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SUMMER EPHEMEROPTERA, PLECOPTERA, AND TRICHOPTERA FROM SOUTHWESTERN DRAINAGES IN GREAT SMOKY MOUNTAINS NATIONAL PARK, WITH ADDITIONAL EPHEMEROPTERA RECORDS

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Abstract.—Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (in total, EPT) were inventoried during May 2003, June 2003, and early July 2004 at 15 stream reaches in southwestern Great Smoky Mountains National Park (GRSM). Adults and immatures were collected using ultraviolet light traps, sweepnetting, and handpicking. At least 169 species were collected, including 54 mayfly species, 38 stonefly species, and 77 caddisfly species. Two small, western, low elevation streams, Shop Creek and Tabcat Creek, produced the greatest number of species at 61 and 56 species, respectively. The two large streams, Eagle and Deep creeks, also produced high species richness at 53 species each. A species accumulation curve and two richness estimates demonstrated that EPT richness in this particular area may be 80 to 120 species higher than observed. A cluster analysis showed that adjacent stream reaches had relatively similar faunas and that different habitats supported quite different assemblages. Significant regional records included *Ameletus tertius* McDunnough and *Epeorus fragilis* (Morgan). Several Ephemeroptera species are reported for the first time from North Carolina (4), Tennessee (6), and GRSM (7). Four Trichoptera species are reported from GRSM for the first time.

Key Words: Ephemeroptera, Plecoptera, Trichoptera, Great Smoky Mountains National Park

The National Park Service has been conducting an All Taxa Biodiversity Inventory (ATBI) in the Great Smoky Mountains National Park (GRSM) since 1997 (Sharkey 2001), one of relatively few Park Service properties receiving any such attention (Baumgardner and Bowles 2005). The inventory efforts in GRSM have yielded data that augment our knowledge of the diversity and distribution of aquatic insects in North America, including the discovery of several new species (Parker 2000; Petersen et al. 2004; Etnier et al. 2004; Jacobus and McCafferty 2006). The southern Appalachian Mountain Range and GRSM, in particular, are important sources of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (hereafter referred to as EPT) diversity (Morse et al. 1993; Jacobus and McCafferty 2003, 2005). DeWalt and Heinold (2005), working in the western Abrams Creek drainage of GRSM, recorded 39 EPT species not previously reported from GRSM, eight of which were new Tennessee state records. Other GRSM areas that appear

Table 1. Location information, approximate stream width, elevation, dates of collection, and methods used at 15 stream sites in southwestern Great Smoky Mountains National Park in May and June 2003 and July 2004. Stream sites oriented from west to east.

Site	Creek	Lat.	Long.	Width (m)	Elevation (m)	Dates	Methods
Blount County, Tennessee							
1	Shop Cr.	35.5308	83.9878	4	268	6/1, 6/9	sweep, handpicking, UV light
2	Tabcat Cr.	35.5196	83.9793	5	299	5/21, 5/22, 6/8	sweep, handpicking, UV light
3	Seeps Cattail Br.	35.5149	83.9763	0.5	311	5/21, 5/22	sweep, handpicking
4	Cattail Br.	35.5149	83.9763	2	311	5/21, 5/22	sweep, handpicking
Swain County, North Carolina							
5	Twentymile Cr. CG 93	35.4730	83.8524	6	579	5/21, 7/2	handpicking, UV light
6	John's Cove	35.4725	83.8515	2	579	5/22	sweep
7	Proctor Br.	35.4856	83.8368	2	768	5/22, 6/5, 7/3	sweep, handpicking, UV light
8	Twentymile Cr. CG 92	35.4968	83.8337	3	713	6/5, 7/3	sweep, handpicking, UV light
9	Gunna Cr.	35.5512	83.7322	6	1109	6/3	sweep, handpicking, UV light
10	Eagle Cr. CG 90	35.4880	83.7718	12	533	5/28, 7/4	sweep, handpicking, UV light
11	Eagle Cr. CG 89	35.4985	83.7638	10	585	5/28, 6/10	sweep, handpicking, UV light
12	Ekaneetlee Cr.	35.4981	83.7664	8	585	5/28, 6/10	sweep, handpicking, UV light
13	Hazel Cr.	35.4744	83.7245	10	531	5/29, 6/11	sweep, UV light
14	Hammer Br.	35.4739	83.4311	2	585	5/24	sweep, handpicking, UV light
15	Deep Cr.	35.4730	83.4300	10	594	5/24, 5/31, 6/12	sweep, handpicking, UV light

to be poorly studied include numerous locales east of Abrams Creek in Tennessee, east into North Carolina. This southwestern end of the Park is remote and constitutes the largest roadless area in GRSM. Much of the region occurs north of Lake Fontana, making access difficult. The building of a proposed highway, the so-called North Shore Road, has loomed as a threat to this area for over 50 years and would run along the northern boundary of Lake Fontana, so it is imperative to record rare species and unique communities from this area to document its importance to GRSM.

Our objective was to inventory the summer EPT of 15 stream reaches spanning the distance from the mouth of Shop Creek in Blount County, Tennessee, to Deep Creek near Bryson City, Swain County, North Carolina. Particular effort was made to inventory several streams that are tributaries of Lake Fontana.

Materials and Methods

Fifteen reaches (Table 1) were accessed by foot and by boat from 21 May to 12 June, 2003 and 1–4 July, 2004. Most sites were inventoried on multiple occasions using multiple methods (Table 1). Ultraviolet (UV) light trapping was conducted using a Bioquip™, 12 v light and battery. Effort was standardized by time (approximately one hour

beginning at sunset) and reflective sheet size (1 m^2). Trays of 80% EtOH were positioned below the sheet to capture falling insects. Mayfly subimagoes were captured from the sheet and reared to imagoes. Males of Perlidae and Perlodidae stoneflies were captured and their intromittent organ extruded to facilitate species identification. Remoteness of access meant that we could not control for variability of weather, hence, some difference in effort is acknowledged. Sweepnetting of riparian vegetation for adults and handpicking in streams for nymphs, larvae, and pupae was also conducted until no new species were detected. Geographic coordinate data were captured using a Garmin™ 12XL global positioning system at each site.

Samples were sorted in their entirety and specimens identified to species. Often only the males of species could be identified, but where it seemed that color pattern, size, or wing veination was consistent with males of known identity, they too were determined. All specimens are housed in the INHS insect collection and were entered into the INHS insect collection database (INHS 2005).

An EPT species richness data matrix was constructed with the number of collections, number of methods, elevation, and stream wetted width (size) as potential correlative variables. Relationships among these were tested using Spearman Rank Correlation (Cody and Smith 1991). Another matrix, one of stream reach-by-species presence or absence was built in order to determine efficacy of sampling. Here, all methods for a reach were pooled, taxa at the genus level discarded unless they were unique, and data from John's Cove excluded due to poor sampling. The data matrix was analyzed using PCOrd™ software (McCune and Mefford 1999), with species accumulation curves and jackknifing options chosen. The species accumulation curve assesses sample adequacy by repeatedly sampling the data matrix to provide a prediction of richness versus subsample units. It also calculates standard deviation about this predicted value. Curves that climb rapidly and level out demonstrate saturation of effort in the area. Those whose slope is steep have not nearly exhausted the available species.

PCOrd also provides two jackknife estimates of species richness from random permutations of the data matrix. McCune and Mefford (1999) provide a brief explanation of two procedures, the first-order and second-order jackknife estimators. The first-order estimator makes use of the number of species occurring in just one sample unit (singletons), the total number of species, and the number of sample units (Palmer 1990). The second-order estimator uses the number of species that occur in two sample units, in addition to the singletons. Biases of both methods are discussed by Hellman and Fowler (1999).

Another data matrix was constructed for species abundances by stream reach. This data set was used in an unweighted pair-group method cluster analysis provided in PCOrd. Options chosen included flexible beta linkage ($\beta = -0.25$) and the distance measure used was Sørensen's (1948) similarity subtracted from one. Five groupings were specified for the analysis, a choice that minimized the percent chaining of small groups to large ones, an outcome that biases cluster analysis results (McCune and Mefford 1999). We assumed here that adjacent streams, those of similar size and gradient, and of the same habitat type should cluster closer together than those that do not share these habitat similarities.

Results

Our efforts yielded 169 EPT species, with mayflies, stoneflies, and caddisflies contributing 54, 38, and 77 species, respectively (Table 2). Mayflies were

Table 2. Ephemeroptera, Plecoptera, and Trichoptera taxa taken from 15 stream reaches in southwestern Great Smoky Mountains National Park, May and June 2003, July 2004. Sites organized from west to east along southern Park boundary. Site numbers refer to stream reaches in Table 1.

Order/Family/Genus	Site Number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Ephemeroptera																0
Ameletidae																0
Ameletus tertius McDunnough															2	2
Baetidae																
Acerpenna macdunnoughi (Ide)	1				1											2
Acentrella ampla Traver	1	1														2
Acentrella sp.										2	8					10
Baetis brunneicolor McDunnough	3															3
Baetis flavistriga McDunnough	1	1														2
Baetis tricaudatus Dodds							4									4
Baetis sp.		1										1	3		12	17
Centroptilum sp.	1															1
Caenidae																0
Caenis macafferti Provonsha	27															27
Ephemerellidae																
Dannella lita (Burks)					4											4
Dannella simplex (McDunnough)					3											3
Drunella lata (Morgan)		2														2
Drunella tuberculata (Morgan)					1											1
Ephemerella catawba Traver		3			1											4
Ephemerella dorothea (Needham)	6	8		12				1	1				1			29
Ephemerella excrucians Walsh									1							1
Ephemerella hispida Allen & Edmunds															1	1
Ephemerella sp.		3			1						10	1	18		27	60
Serratella deficiens (Morgan)	1	4														5
Serratella molita (McDunnough)	1									1						
Serratella serrata (Morgan)					11											11
Serratella sp.	1															1

Table 2. Continued.

Order/Family/Genus	Site Number															Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Ephemeridae																0
Ephemera guttulata Pictet		2			3									3		8
Ephemera varia Eaton															2	2
Hexagenia limbata (Serville)	1														2	3
Heptageniidae																
Epeorus dispar (Traver)		3					9	4			6	1			18	41
Epeorus fragilis (Morgan)															1	1
Epeorus rubidus (Traver)					3											
Epeorus subpallidus (Traver)					1											1
Epeorus vitreus (Walker)		1														1
Epeorus sp.															20	20
Leucrocuta aphrodite (McDunnough)	43	26								20						89
Leucrocuta juno (McDunnough)										21					15	36
Leucrocuta minerva (McDunnough)		3														3
Leucrocuta thetis (Traver)	1						4	4								9
Leucrocuta sp.	12	15			7											34
Maccaffertium carlsoni (Lewis)	2									4			1			7
Maccaffertium ithaca (Clemens & Leonard)	2												2		2	6
Maccaffertium meririvulanum (Carle & Lewis)							2									2
Maccaffertium mexicanum (McDunnough)		1														1
Maccaffertium modestum (Banks)	1	7									2					10
Maccaffertium pudicum (Hagen)	2	4								4		1			1	12
Maccaffertium terminatum (Walsh)				3	7			1	1				6			18
Maccaffertium vicarium (Walker)												1				1
Maccaffertium sp.	1													1		2
Nixe spinosa (Traver)															1	1
Rhithrogena amica Traver											1				1	2
Rhithrogena fasciata Traver										20						20
Rhithrogena sp.											3					3
Stenacron carolina (Banks)	1							2								3
Stenacron interpunctatum (Say)	4	6									2	1			1	14
Stenacron pallidum (Traver)	1	6			4		5									16
Isonychiidae																
Isonychia bicolor (Walker)										1	1				1	3
Isonychia similis Traver							4									4

Table 2. Continued.

Order/Family/Genus	Site Number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Leptophlebiidae																
Habrophlebia vibrans Needham	4		16								3	4		3		30
Habrophlebiodes americana (Banks)	7	3	9	1							2		1			23
Habrophlebiodes sp.	3	2			1											6
Paraleptophlebia assimilis (Banks)		1					2				3			1		7
Paraleptophlebia guttata (McDunnough)		1	1				1	1								4
Paraleptophlebia mollis (Eaton)															4	4
Paraleptophlebia sp.					1				2					1		4
Neoephemeridae																
Neoephemera purpurea (Traver)															1	1
Siphlonuridae																
Siphlonurus typicus (Eaton)															1	1
Chloroperlidae																
Alloperla atlantica Baumann															12	12
Alloperla nanina Banks							2									2
Alloperla usa Ricker					1			3								4
Alloperla sp.		3			1		3									7
Haploperla brevis (Banks)							1				1				1	3
Suwallia marginata (Banks)								1								1
Sweltsa lateralis (Banks)									2							2
Sweltsa mediana (Banks)											5			1	3	9
Sweltsa sp.	1	2				1	2		2				1			9
Leuctridae																
Leuctra carolinensis Claassen							13							3		16
Leuctra ferruginea (Walker)	14	19														33
Leuctra mitchellensis Hanson									18							18
Leuctra sibleyi Claassen							1									1
Leuctra sp.	13			3			2		12		1	1	1		3	36
Nemouridae																
Amphinemura nigritta (Provancher)		1	1				1		4		1					8
Amphinemura wui (Claassen)						2	23				5	1		10		41
Amphinemura sp.	1			1			2	1		1	10	1			1	18
Soyedina sp.			2													2

Table 2. Continued.

Order/Family/Genus	Site Number															Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Peltoperlidae																
Tallaperla anna (Needham & Smith)							6	2								8
Tallaperla cornelia (Needham & Smith)							16		3							19
Tallaperla elisa Stark											1					1
Tallaperla laurie (Ricker)		3	17	1			1				2					24
Tallaperla maria (Needham & Smith)	1		2												2	5
Tallaperla sp.															2	2
Viehoperla ada (Needham & Smith)							6				1					7
Perlidae																
Acroneuria abnormis (Newman)	6	16			8		1	7		5	10	6	1			60
Acroneuria filicis Frison					1											1
Agnetina capitata (Pictet)		1														1
Eccoptura xanthenes (Newman)	1				3			3				1				8
Neoperla occipitalis (Pictet)	26															26
Neoperla sp.	3	6														9
Perlesta frisoni Banks					1		1	4			1		2			9
Perlodidae																
Cultus decisus (Walker)											2					2
Diploperla duplicata (Banks)		6	1								2				1	10
Isoperla dicala Frison											1		1		5	7
Isoperla distincta Nelson									1							1
Isoperla holochlora (Klapalek)	4	5					4	1			3	1		2		20
Isoperla orata Frison											2		1			3
Isoperla sp.M8		3			1			3							11	18
Isoperla sp.											36					36
Oconoperla innubila (Needham & Claassen)							2									2
Remenus bilobatus (Needham & Claassen)	1	5	1	3	1		1		1		1	1				15
Yugus arinus (Frison)											1			2		3
Pteronarcyidae																
Pteronarcys scotti Ricker					1											1
Pteronarcys sp.	1	3									1				1	6
Taeniopterygidae																
Bolotoperla rossi (Frison)											1					1

Table 2. Continued.

Order/Family/Genus	Site Number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Trichoptera																
Brachycentridae																
Brachycentrus sp.					1											1
Micrasema charonis Banks											1				1	2
Micrasema rickeri Ross & Unzicker															8	8
Micrasema wataga Ross		1														1
Micrasema sp.									1						5	6
Dipseudopsidae																
Phylocentropus carolinus Carpenter												1				1
Phylocentropus lucidus Hagen								1	1		1	1				4
Glossosomatidae																
Agapetus pinatus Ross										4	3				6	13
Agapetus iridis Ross								1						3		4
Agapetus sp.	1	1								76	17	2		1	33	131
Glossosoma nigrior Banks		1		1												2
Glossosoma sp.	11	3			8			3		1			2			28
Goeridae																
Goera calcarata Banks	7									6			2		7	22
Helicopsychidae																
Helicopsyche borealis (Hagen)		2								8						10
Hydropsychidae																
Arctopsyche irrorata Banks								1								1
Ceratopsyche macleodi (Flint)												4				4
Ceratopsyche morosa (Hagen)														1		1
Ceratopsyche slossonae (Banks)					12					2	6				2	22
Ceratopsyche sparna (Ross)	23	9						1		17	8	11	10	30	110	219
Ceratopsyche sp.												2				2
Cheumatopsyche harwoodi Denning	18	2								3	42	10	14		94	183
Cheumatopsyche analis (Banks)	4															4
Cheumatopsyche sp.	8	23														31
Diplectrona metaqui Ross	1	1	3													5
Diplectrona modesta Banks	6	21		4	40		3	42	2	3	14	21			1	157
Hydropsyche betteni Ross	3	4														7
Hydropsyche betteni or depravata	7														1	8
Hydropsyche sp.												1				1
Parapsyche cardis Ross							2	1						2		5

Table 2. Continued.

Order/Family/Genus	Site Number															Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Hydroptilidae																
Hydroptila oneili Harris	3															3
Hydroptila valhalla Denning	1															1
Hydroptila sp.		15									1				7	23
Stactobiella delira (Ross)					6											6
Stactobiella martynovi Schmid															3	3
Stactobiella sp.														7	11	18
Lepidostomatidae																
Lepidostoma lydia Ross											1					1
Lepidostoma ontario Ross															1	1
Lepidostoma pictile (Banks)														5	2	7
Lepidostoma tibiale (Carpenter)										19						19
Lepidostoma sp.		3	1		4					1						9
Theliopsyche grisea (Hagen)	1															1
Leptoceridae																
Ceraclea diluta (Hagen)															5	5
Ceraclea flava (Banks)										1						1
Ceraclea tarsipunctata (Vorhies)	1															1
Ceraclea transversa (Hagen)	122	35			1					1	3					162
Nectopsyche exquisita (Walker)	2															2
Oecetis avara (Banks)										10						10
Oecetis inconspicua (Walker)	8	1			3							1			1	14
Oecetis persimilis (Banks)										23						23
Oecetis sp.	1															1
Triaenodes taenius Ross		1														1
Limnephilidae																
Hydatophylax argus (Harris)															7	7
Pseudostenophylax sparsus (Banks)					1		27	11	103							142
Pycnopsyche flavata (Banks)									2							2
Pycnopsyche gentilis (McLachlan)			2				2				1					5
Pycnopsyche sp.	2	1			2			1				1				7
Molannidae																
Molanna ulmerina Navas	12															12
Molanna sp.											1					1

Table 2. Continued.

Order/Family/Genus	Site Number															Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Odontoceridae																
Psilotreta amera Ross								1								1
Psilotreta sp.			1													1
Philopotamidae																
Chimarra aterrima Hagen			3													3
Dolophilodes distinctus (Walker)					11		1				1				1	14
Dolophilodes major (Banks)					1											1
Dolophilodes sp.		2						4			3				4	13
Wormaldia moesta (Banks)														1		1
Wormaldia sp.	1	2	1						1							5
Phryganeidae		1														1
Ptilostomis ocellifera (Walker)					1			1								2
Polycentropodidae																
Neureclipsis sp.	1															1
Nyctiophylax affinis (Banks)	2															2
Nyctiophylax celta Denning										5						5
Nyctiophylax denningi Morse	6	12														18
Nyctiophylax moestus Banks	3															3
Nyctiophylax nephophilus Flint					5			5			3	3				16
Nyctiophylax sp.	5										1		1		3	10
Plectrocnemia cinerea (Hagen)	6	3			1			4								14
Polycentropus confusus Hagen	42	2								1					2	47
Polycentropus maculatus Banks					1											1
Polycentropus sp.	31	1			1					32	1					66
Psychomyiidae																
Lype diversa (Banks)	7	1	1		8		1	10	3	1	6	2		2		42
Psychomyia flavida Hagen	3	6			8				1		62	14			2	96

Table 2. Continued.

Order/Family/Genus	Site Number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Rhyacophilidae																
Rhyacophila amicis Ross															5	5
Rhyacophila atrata Banks												3				3
Rhyacophila carolina Banks	1				3	1		2	1	1	1			5	5	20
Rhyacophila carpenteri Milne							2		1						1	4
Rhyacophila fuscula (Walker)					3			2			10	11	2	2	22	52
Rhyacophila glaberrima Ulmer								1						1		2
Rhyacophila nigrita Banks						1	11		4		1	3				20
Rhyacophila teddyi Ross											3				1	4
Rhyacophila torva Hagen	1							2	1		1			1		6
Rhyacophila sp.							1		1						1	3
Sericostomatidae																
Agarodes griseus Banks or *tetron* (Ross)															1	1
Fattigia pele (Ross)						2	2		1		3					8
Uenoidae																
Neophylax consimilis Betten	4															4
Neophylax mitchelli Carpenter					9		2	3	7							21
Neophylax oligius Ross											2		1			3
Neophylax ornatus Banks		1			4			5	1							11
Neophylax sp.		1														1
Total Count	559	341	74	45	221	31	201	172	215	334	370	161	123	144	568	3074
Ephemeroptera	21	19	3	3	14	0	8	6	4	8	10	7	6	4	17	54
Plecoptera	10	13	6	4	8	2	16	9	6	2	19	6	6	5	10	38
Trichoptera	30	24	7	2	22	3	10	21	15	17	24	16	7	12	26	77
Total EPT	61	56	16	9	44	5	34	36	25	27	53	29	19	21	53	169

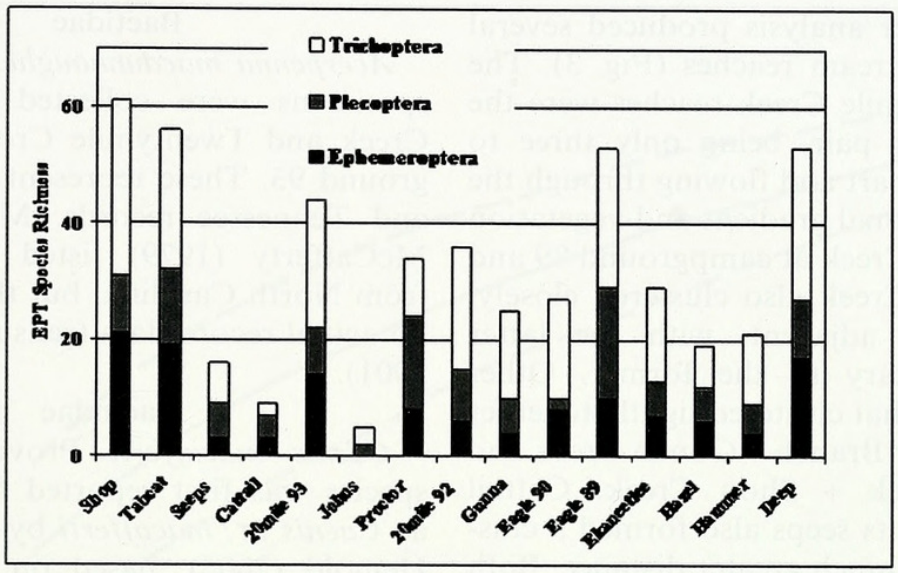

Fig. 1. Ephemeroptera, Plecoptera, and Trichoptera species richness from stream reaches in southwestern Great Smoky Mountains National Park, Tennessee and North Carolina.

dominated by Heptageniidae (23 species among six genera) and Ephemerellidae (11 species among four genera). Plecoptera were dominated by Perlodidae (10 species among six genera) and Chloroperlidae (seven species among four genera). Among the Trichoptera, the Hydropsychidae were dominant (11 species among five genera). Nine species were collected from each of three other families: Leptoceridae, Polycentropodidae, and Rhyacophilidae. Caddisflies dominated species richness at 12 of 15 locations. This appeared to be a natural pattern for reaches with diverse faunas and wetted widths greater than 2 m. Proctor Branch, a moderately diverse (34 EPT) and narrow stream (2 m), was the only site where stoneflies contributed the greatest number of EPT species.

Our data suggest that the most important factor explaining species richness in this study is the number of collections, essentially the number of visits, to a given reach (Spearman Rank correlation, $R=0.70$, $p=0.004$). Neither elevation, wetted width, nor the number of methods used produced a significant correlation. Species richness ranged from five (Johns Creek, incompletely sampled) to 61 (Shop Creek) (Fig. 1). Five streams could be viewed as hyperdiverse (>40 species) in light of the richness of the other 10 reaches. These included Shop Creek and Tabcat Creek, Twentymile Creek at campground 93, Eagle Creek at campground 89, and Deep Creek.

Shop Creek and Tabcat Creek each drained relatively open, hardwood forests, had narrow widths (4–5 m wetted width), and were at the lowest elevations (268–299 m) of all reaches sampled. Additionally, the Tabcat Creek drainage was unique in that it had a well-developed floodplain above and below the sample reach. The remaining hyperdiverse reaches were moderate to large streams with high gradients. Deep Creek was the most open canopied of the large streams.

It appears that our sampling was not so extensive as to exhaust the area species pool. This is evident by the slope of the species accumulation curve being nearly 45, with only a hint of leveling off. Jackknife estimator procedures both produced estimates much greater than our current 169 species. The first-order jackknife was 245 species, while the second-order was 293. Between these two estimates are 76–124 addition EPT species to be found in the local area of SW GRSM.

The cluster analysis produced several clusters of stream reaches (Fig. 3). The two Twentymile Creek reaches were the most similar pair, being only three to four miles apart and flowing through the same elevational gradient and vegetation type. Eagle Creek at campground 89 and Ekaneetlee Creek also clustered closely. These were adjacent, with the latter being tributary to the former. Other reach pairs that clustered tightly together were Proctor Branch + Gunna Creek and Tabcat Creek + Shop Creek. Cattail Branch and its seeps also formed a cluster, but at a much greater distance. Both drain low gradient floodplain habitat and were curiously depauperate. Overall, the cluster analysis suggested that many of these reaches have great turnover in EPT community composition and that EPT fauna are not evenly distributed in the region.

Significant Records

Ephemeroptera

Ameletidae

Ameletus tertius McDunnough.—Two larvae were collected from Deep Creek. Zloty (1996) reported *A. tertius* from southeastern Canada, Maine, Vermont, and New York in his review of North American species of the genus. This is the first record of the species from GRSM, North Carolina, and the southern Appalachian Mountains. Additional GRSM specimens exist in the Purdue Entomology Research Collection [PERC]: NC: Swain Co., Oconaluftee River, 35°31′59″N, 83°18′08″W, 15-V-2001, C. D. & R. P. Randolph, L. M. Jacobus, one nymph. TN: Blount Co., Middle Prong, 35°38′30″N, 83°41′25″W, 18-V-2001, C. D. & R. P. Randolph, L. M. Jacobus, one nymph; Cocke Co., Cosby Creek, 35°46′59″N, 83°13′06″W, 17-V-2001, C. D. & R. P. Randolph, L. M. Jacobus, one nymph; Sevier Co., Jakes Creek, 35°38′44″N, 83°35′02″W, 12-VI-2003, J. M. Webb, L. M. Jacobus, one nymph.

Baetidae

Acerpenna macdunnoughi (Ide).—Two specimens were collected from Shop Creek and Twentymile Creek at campground 93. These represent new GRSM and Tennessee records. Morihara and McCafferty (1979) listed this species from North Carolina, but they provided no actual record data (sensu McCafferty 2001).

Caenidae

Caenis macafferti Provonsha.—This species was first reported from GRSM as *Caenis* nr. *macafferti* by DeWalt and Heinold (2005), based on adult specimens from lower Abrams Creek. We now have larvae from Shop Creek and Abrams Creek Campground and one reared adult of each sex from the latter location. The larvae might be identified as *C. tardata* McDunnough when using the key provided by Provonsha (1990); they have the operculate second gill uniformly brown and hind tarsal fimbriate spurs numbering 12. However, the Y-ridge diverges in the anterior half of the operculate gill, not in the posterior as in *C. tardata*. Adults will key (Provonsha 1990) to near *C. macafferti*, with forewing vein ICuA1 forked from CuA2 just distad of the CuA1-CuP crossvein; abdominal terga 1–10 shaded blackish brown and terga nine and 10 lacking triads of black dots; each egg has one polar cap. However, they lack the fleshy protuberance characteristic of *C. macafferti* (Provonsha 1990). Provonsha (1990) lists it from Florida to New York, with a disjunct population in the Ozark Mountains of Arkansas. This is a new North Carolina state record.

Ephemeridae

Hexagenia limbata (Serville).—Three specimens were collected from Deep Creek and Shop Creek. The species has a transcontinental distribution on North America (McCafferty 1994) including North Carolina Pescador et al. (1999) and Tennessee (Long and Kondratieff

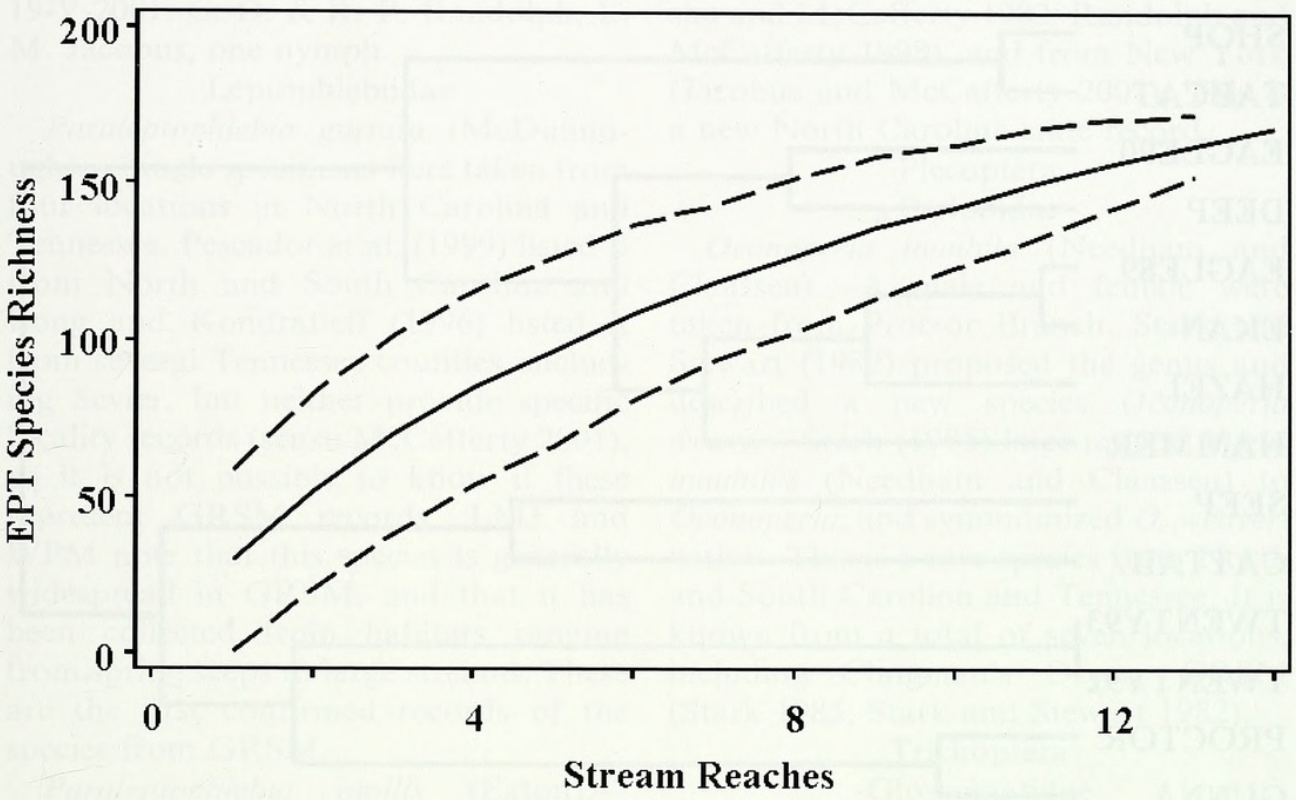

Fig. 2. Species accumulation curve for Ephemeroptera, Plecoptera, and Trichoptera species richness from stream reaches in southwestern Great Smoky Mountains National Park, Tennessee and North Carolina. Solid line is predicted line-of-best-fit, dashed lines are one standard deviation out as confidence intervals.

1996). It was reported by Spieth (1941) from Bryson City, North Carolina, just outside of GRSM, but this is the first published record from within GRSM.

Heptageniidae

Epeorus fragilis (Morgan).—A single female subimago was collected from Deep Creek. A male adult was collected from a nearby drainage in GRSM: NC: Haywood Co., Trib. Hemphill Creek, 5 km WNW Jonathan, 35°34′35″N, 83°04′22″W, 31-V-2003, R. E. DeWalt, Catalogue # INHS 9961. Authors LMJ and WPM report additional specimens from several streams elsewhere in GRSM—NC: Haywood Co., Big Creek at Big Creek picnic area, 35°45′05″N, 83°06′31″W, 12-VI-2003, J. M. Webb, L. M. Jacobus, one nymph. TN: Sevier Co.,Tributary Little River, 35°38′45″N, 83°35′03″W, 16-V-2001, C. D. & R. P. Randolph, L. M. Jacobus, 4 nymphs; Sevier Co., Injun Creek at Greenbrier Ranger Station, 35°43′49″N, 83° 24′22″W, 7-XII-2001, J. F. MacDonald, L. M. Jacobus, 4 nymphs [PERC]. The species has been reported from West Virginia (Faulkner and Tarter 1977), Virginia (Kondratieff and Voshell 1983), and New York (Jacobus and McCafferty 2001). Our data represent new GRSM, North Carolina, and Tennessee records.

Nixe spinosa (Traver).—A single specimen was taken from Deep Creek. It is known from North Carolina (Pescador et al. 1999) and the Abrams Creek drainage of GRSM (DeWalt and Heinold 2005). The species is seldom reported, perhaps because the larva is unknown. However, LMJ and WPM note that adults have been collected commonly at lights elsewhere in GRSM, especially from some of the more eastern drainages (Jacobus and McCafferty, unpublished data).

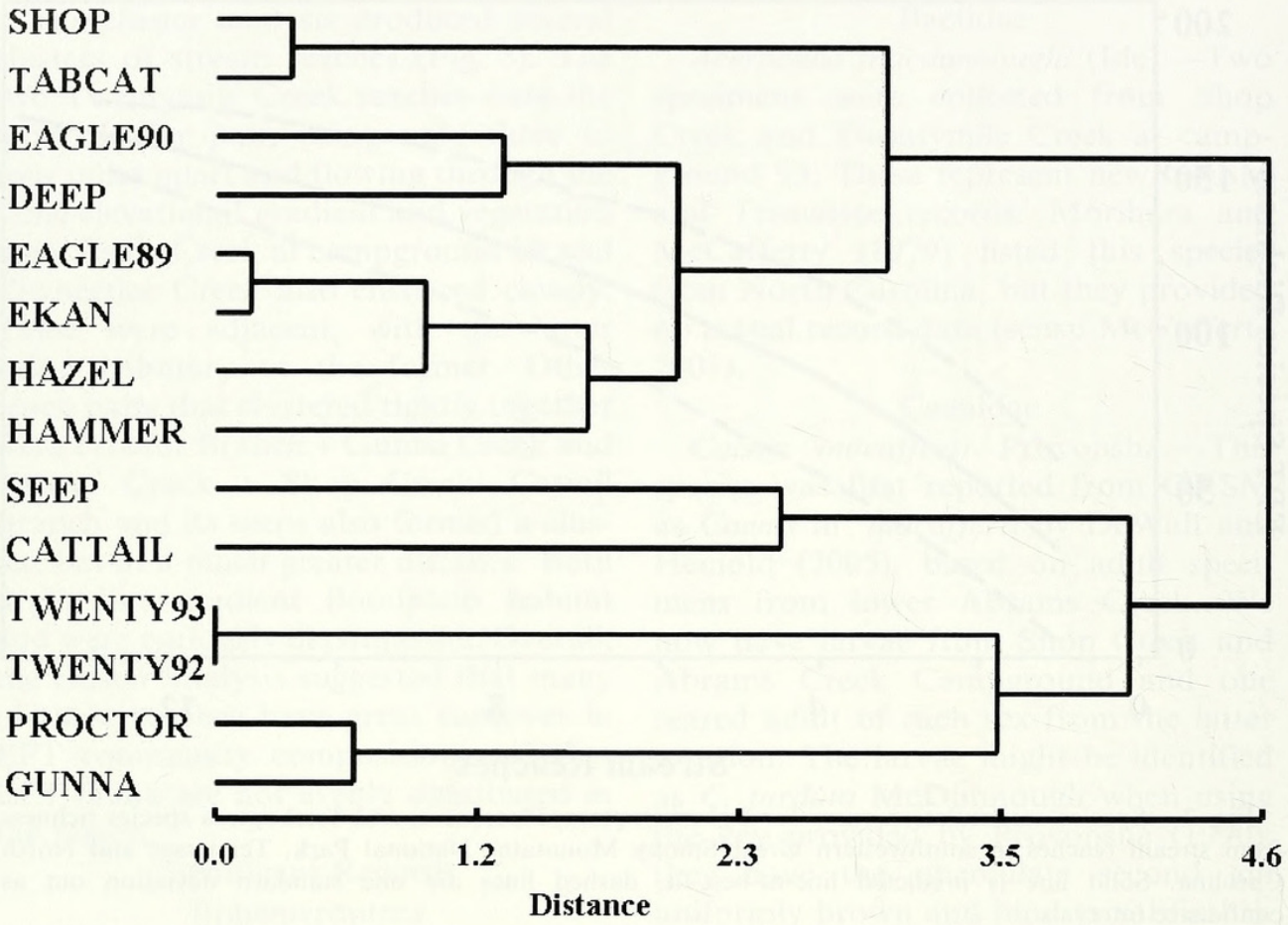

Fig. 3. Unweighted pair-group method cluster analysis of Ephemeroptera, Plecoptera, and Trichoptera assemblages in stream reaches in southwestern Great Smoky Mountains National Park, Tennessee, and North Carolina.

Rhithrogena fasciata Traver.—A large population was taken at Eagle Creek at campground 90. Traver (1933) listed it from several western North Carolina sites, including Waynesville in Haywood County, adjacent to GRSM. It has been reported also from South Carolina (Pescador et al. 1999) and Georgia (Berner 1977). The species has been collected from one other GRSM location: NC: Swain Co., Bradley Fork at Smokemont, 24-IX-2002, L. M. & P.D. Jacobus, one nymph [PERC]. These are new records for GRSM.

Stenacron pallidum (Traver).—Sixteen specimens were collected from four locations in Tennessee and North Carolina. Lewis (1974) reported it as restricted to the North Carolina mountains. Subsequently, it was reported from South Carolina (Morse et al. 1989), New York (Jacobus and McCafferty 2001), and Tennessee (DeWalt and Heinold 2005) in GRSM. Authors LMJ and WPM have collections from widely distributed locations in the GRSM.

Maccaffertium carlsoni Lewis.—Seven specimens were collected as part of this study from three reaches in Tennessee and North Carolina, representing new GRSM and Tennessee records. Morse et al. (1989) previously reported *M. carlsoni* from North Carolina. Additional specimens residing in PERC include: TN: Sevier Co., LeConte Creek, 35°40′34″N, 83°29′16′W, 16-V-2001, C. D. & R. P. Randolph, L. M. Jacobus, one nymph; Sevier Co., Tributary LeConte Creek, 35°40′41″N, 83°28′55′W, 3-XII-2001, C. D. & R. P. Randolph, L. M. Jacobus, one nymph; Blount Co. Tributary Anthony Creek, 35°35′06″N, 83°45′29′W,

19-V-2001, C. D. & R. P. Randolph, L. M. Jacobus, one nymph.

Leptophlebiidae

Paraleptophlebia guttata (McDunnough).—Single specimens were taken from four locations in North Carolina and Tennessee. Pescador et al. (1999) listed it from North and South Carolina and Long and Kondratieff (1996) listed it from several Tennessee counties, including Sevier, but neither provide specific locality records (sensu McCafferty 2001), so it is not possible to know if these represent GRSM records. LMJ and WPM note that this species is generally widespread in GRSM, and that it has been collected from habitats ranging from spring seeps to large streams. These are the first confirmed records of the species from GRSM.

Paraleptophlebia mollis (Eaton).—Four specimens were collected from Deep Creek. Pescador et al. (1999) recorded it from North and South Carolina and Long and Kondratieff (1996) reported it only from Sevier County in Tennessee. Neither work provided specific locality data. This is the first confirmation of its presence in GRSM.

Neoephemeridae

Neoephemera purpurea (Traver).—One larva was collected from Deep Creek as part of this study. It is noted here due it apparent rarity in GRSM. Elsewhere, it is relatively widespread, being known from Florida, Georgia, Kentucky, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia (Traver 1935; Faulkner and Tarter 1977; Harker et al. 1979; Bae and McCafferty 1998).

Siphlonuridae

Siphlonurus typicus (Eaton).—One specimen was collected from Deep Creek as part of this study. DeWalt and Heinold (2005) reported a single male from Abrams Creek. It is known from scattered locations in the Midwest, the northeastern states and Canada (Provonsha and McCafferty 1982; Randolph and McCafferty 1998), and from New York (Jacobus and McCafferty 2001). This is a new North Carolina state record.

Plecoptera

Perlodidae

Oconoperla innubila (Needham and Claassen).—A male and female were taken from Proctor Branch. Stark and Stewart (1982) proposed the genus and described a new species *Oconoperla weaveri*. Stark (1985) later moved *Yugus innubilus* (Needham and Claassen) to *Oconoperla*, and synonomized *O. weaveri* with it. This is a rare species from North and South Carolina and Tennessee. It is known from a total of seven locations, including Clingman's Dome, GRSM (Stark 1985; Stark and Stewart 1982).

Trichoptera

Glossomatidae

Agapetus iridis Ross.—Three males were taken from Hammer Branch. Unzicker et al. (1982) reported it from mountain and piedmont ecoregions of North and South Carolina. It is known from two counties in Tennessee (Etnier et al. 1998) and is a new GRSM record.

Leptoceridae

Ceraclea diluta (Hagen).—Several specimens were taken from Deep Creek. It was reported from the North Carolina coastal plain by Unzicker et al. (1982) and several east-central counties of Tennessee Etnier et al. (1998). It is a new GRSM record.

Triaenodes taenius Ross.—A single male was collected from Tabcat Creek. It was described at the GRSM doorstep by Ross (1938) and was confirmed for GRSM by DeWalt and Heinold (2005). Morse (unpubl. data) reported it from the Ravensford area of GRSM. Etnier et al. (1998) provided one Cocke Co. record adjacent to GRSM.

Molannidae

Molanna ulmerina Navas.—Twelve specimens were taken from Shop Creek. DeWalt and Heinold (2005) reported it

from low elevation Abrams Creek reaches of GRSM. It is known from Cumberland County in Tennessee (Etnier et al. 1998).

Polycentropodidae

Nyctiophylax denningi Morse.—Thirteen males were taken from Shop and Tabcat creeks. Armitage and Hamilton (1990) listed it from Alabama, Georgia, Mississippi, South Carolina, and Tennessee (the latter also by Etnier et al. 1998). It is a new GRSM record.

Sericostomatidae

Agarodes tetron (Ross) or *grisea* Banks.—One female was taken from Deep Creek. Ross and Scott (1974) provided a key to *Agarodes*, but could not separate females of these species. *Agarodes tetron* has been reported from unspecified Tennessee locations adjacent to GRSM (Etnier et al. 1998) and from Ravensford in North Carolina by Morse (unpubl. data). This is a new generic GRSM record.

Discussion

This inventory produced a total of 169 EPT species, four more than was found by DeWalt and Heinold (2005) in their examination of the Abrams Creek drainage in GRSM. Sørensen's quotient of similarity between these two data sets demonstrated a 61% overlap in species composition.

This study produced many more mayfly species, especially in the families Heptageniidae, Ephemerellidae, and Baetidae than did the Abrams Creek work. Among the latter two families, additional handpicking of larvae may have helped to increase our recognition of species richness. Among stoneflies, Perlidae were not as rich as in Abrams Creek, the majority being lost in the genus *Perlesta*. Additionally, caddisfly richness was much less than for Abrams Creek, with major losses among the Hydroptilidae and Leptoceridae. The lack of a large, warm, placid stream, like lower Abrams Creek, is probably the cause of the difficiency in these two families.

The current study produced significant regional records for the mayflies *Ameletus tertius* and *Epeorus fragilis*. Additionally, a number of first reports of Ephemeroptera species are provided for North Carolina (four), for Tennessee (five), and for GRSM (seven). Four new GRSM records of Trichoptera are included also.

Species accummulation curves predicted that potentially 80 to 120 more EPT species will be collected from this region of GRSM. There are still many drainages north of Lake Fontana that have been poorly studied, and it is likely that other areas will yield additional species. For instance, further inventories of EPT species in the highest elevations of GRSM will yield records representing significant range extensions for some species (E. Fleek, pers. comm.). Investigations of remote, higher elevation streams in the southern Appalachians, in general, are needed to assess the biological diversity of this region. For example, recent sampling from remote stream reaches in southern North Carolina revealed a genus previously unreported from North America (Waltz 2002).

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