmalea*, *Trapelia glebulosa, T. placodioides,* and *Trapeliopsis flexuosa*. The new lichenicolous fungi records were: *Mycocalicium subtile, Phaeocalicium polyporaeum,* and *Sphinctrina turbinata*.

Introduction

One of the world's most biologically diverse temperate regions, Great Smoky Mountains National Park (GSMNP), comprises approximately 210,566 ha, with roughly 40,000 ha of old-growth forest (Snell et al. 2003). This area is known for high tree-species diversity, including tertiary relics that survived in eastern North America and eastern Asia, but became extinct in Europe. This type of distribution has been known to occur in higher plants, but has only recently been discovered for lichens (Yoshimura 1968). Since Yoshimura's pioneering work, this distribution type has been discussed repeatedly in the macrolichen literature (e.g., Culberson 1972, Kurokawa 1972, Yoshimura 1987). Miyawaki (1994) also listed numerous crustose lichens with the same type of distribution. The importance of GSMNP as a glacial refugium for widely disjunct lichen species is demonstrated by those

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species that occur in eastern North America as well as in the Pontis region (Turkey), and in eastern Asia.

There are few studies devoted solely to the lichen biota of GSMNP. Degelius (1941), in his treatment of the lichen flora of North America, provided data collected from GSMNP. He listed 206 species for the Park, including 15 species new to science. Dey (1978) identified 178 species of macrolichens in the high-mountain areas of the southern Appalachians, which included areas of the GSMNP. He recorded 4% of the species as endemic and also noted continental disjuncts known only from Japan. Skorepa (1972) listed lichens from the Park in his checklist, and DePriest (1984) included records in a bibliography of southern Appalachian lichens. Ciegler et al. (2003) collected lichens from the tree canopy in GSMNP and noted geographical disjuncts generally found in more-northern regions.

Esslinger (2006) has created a collective checklist of lichenicolous, lichen-forming, and allied fungi for North America. The most recent version (10 April 2006) is available at the North Dakota State University web site (http://www.ndsu.nodak.edu/instruct/esslinge/chcklst/chcklst7.htm) listing 721 genera and 7734 species. The number of lichen species published from GSMNP, and/or reported as part of the GSMNP checklist updated periodically by the National Park Service, is approximately 563, with an estimated total number between 600–700 species (Becky Nichols, GSMNP, Gatlinburg, TN, pers. comm.). Many of the recent additions to the lichen checklist and species new to science are the result of specialists in the crustose lichens exploring the GSMNP and completing regional monographs or papers (Tønsberg 2002, 2004; Printzen and Tønsberg 2003, 2004).

"Bio-Quest" and/or "Bio-Blitz" are terms used for special field surveys and biotic inventories that occur within limited time duration, usually 24 to 48 hours. These events are designed to increase the public's awareness of biodiversity in a given area, and also to survey for new taxonomic records and new species. If the area is small, containing several hundred hectares, every taxonomic group is collected and identified. Larger geographic areas, such as GSMNP, require a number of expert taxonomists to survey and inventory as many habitats as possible, concentrating on the collection and identification of a single target group of organisms such as lichens. The All Taxa Biodiversity Inventory (ATBI), with staff and financial support from Discover Life in America, Inc., is an initiative to identify all of the life forms in GSMNP (Sharkey 2001). One approach for obtaining this data is to support taxonomists to survey, inventory, and identify different groups of organisms in diverse fields such as bryology, entomology, lichenology, mycology, myxomycology, phycology, pteridology, and tardigradology. Another approach is to sponsor Bio-Quests that may produce new records and new species.

The purpose of this paper is to report the results of the first Lichen Bio-Quest for GSMNP held at the Great Smoky Mountains Institute at

Tremont (GSMIT) on 19–20 June 2004. Our primary goal was to bring together school teachers, students, Park volunteers and staff, area residents, parataxonomists, and professional lichenologists to teach and learn how to collect and identify lichens in GSMNP. The objectives of the Lichen Bio-Quest included an educational component that answered the following questions: What is a lichen? Where do lichens grow? How do you collect and preserve lichen specimens? How do you recognize growth forms? How do you use lichen terminology? How do you identify lichens using picture keys? A secondary objective was to inventory and contribute to an annotated checklist of lichens associated with specific high-elevation and low-elevation sites in GSMNP as part of the ATBI. The final objective was to curate, identify, and characterize new lichen records for GSMNP, and enter geo-referenced collection data into the ATBI database.

Methods

The Lichen Bio-Quest was held at the Great Smoky Mountains Institute at Tremont (GSMIT), which is within GSMNP, from 8:00 am to 6:00 pm on 19–20 June 2004. More than 30 individuals registered and participated. Two lichenologists, H. Thorsten Lumbsch, an expert on crustose lichens, and Steven B. Selva, an expert on calicioid (stubble) lichens, served as instructors and foray captains, and also helped identify specimens. Saturday morning and early afternoon were devoted to lectures and field training of the participants. Keith Langdon, Inventory and Monitoring Coordinator, GSMNP, gave a brief introduction to collecting in the Park, with special remarks about habitat and distribution of the federally endangered lichen species *Cetradonia linearis* (Evans) J.-C. Wei & Ahti. H. Thorsten Lumbsch, Department of Botany, The Field Museum, presented a lecture that covered lichen symbiosis, morphology (growth forms and terminology), reproduction, physiology, ecology, importance, systematics, and taxonomic characters. Steven B. Selva, University of Maine at Fort Kent, presented a lecture on the use of calicioid (stubble) lichens as environmental indicators of old-growth forests and described morphological characters that distinguish this group of lichens. Participants viewed lichen specimens using microscope video cameras to illustrate morphology, terminology, and taxonomic characters. Examples were shown representing the crustose, foliose, and fruticose lichen growth forms. Time constraints limited late-afternoon foray activities to the GSMIT grounds and nearby areas.

The next day was spent as an all-day foray; one team went to high-elevation sites in the vicinity of the Spruce-Fir Nature Trail, and another team collected along the Heintooga Ridge Road and Balsam Mountain Road. There were only 2 to 3 hours to picture-key and identify specimens after our return to GSMIT. Many reference books on lichens were available for perusal and were used for practice keying, but the most user-friendly book for the beginner, with pictures and keys, was Brodo et al. (2001).

Field collection sites

Low-elevation sites at about 405 to 550 m were surveyed by the Bio-Quest teams near GSMIT, Blount County, TN along the Lumber Ridge Trail and along the Spruce Flats Falls Trail. The Lumber Ridge Trail is dominated by *Tsuga canadensis* (L.) Carrière (eastern hemlock) and is located on a moist northwest-facing slope. The Spruce Flats Falls Trail is in a mixed community of *T. canadensis*, *Liriodendron tulipifera* L. (yellow poplar), *Carya ovata* (Mill.) K. Koch (shagbark hickory), and *Aesculus flava* Ait. (yellow buckeye), and is very similar to a cove hardwood forest with a southwest-facing drier slope. The Spruce Flats Falls trailhead and the water-tower glade area at GSMIT (site of three new lichen records for the Park) were dominated by *Pinus virginiana* Mill. (Virginia pine), *Rhus copallina* L. (winged sumac), *Danthonia* spp. (oatgrasses), and *Schizachyrium scoparium* (Michx.) Nash (little bluestem).

A foray team of three people concentrated on collecting calicioid lichens from high-elevation sites at Indian Gap (1524 m) and along the Spruce-Fir Nature Trail (1620 m), which are areas dominated by *Abies fraseri* (Pursh) Poir. (Fraser fir) and *Picea rubens* Sarg. (red spruce). The other teams followed Heintooga Ridge Road, which leads to the Balsam Mountain Campground area (1706 m), and then followed Balsam Mountain Road down to Lower Beech Gap Trail (1094 m). This portion of the Park is dominated by *Abies fraseri* and *Picea rubens* at the highest elevations and mixed deciduous trees such as *Acer rubrum* L. (red maple), *Acer saccharum* Marshall (sugar maple), *Aesculus flava*, *Betula alleghaniensis* Britton (yellow birch), and *Prunus serotina* Ehrh. (black cherry) downslope. Boulders and rock outcrops along the road also provided habitats for a variety of lichens.

Lichen taxa listed in the Results section are arranged alphabetically by genus and species, as recognized by Esslinger (2006). An asterisk (*) indicates a new lichen species for the Park's checklist and/or a new published record for the state of Tennessee. Collection details are given for this noteworthy species group. Representative species are grouped under the field sites where they were collected, without repeating duplicate or noteworthy species. Some species were sight-identified by expert lichenologists, and voucher specimens do not exist. The Universal Transverse Mercator (UTM) coordinate system was used to record the global positioning system (GPS) units. Voucher specimens for the calicioid lichens collected by Steven B. Selva were deposited in the herbarium at the University of Maine at Fort Kent (UMFK) and GSMNP; specimens collected by H. Thorsten Lumbsch were deposited at the Field Museum (F).

Results

Noteworthy species collected during the Lichen Bio-Quest were identified, and voucher specimens and new Park records were processed. There

were 136 lichen and lichenicolous fungi taxa collected, representing 88 species and 10 new published Park records. There were 57 genera, 29 families, 5 suborders, and 7 orders inventoried for GSMNP. The majority of species recorded belong to the Lecanorales (n = 76, 59.5%) with 46 genera and 19 families. Parmeliaceae (n = 26), Cladoniacaeae (n = 9), Lecanoraceae (n = 8), Physciaceae (n = 6), and Lobariaceae (n = 6) contained the majority of other taxa recorded. These taxonomic groups represented nearly 63.6% of the species encountered. The majority of these species are foliose and fruticose lichens, which are larger, more conspicuous, and more likely collected by first-time collectors.

Two stubble lichens that were new to the Park belong to the Caliciales; *Calicium glaucellum* (Caliciaceae) and *Chaenotheca brunneola* (Coniocybaceae). *Phaeocalicium polyporaeum* and *Mycocalicium subtile* were also new records and represent two non-lichenized fungi that morphologically resemble stubble lichens, but belong to an unrelated group of saprophytic fungi (Mycocaliciaceae, Mycocaliciales). All of these lichens are often overlooked because of their small size (less than 1–2 mm) and stalked habit more similar to myxomycetes and other fungi. This group is understudied, even by lichenologists, as evidenced by a recent (2005) two-week summer collecting trip that resulted in 23 new records for calicioid lichens and fungi for the Park (S.B. Selva, unpubl. data).

Noteworthy species

**Aspicilia caesiocinerea* (Nyl. ex Malbr.) Arnold. Siliceous, on exposed schistose rocks. All saxicolous lichen specimens were growing on siliceous rocks in an open and sunny ravine with sparse vegetation of pines and shrubs (UTM 17S 0257111E 3946498N) at the end of Spruce Flats Falls Trail near GSMIT, 19 June 2004, Lumbsch 19277e. This is a common species on siliceous rocks in eastern North America. It probably has been overlooked since natural areas with exposed rocks are frequent in GSMNP.

**Calicium glaucellum* Ach. Lignicolous on standing conifer snags (UTM 17S 0278493E 3943338N) near Indian Gap parking lot, 20 June 2004, Selva 9334A; lignicolous on standing *Abies fraseri* snags (UTM 17S 0277192E 3941683N), Spruce-Fir Nature Trail, Selva 9336. This is a fairly common species in northeastern North America, which suggests that some calicioid lichens have been overlooked in GSMNP.

**Chaenotheca brunneola* (Ach.) Müll. Arg. Lignicolous on standing *Abies fraseri* snags (UTM 17S 0278294E 3943313N) near Indian Gap parking lot, 20 June 2004, Selva 9333, 9334B. This is perhaps the second most common calicioid species known (S.B. Selva, pers. observ.). Brodo et al. (2001) describes a northwestern, northeastern, and Florida distribution for this species.

**Mycocalicium subtile* (Pers.) Szatala. Lignicolous on a fallen, decaying *Quercus alba* L. (white oak) log covering an extensive area of several

m^2 (UTM 17S 0256460E 3947502N), Lumber Ridge Trail near GSMIT, 19 June 2004, HWK 4784, Selva 9331B. This lichenicolous fungus is probably the most common calicioid species known. The substrate is most often wood rather than bark, which was the case in GSMNP. Species typically found on lignum, such as *Mycocalicium subtile*, also are more frequently found on bark in aging forests (S.B. Selva, pers. observ.). The black, stalked habit with a rounded capitulum of the apothecium appears similar in gross morphology to stalked myxomycete species in the genus *Licea* (H.W. Keller, pers. observ.).

**Phaeocalicium polyporaeum* (Nyl.) Tibell. On a polypore bracket fungus, *Trichaptum pergamenum* (Fr.) G. Cunn., growing on standing dead *Liquidambar styraciflua* L. (sweet gum), Selva 9331A, HWK 4783 and *Betula lenta* L. (black birch), Selva 9332A (UTM 17S 025640E 3947500N), Lumber Ridge Trail behind dorm at GSMIT, 19 June 2004.

**Placynthiella icmalea* (Ach.) Coppins & P. James. On wood of an old picnic table bench on grounds of GSMIT next to Spruce Flats Falls Trailhead (UTM 17S 0256507E 3947014N), 19 June 2004, Lumbsch 19274. This inconspicuous crustose lichen is among the most common lichens in the temperate northern hemisphere and is often a pioneer on wood and soil. This wooden picnic table was totally encrusted with lichens. Two new Park lichen records were found here while we ate lunch. This is a common and widespread species and should be found more frequently in the Park.

**Sphinctrina turbinata* (Pers.: Fr.) De Not. Growing over the lichen *Pertusaria macounii* (Lamb) Dibben on *Fagus grandifolia* Ehrh. (American beech) (UTM 17S 0278630E 3943389N) along Indian Gap Trail near parking lot, 20 June 2004, Selva 9335A.

**Trapelia glebulosa* (Sm.) J.R. Laundon. On siliceous rocks near ground behind water tower in glade near GSMIT (UTM 17S 0256589E 3947066N), 19 June 2004, Lumbsch 19278e. This is another pioneer lichen species expected in the Park since it is a common and cosmopolitan species.

**Trapelia placodioides* Coppins & P. James. On exposed siliceous rocks, behind water tower in glade near GSMIT (UTM 17S 0256589E 3947066N), 19 June 2004, Lumbsch 19270a. This sorediate species was described in 1984 and was formerly included in *T. glebulosa;* however, it differs in having a continuous, sorediate thallus. The distribution of this species in North America is not well known, but it is very common in Europe.

**Trapeliopsis flexuosa* (Fr.) Coppins & P. James. On wood of an old picnic table bench on grounds of GSMIT next to Spruce Flats Falls Trailhead (UTM 17S 0256507E 3947014N), Lumbsch 19274a. This is another example of a common species overlooked in the Park, often a pioneer colonizer on wood.

Representative species from field sites

Lumber Ridge Trail near GSMIT: *Graphis scripta* (L.) Ach., *Hypotrachyna imbricatula* (Zahlbr.) Hale, *Lepraria lobificans* Nyl., *Porpidia*

albocaerulescens (Wulfen) Hertel & Knoph, and *Psilolechia lucida* (Ach.) M. Choisy.

Spruce Flats Falls Trail and glade near GSMIT: *Anaptychia palmulata* (Michaux) Vainio, *Bacidia schweinitzii* (Fr. ex E. Michener) A. Schneider, *Baeomyces rufus* (Hudson) Rebent., *Buellia stillingiana* J. Steiner, *Cetrelia olivetorum* (Nyl.) Culb. & C. Culb., *Chrysothrix chlorina* (Ach.) J.R. Laundon, *Cladonia chlorophaea* (Flörke ex Sommerf.) Sprengel, *C. coniocraea* (Flörke) Sprengel, *C. fimbriata* (L.) Fr., *C. macilenta* Hoffm., *C. squamosa* Hoffm., *Dibaeis baeomyces* (L.f.) Rambold & Hertel, *Flavoparmelia baltimorensis* (Gyelnik & Fóriss) Hale, *F. caperata* (L.) Hale, *Heterodermia casarettiana* (A. Massal.) Trevisan, *Hypocenomyce scalaris* (Ach.) M. Choisy, *Hypogymnia physodes* (L.) Nyl., *Hypotrachyna livida* (Taylor) Hale, *Imshaugia aleurites* (Ach.) S.F. Meyer, *Ionaspis lacustris* (With.) Lutzoni, *Lecanora allophana* Nyl., *L. hybocarpa* (Tuck.) Brodo, *L. imshaugii* Brodo, *L. polytropa* (Hoffm.) Rabenh., *L. thysanophora* Harris, *Lepraria lobificans* Nyl., *L. neglecta* (Nyl.) Erichsen, *L. membranacea* (Dickson) Vainio, *Parmelia squarrosa* Hale, *Parmotrema perforatum* (Jacq.) A. Massal., *P. reticulatum* (Taylor) M. Choisy, *Pertusaria amara* (Ach.) Nyl., *P. velata* (Turner) Nyl., *Platismatia tuckermanii* (Oakes) Culb. & C. Culb., *Pseudevernia consocians* (Vainio) Hale & Culb., *Punctelia rudecta* (Ach.) Krog, *Rhizocarpon obscuratum* (Ach.) A. Massal., *Sticta beauvoisii* Delise, *Tuckermannopsis chlorophylla* (Willd.) Hale, *T. ciliaris* (Ach.) Gyelnik, *Usnea pensylvanica* Mot., *U. strigosa* (Ach.) Eaton, and *Xanthoparmelia conspersa* (Ehrh. ex Ach.) Hale.

Balsam Mountain Road: *Allocetraria oakesiana* (Tuck.) Randlane & Thell, *Bryoria furcellata* (Fr.) Brodo & D. Hawksw., *Cetrelia cetrarioides* (Duby) Culb. & C. Culb., *Cladonia furcata* (Hudson) Schrader, *C. peziziformis* (With.) J.R. Laundon, *C. pleurota* (Flörke) Schaerer, *Coccocarpia palmicola* (Sprengel) Arv. & D.J. Galloway, *Coenogonium pineti* (Ach.) Lücking & Lumbsch, *Fuscopannaria leucosticta* (Tuck.) P.M. Jørg., *Heterodermia leucomela* (L.) Poelt., *Hypotrachyna revoluta* (Flörke) Hale, *Lasallia papulosa* (Ach.) Llano, *Lecanora caesiorubella* Ach., *L. subrugosa* Nyl., *Leptogium cyanescens* (Rabenh.) Körber, *Lobaria pulmonaria* (L.) Hoffm., *L. quercizans* Michaux, *Menegazzia terebrata* (Hoffm.) A. Massal., *Nephroma parile* (Ach.) Ach., *Ochrolechia androgyna* (Hoffm.) Arnold, *Peltigera polydactylon* (Necker) Hoffm., *Physcia aipolia* (Ehrh. ex Humb.) Fürnr., *Porpidia crustulata* (Ach.) Hertel & Knoph, *P. macrocarpa* (DC.) Hertel & A.J. Schwab, *Pseudocyphellaria crocata* (L.) Vainio, *Pyxine sorediata* (Ach.) Mont., *Ramalina americana* Hale, *Stereocaulon dactylophyllum* Flörke, *Umbilicaria mammulata* (Ach.) Tuck., and *Usnea subgracilis* Vainio.

Discussion

This type of field excursion has advantages and disadvantages. There should be a limit placed at 25 persons or less and at least five foray captains

to serve as experts for different lichen taxonomic groups, or about a 5:1 instructor-participant ratio. With inexperienced middle school, high school, and university students, teachers, and general public groups collecting lichens, fungi, or myxomycetes, one-on-one personal attention often is required to help with identifications and to answer questions (H.W. Keller, pers. observ.). We placed no restrictions on who could register so that the general public could benefit from learning more about lichens. However, because of the complexity of lichen terminology, chemicals used to test color reactions, the need for both dissecting and compound microscopes, and the number of species involved (approximately 600–700 in GSMNP), only a cursory introduction was possible. In addition, a Bio-Quest of this type is useful as an educational tool, but is not practical for novices to conduct survey work. Participants learned what was and was not a lichen, and how to recognize lichen growth forms. Participants also gained a better appreciation of the presence of lichens and the important role they play in different ecosystems in GSMNP. Obviously, two days is not enough time to master lichen identification using dichotomous keys or even picture keys. Students who want to learn more in-depth details about lichen morphology and identification should consider attending summer field courses on lichens at field stations such as the Humboldt Field Research Institute in Maine (www.eaglehill.us).

A list of 88 species and 10 new published Park lichen records, including three lichenicolous fungi, represents a successful Bio-Quest. The new records (all common species) indicate that certain groups, such as the stubble lichens, are understudied and are often overlooked even by lichenologists. This is due in part to their small size and the requirement that at least a 10x hand lens be used to scan wood or bark surfaces. Additionally, many lichen habitats are often overlooked, such as rock surfaces and outcrops restricted to smaller areas (saxicolous lichens), inside rocks (endolithic), on the bark of living trees (corticolous), and especially in the tree canopy (Ciegler et al. 2003, Keller 2004). Targeting specific habitats that are difficult to access will increase the chances of discovering new records and species.

An important objective of many Bio-Quests is to increase the general public's awareness of life forms in city and state parks, nearby natural areas, and even forested areas in their own backyard. However, all of the new Park records were collected by professional lichenologists, suggesting that a certain level of expertise is needed to discover new records and species.

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